TGD AND QUANTUM BIOLOGY: PART II

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0.1 PREFACE

Brief summary of TGD

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

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

The basic ideas of TGD

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

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

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

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

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

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

Physics as geometry

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

- Standard model symmetries uniquely fix the choice of 8-D space in which space-time surfaces live to $H = M^4 \times CP_2$ [L180]. 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 [L61, L80](see **Fig. 13**). The geometrization applies even to the quantum theory itself and the space of space-time surfaces - "world of classical worlds" (WCW) - becomes the basic object endowed with Kähler geometry (see **Fig. 14**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L183].

- 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 [K117, L96].

- 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 [K30, K59] [L164].

- 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 [L173]. 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 [L188].

- 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 [L59, L60] fusing real and various p-adic physics is part of the number theoretic vision, which provides a kind of dual description for the description based on space-time geometry and the geometry of "world of classical words". Adelic physics predicts two fractal length scale hierarchies: p-adic length scale hierarchy and the hierarchy of dark length scales labelled by $h_{eff} = nh_0$, where n is the dimension of extension of rational. The interpretation of the latter hierarchy is as phases of ordinary matter behaving like dark matter. Quantum coherence is possible in arbitarily long scales. These two hierarchies are closely related. p-Adic primes correspond to ramified primes for a polynomial, whose roots define the extension of rationals: for a given extension this polynomial is not unique.

$M^8 - H$ duality

The concrete realization of the number theoretic vision is based on $M^8 - H$ duality (see **Fig. 15**). What the precise form is this duality is, has been far from clear but the recent form is the simplest one and corresponds to the original view [L185]. M^8 corresponds to octonions O but with the number theoretic metric defined by $Re(o^2)$ rather than the standard norm and giving Minkowskian signature.

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

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

p-Adic physics

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

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

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

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

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

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

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

TGD as an analog of topological QFT

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

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

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

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

Zero energy ontology

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

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

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

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

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

Equivalence Principle in TGD framework

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

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

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

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

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

could say that at the quantum level gravitational and gauge interactions are eliminated everywhere except at the singularities identifiable as defects of the ordinary smooth structure. The exotic smooth structures [L151], 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 [A6]. I have proposed [K52, K32, K114, K89, L183] 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 [K117, L96] 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 [L179]. 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 [L142, L143] 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 [L188].

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 [L167]. 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.

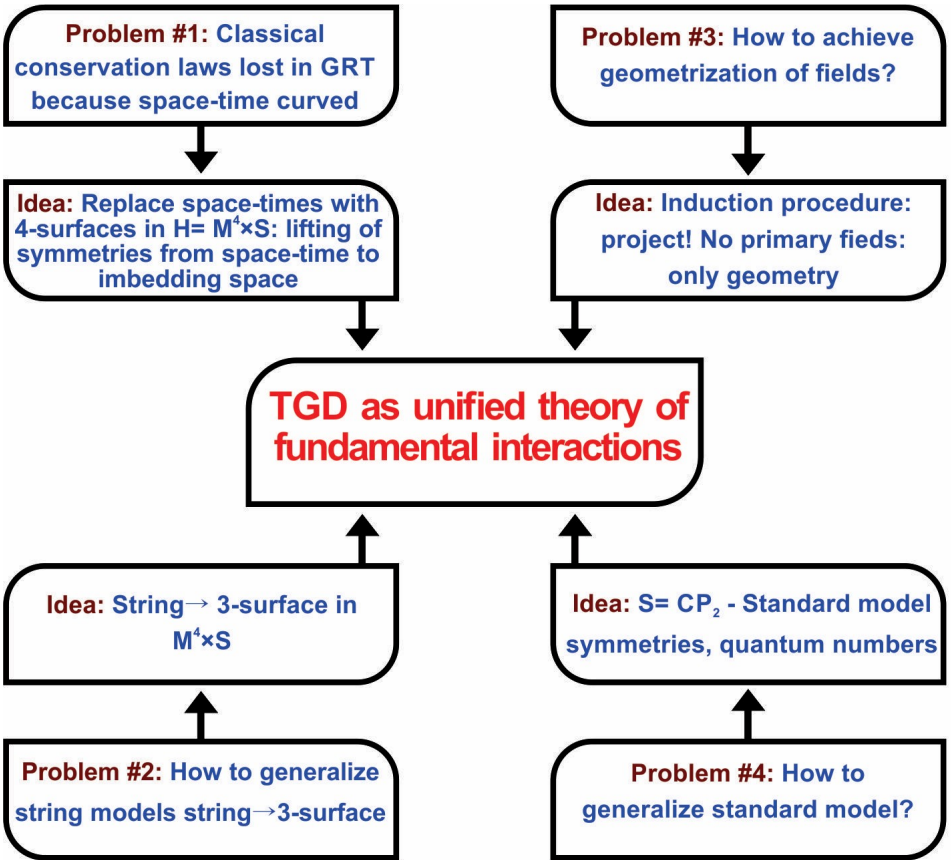


Figure 1: The problems leading to TGD as their solution.

- 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.

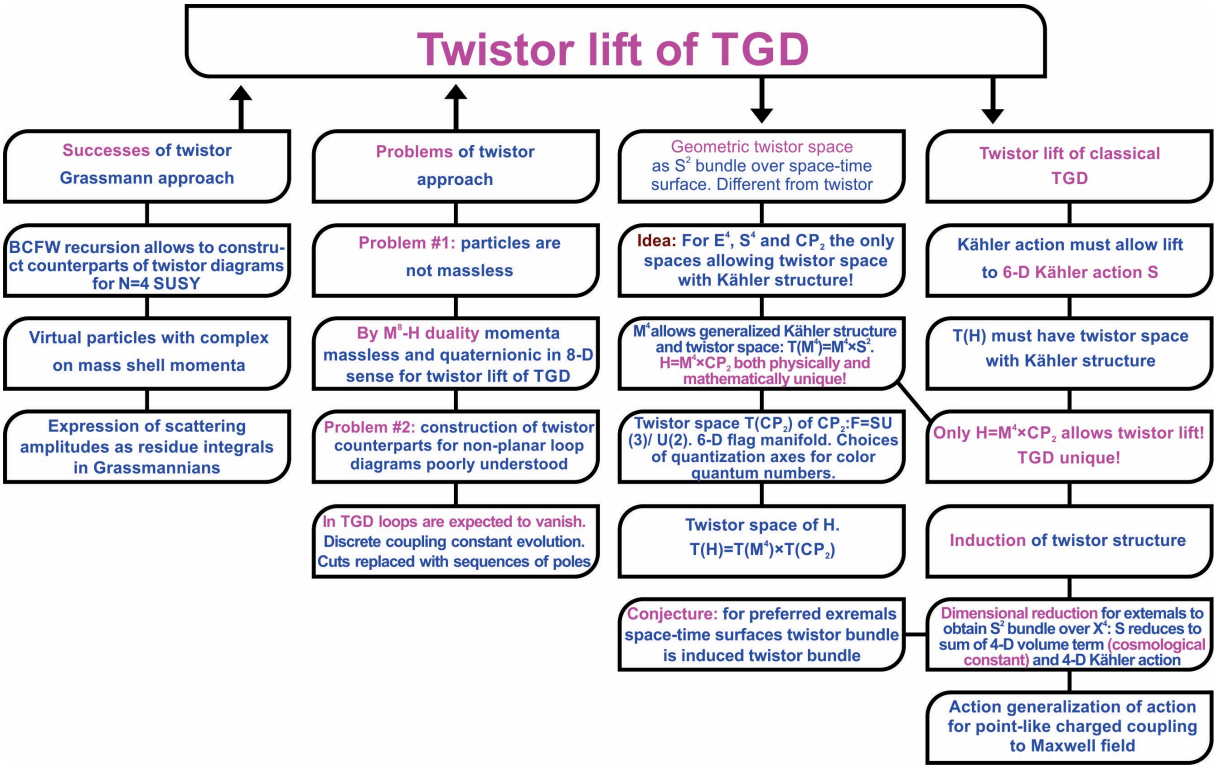


Figure 2: Twistor lift

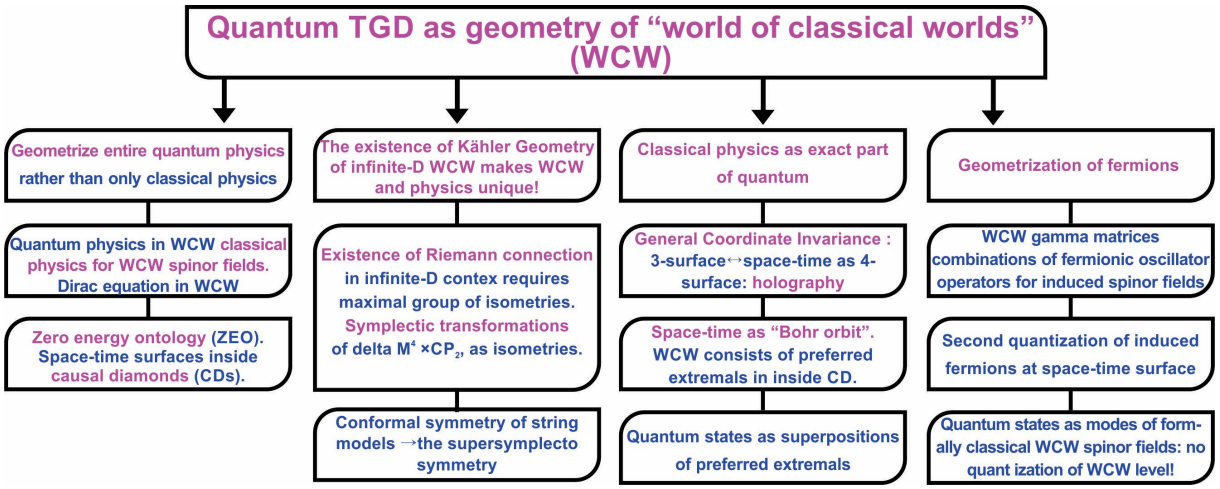


Figure 3: Geometrization of quantum physics in terms of WCW

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

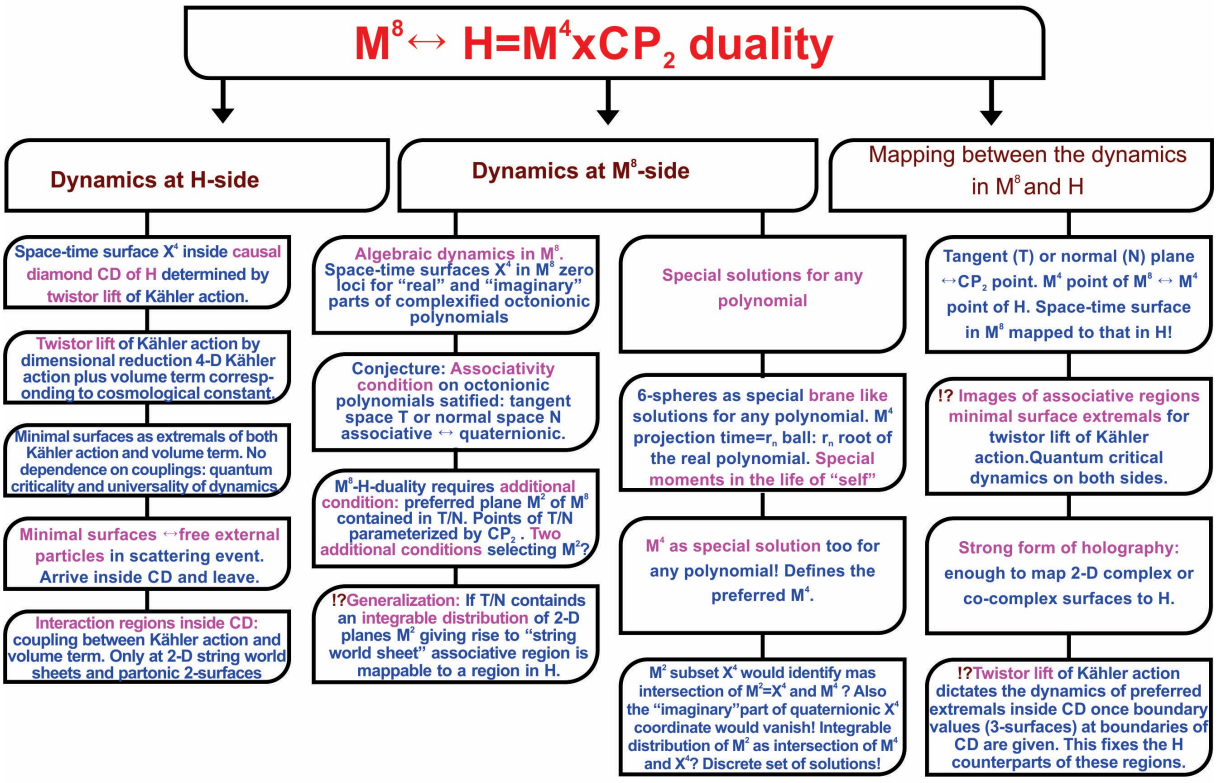


Figure 4: $M^8 - H$ duality

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

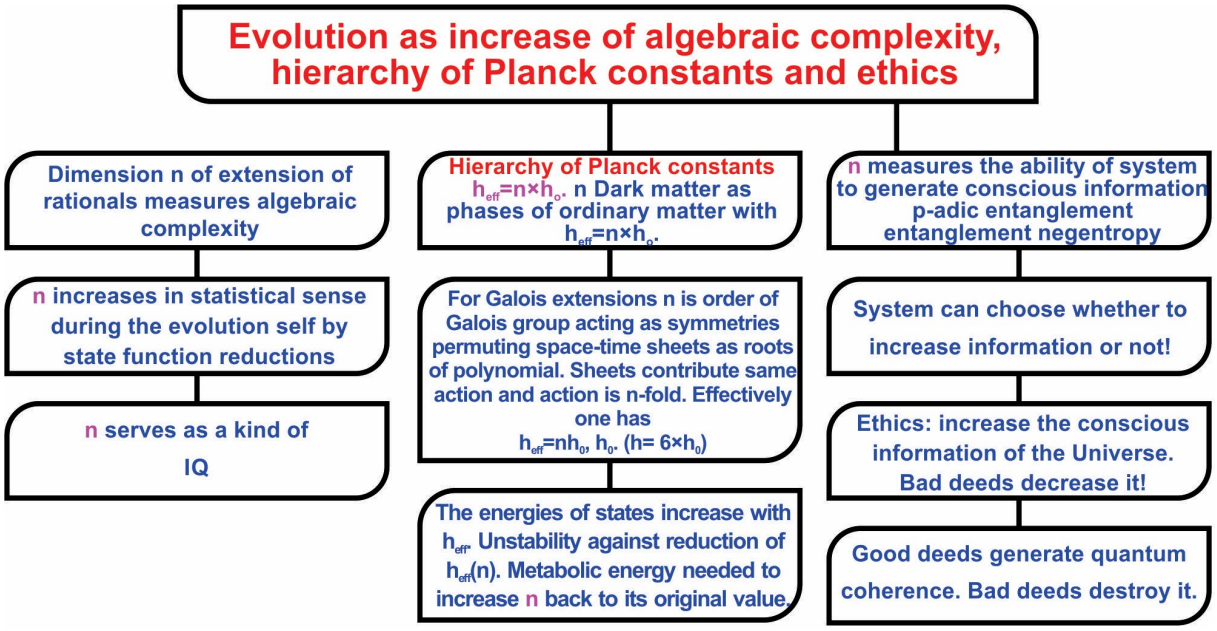


Figure 5: Number theoretic view of evolution

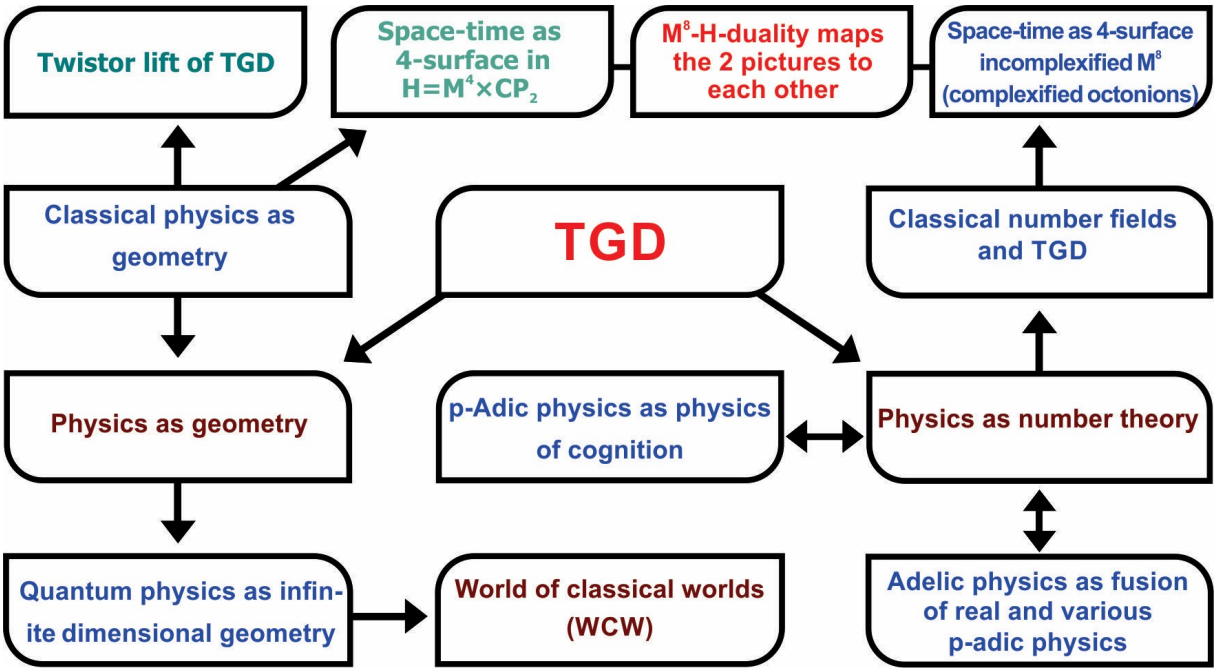


Figure 6: TGD is based on two complementary visions: physics as geometry and physics as number theory.

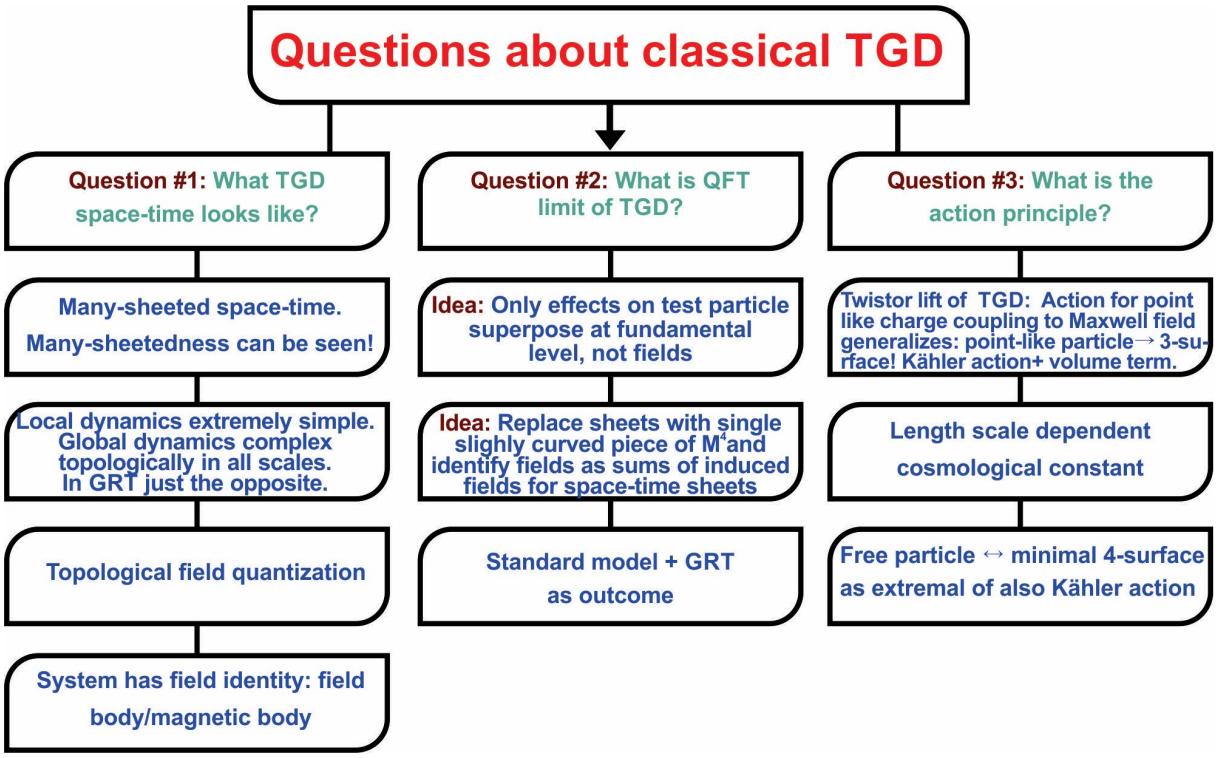


Figure 7: Questions about classical TGD.

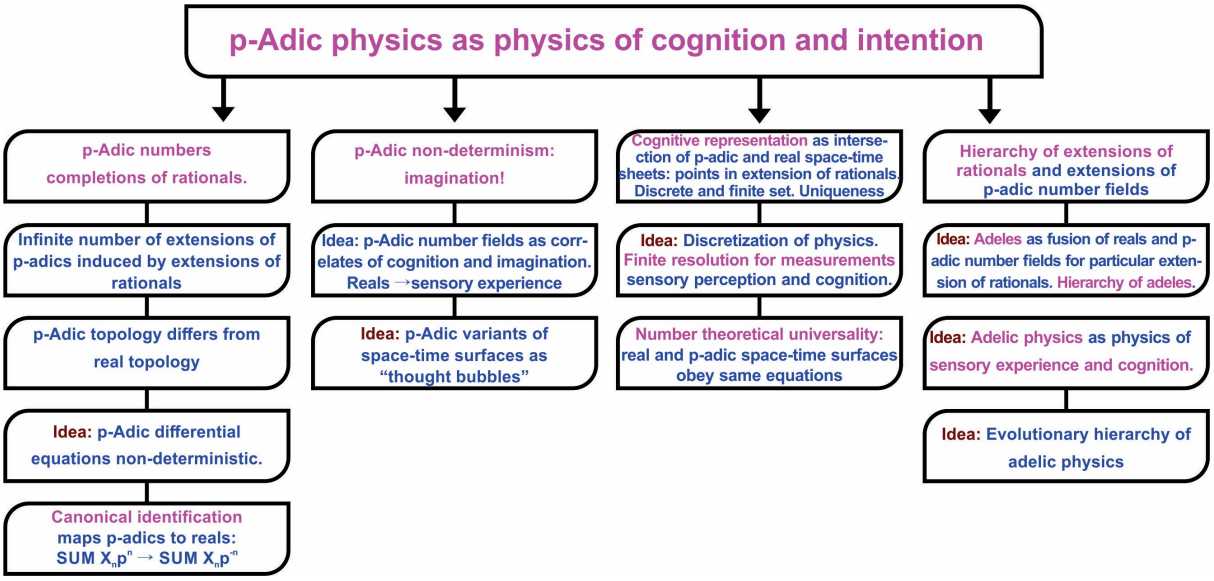


Figure 8: p-Adic physics as physics of cognition and imagination.

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.

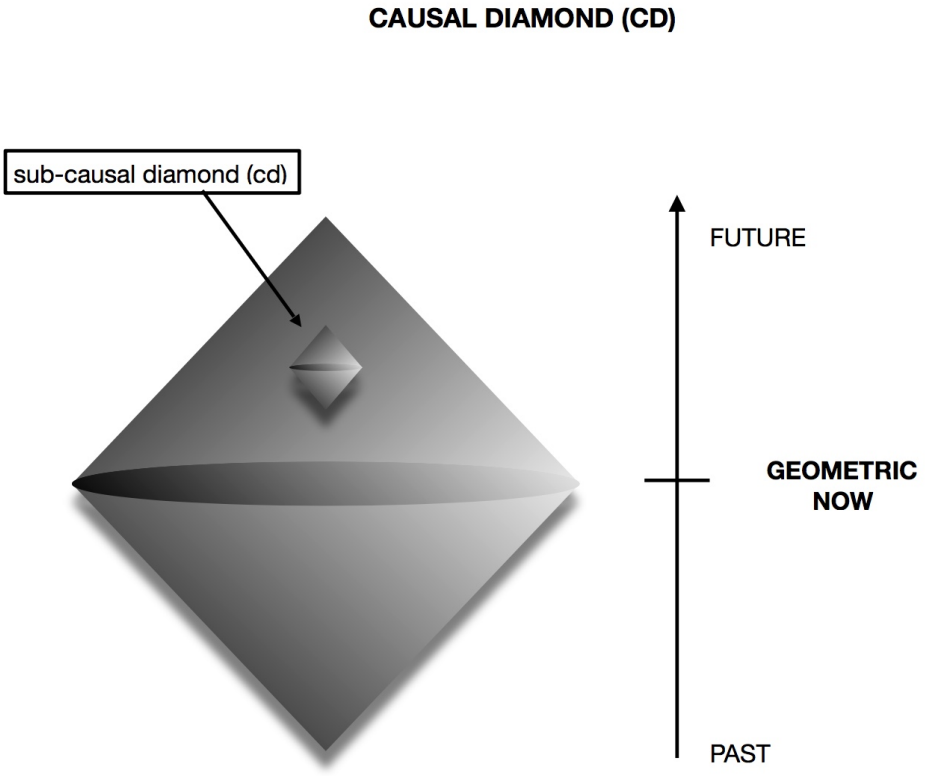


Figure 9: Causal diamond

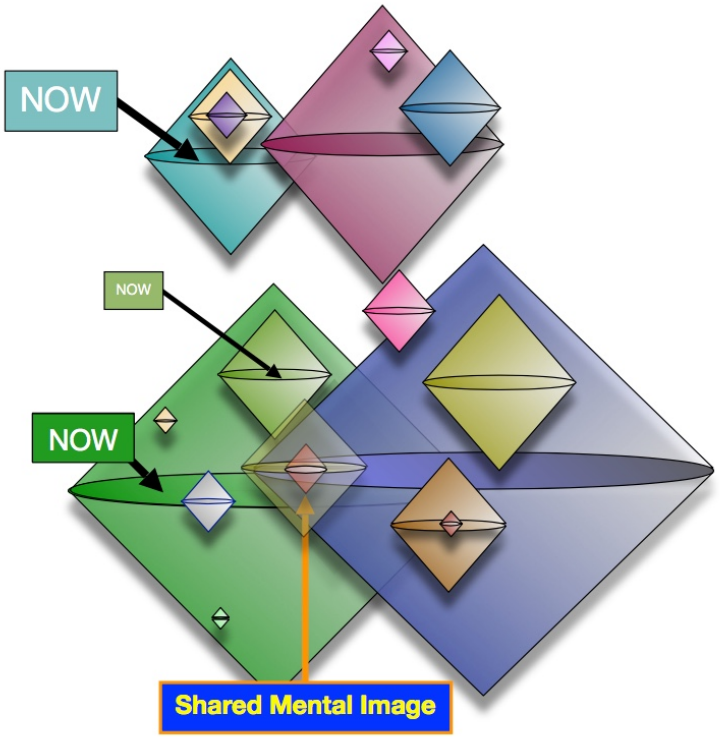


Figure 10: CDs define a fractal "conscious atlas"

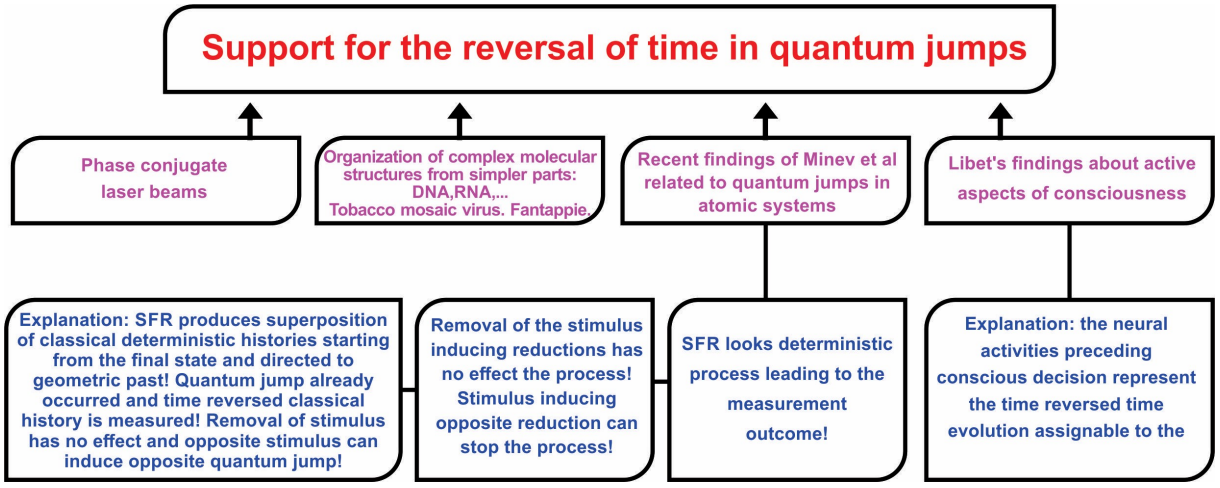


Figure 11: Time reversal occurs in BSFR

Figures

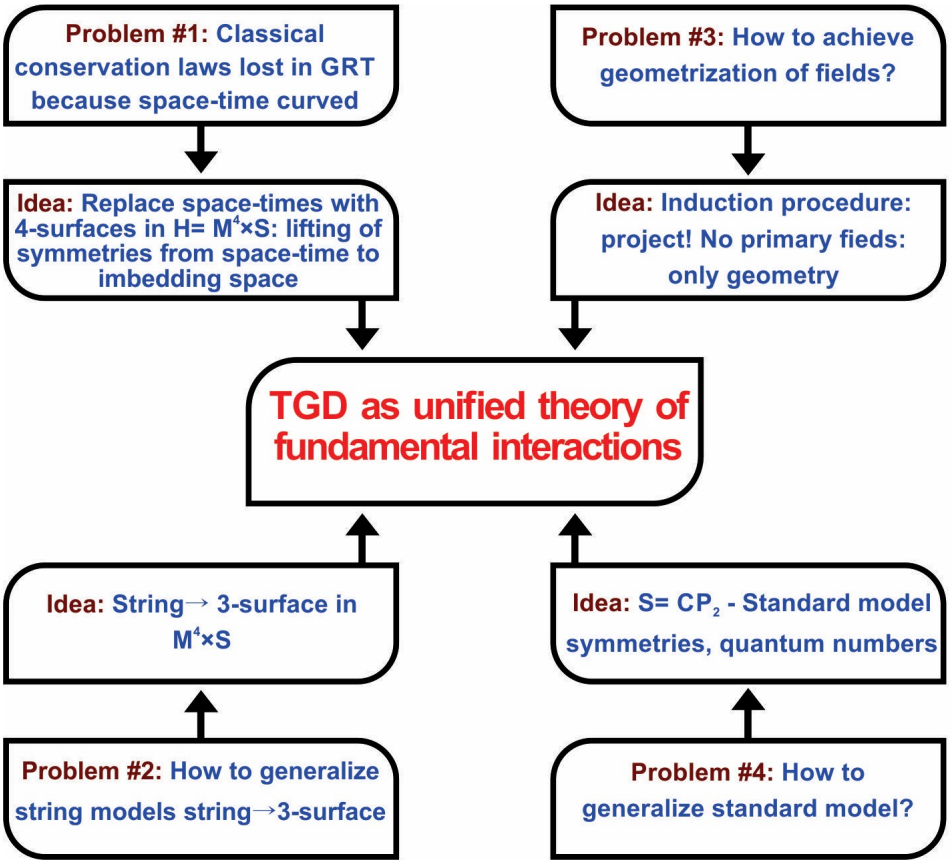
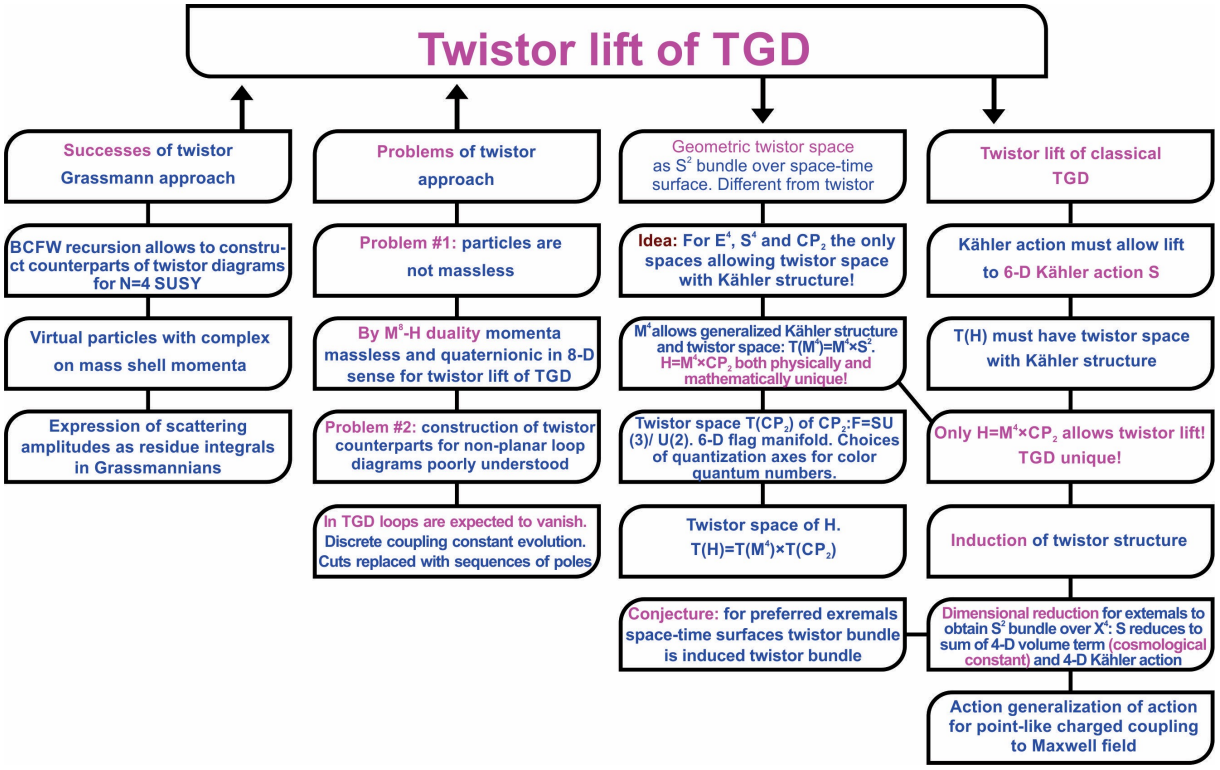


Figure 12: The problems leading to TGD as their solution.

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

Karkkila, April 22, 2024, Finland

Matti Pitkänen



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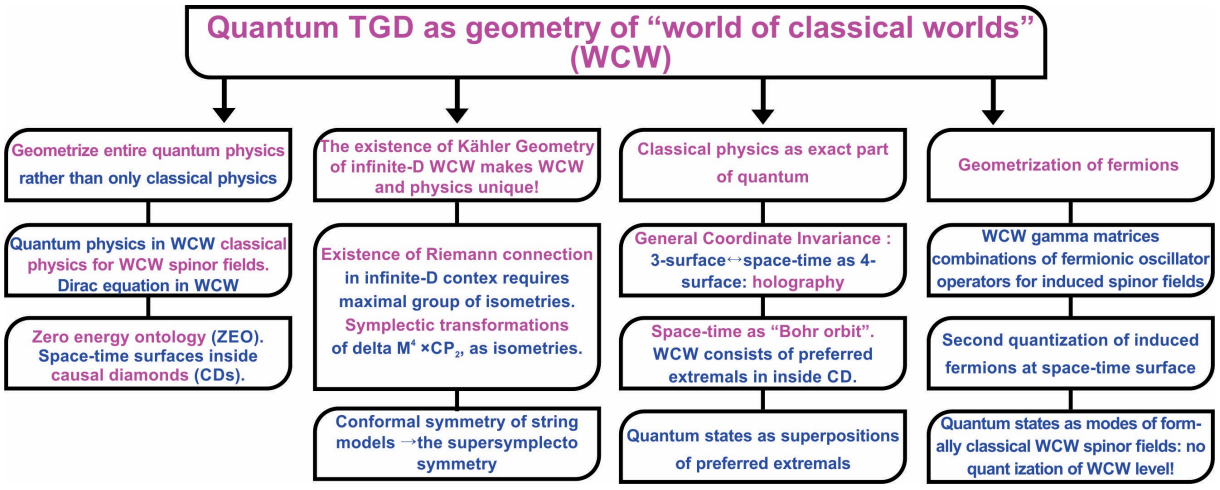


Figure 14: Geometrization of quantum physics in terms of WCW

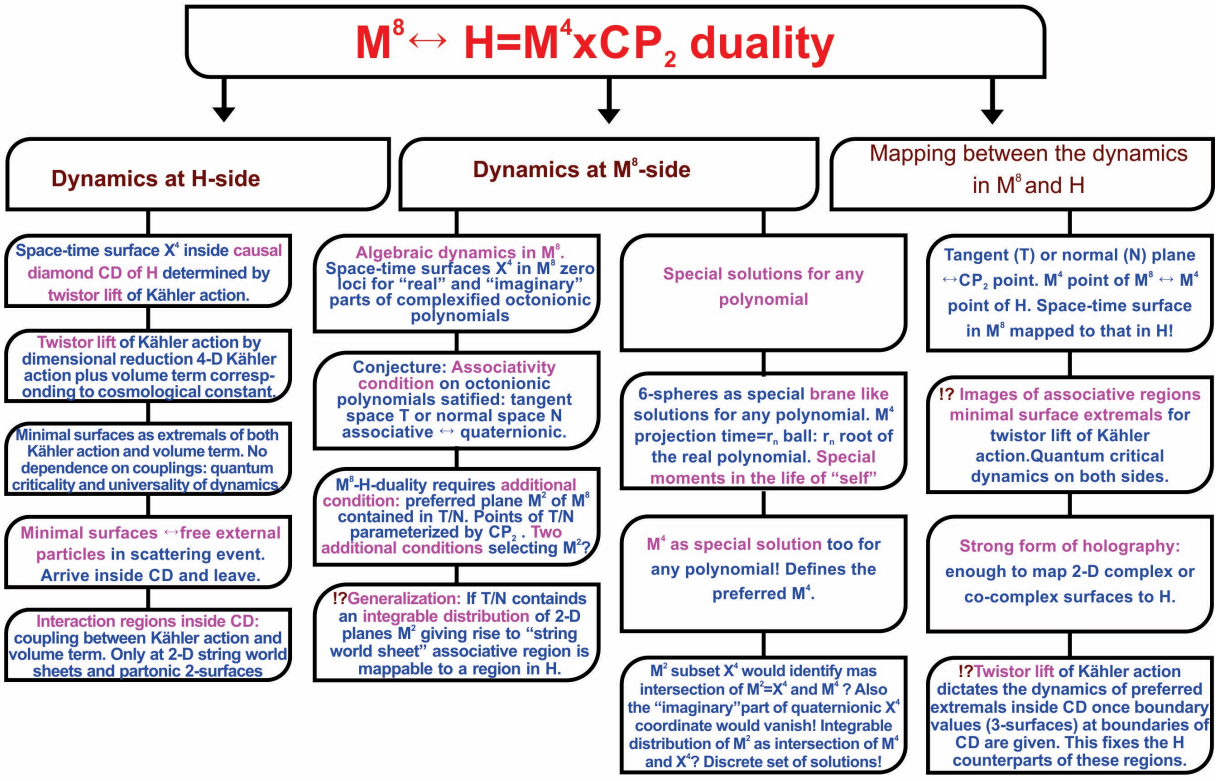


Figure 15: $M^8 - H$ duality

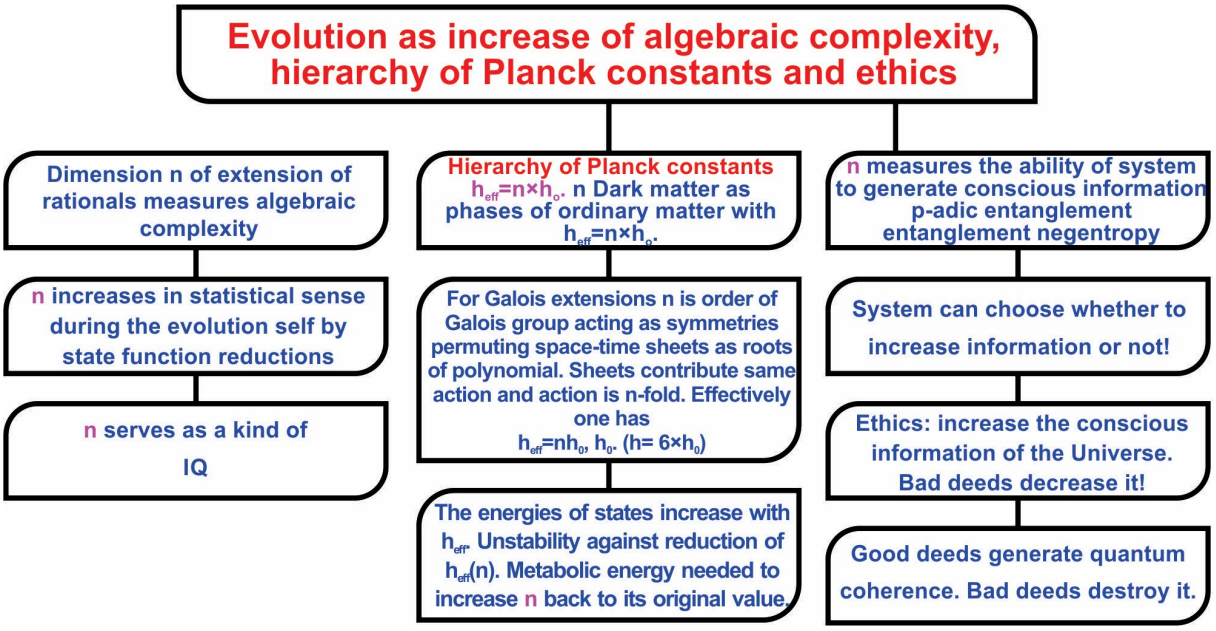
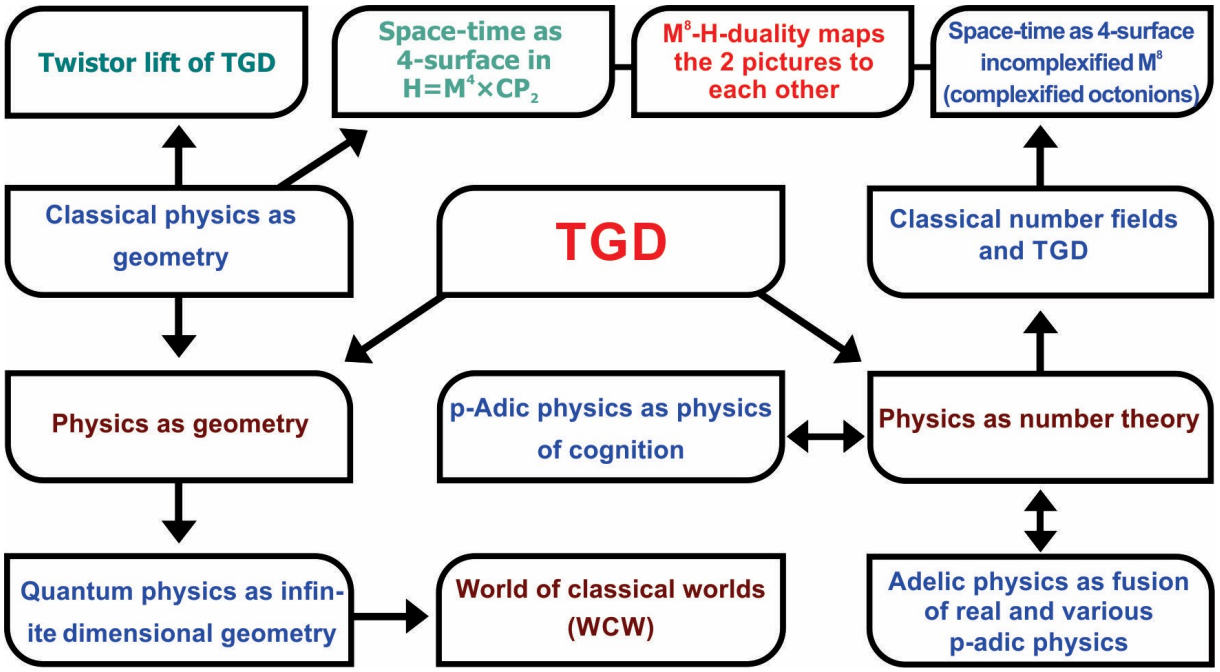


Figure 16: Number theoretic view of evolution



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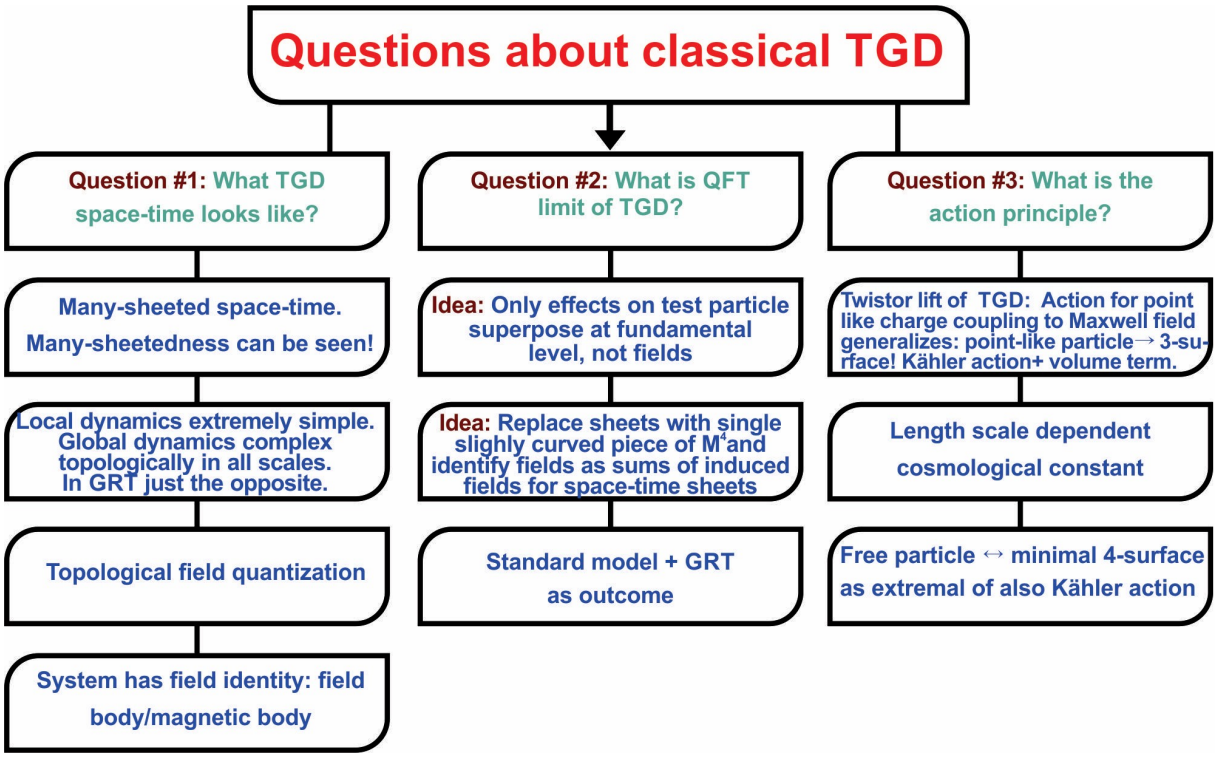

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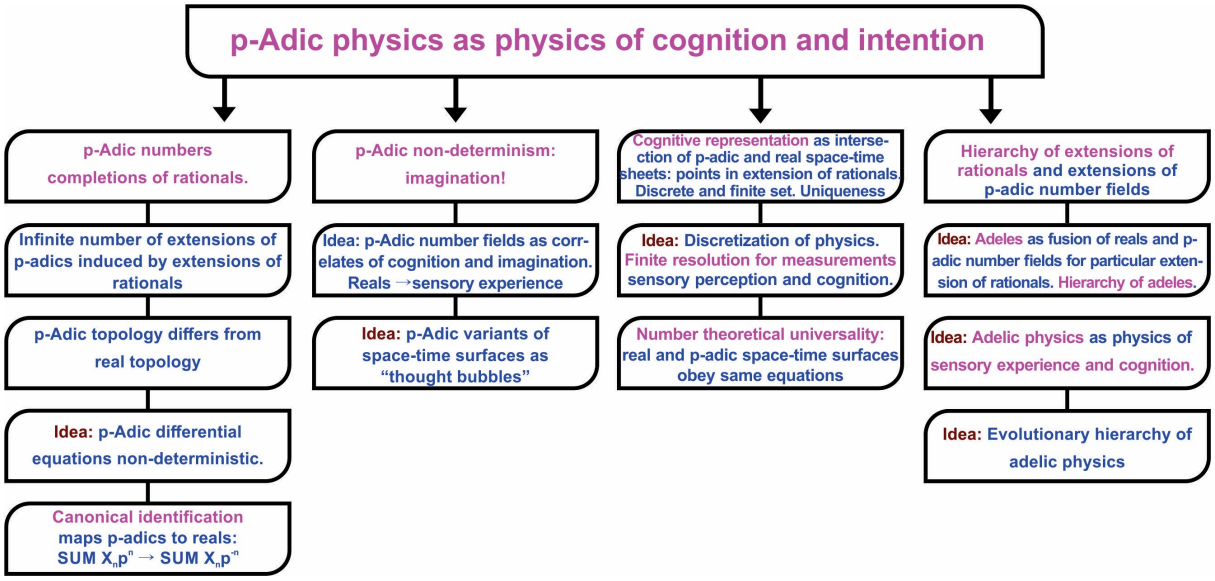


Figure 19: p-Adic physics as physics of cognition and imagination.

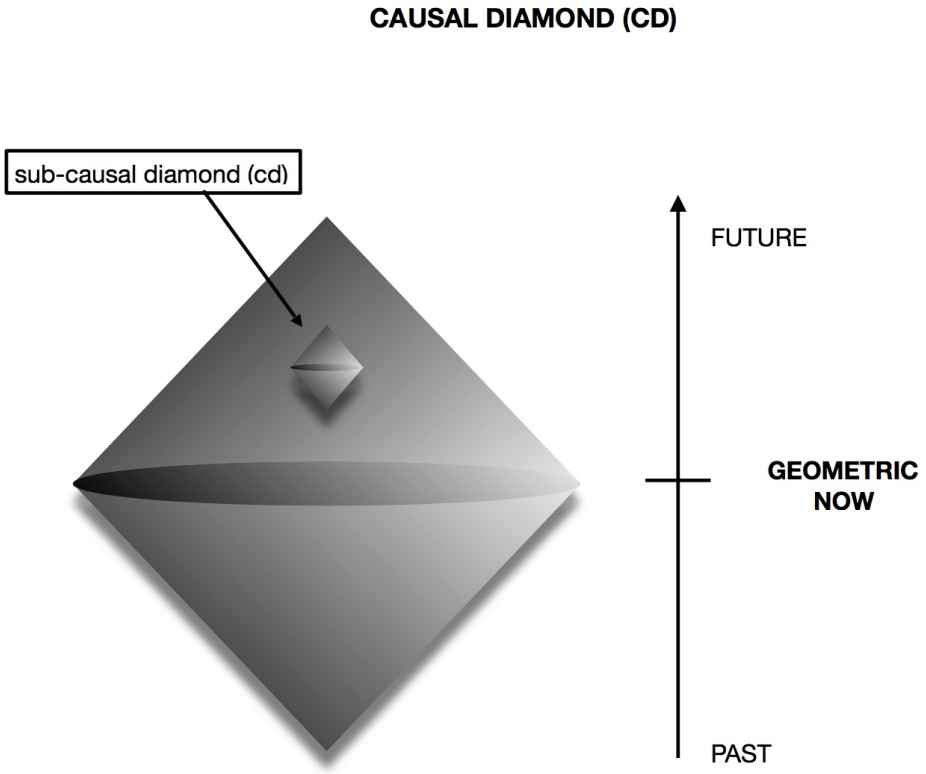
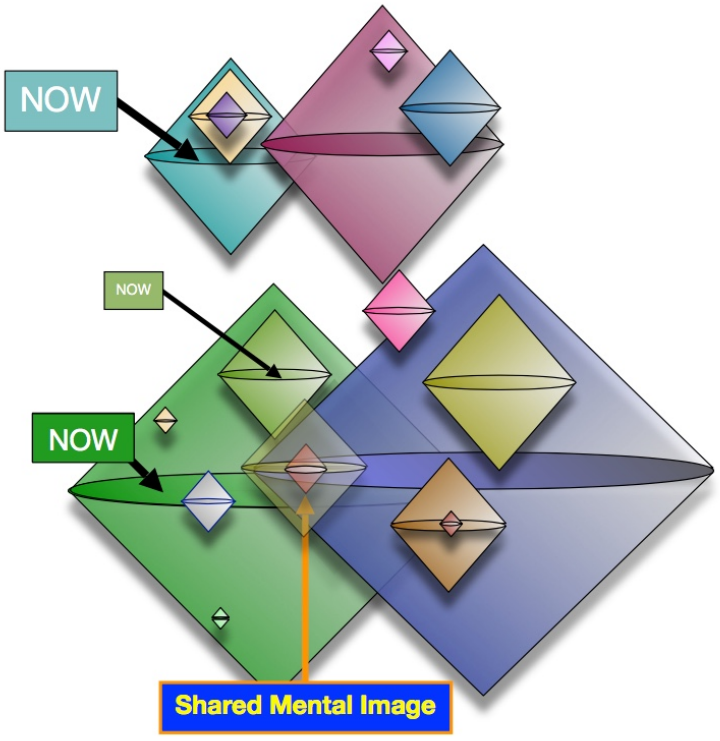


Figure 20: Causal diamond



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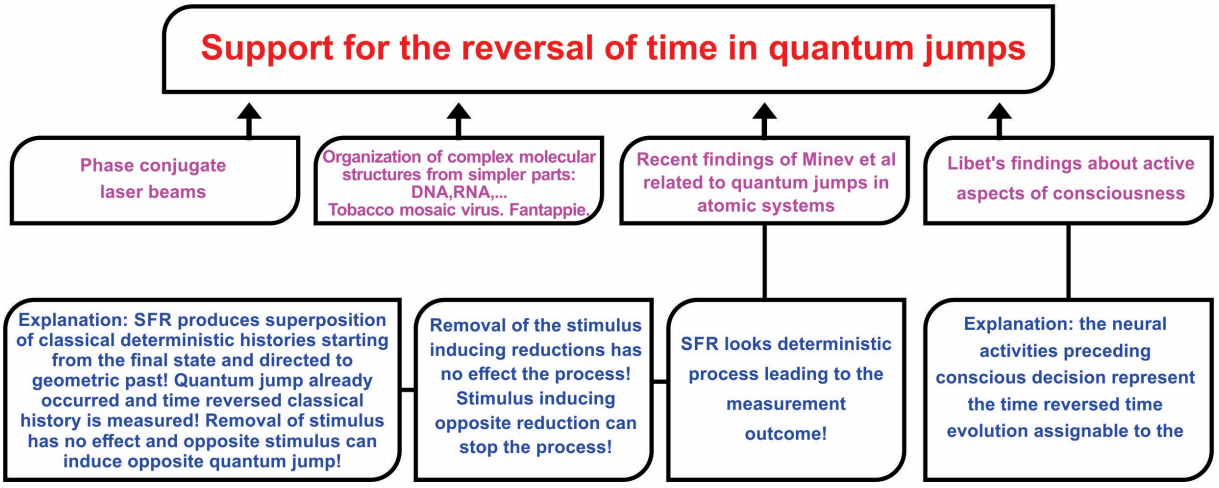

Figure 22: Time reversal occurs in BSFR

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

Contents

List of Figures

Chapter 1

Introduction

1.1 Basic Ideas of Topological Geometrodynamics (TGD)

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

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

1.1.1 Geometric Vision Very Briefly

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

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

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

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

Twistor lift of TGD means that one can lift space-time surfaces in H to 6-D surfaces a analogs of twistor space of space-time surface in the Cartesian product of the twistor spaces of M^4 and CP_2, which are the only 4-manifolds allowing twistor space with Kähler structure [A12]. 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 [A2] [B8, B5, B6]), 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 [B3]) 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 [A8, A11, A5, A10].

The identification of the space-time as a sub-manifold [A9, 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 [A14, A19, A23]. 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 [K68]. 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 [K64].

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 [E1] 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 [K94].

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 [K82, K83, K80]) 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 [K105]. 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 [A12]. 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 co-incides 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 [L78].

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 [L60]. 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 Quantum Biology: Part II"

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

The three parts of the book discuss the possible biological implications of the TGD view of quantum gravitation; of the new view of space-time and particles in morphogenesis, and of zero energy ontology (ZEO) in biological self-organization.

1. In the first part of the book the TGD view of quantum gravitational coherence is based on the view that the gravitational interaction is at the fundamental level mediated by the U-shaped monopole flux tubes carrying particles which are dark particles in the TGD sense. Nottale's hypothesis for gravitational Planck constant implies that quantum coherence is possible even in astrophysical scales. Also the Orch-OR hypothesis of Hameroff and Penrose is discussed from the TGD point of view.

2. The second part of the book contains chapters about morphogenesis. Michael Levin's work and the TGD view of water memory and its role in morphogenesis are dicussed. There is also a chapter about the anomalies of rotating magnetic systems suggesting the active role of the magnetic body of the system also in other than biological systems.

3. Zero energy ontology (ZEO) forms the basis of both TGD based quantum measurement theory, of the TGD inspired theory of consciousness and of the TGD based quantum biology. ZEO provides a new view of biological self-organization and homeostasis. In TGD, the counterparts of ordinary state function reductions change the arrow of time at the magnetic body in long time scales. This induces long lasting effective changes of the arrow of time at the level of ordinary biomatter and makes possible goal directed intentional behaviors by trial and error process. Quantum coherence of the magnetic body forces ordinary long scale coherence at the biological body. The chapters discuss some applications of this vision.

1.3 Sources

The eight online books about TGD [K111, K106, K88, K71, K27, K69, K51, K97] and nine online books about TGD inspired theory of consciousness and quantum biology [K102, K22, K79, K21, K47, K57, K60, K96, 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 GRAVITATION AND BIOLOGY

Quantum gravitation and quantum biology in TGD Universe

The finding of Manu Prakash et al that animals without a nervous system behave as if they had it, is a challenge for standard biology. Similar challenges are posed by the observation that organisms without a nervous system, even plants and bacteria, have senses and purposeful motor actions, and are also able to learn. This finding led to a considerably progress in the understanding of TGD inspired quantum biology.

The TGD based view about cell and neuronal membrane, nerve pulse and EEG assumes pre-neural level which is quantal. In this view, cell membranes act as Josephson junctions and communicate sensory input to the magnetic body (MB) of the system as dark Josephson radiation. MB in turn controls the cell by dark cyclotron radiation produced as pulses as MB receives frequency modulated Josephson radiation resonantly.

Gravitational MB of Earth, which consists of very long loop-like flux tubes with gravitational Planck constant introduced by Nottale explains the findings of Blackman and others, is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs) so that hydrogen is effectively negatively ionized. Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide H_2O_2). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

A correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton hydrogen bond becomes ordinary is obtained. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.

Also the gravitational MB of Sun could be involved and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies so that pho-

tosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as metabolic energy storage.

Electronic metabolism would solve the problem due the lack of ATP machinery inside cilium and near it. This picture leads to a rather detailed model of the role of phosphate in metabolism and also to a detailed model for the pairing of DNA and dark DNA (DDNA) and forces to modify the earlier model somewhat. The quantum gravitational view about metabolism leads also to modifications of the views about nerve pulses: in particular, of the role of biologically important metal ions identified as dark ions.

Cilium can be interpreted as a predecessor of the axonal membrane and the pre-nerve pulses are predicted to be equal to miniature potentials and the reported 'spikes' as analogs of nerve pulses are assigned with de-adhesion of cilium from its neighbor or the surfaces at which the animal moves. The 'spikes' correspond to at least 100 miniature potentials just as real spikes do.

Cilium is modeled as a 2-D quantum gravitational pendulum with gravitational Planck constant controlled by MB using electronic metabolic energy quanta and the resulting model for the motion is in many respects similar to the model of nerve pulse.

Miniature spikes could appear also in plants. For the recently observed spike sequences in fungi, the voltage spike has an amplitude whose order of magnitude is consistent with the electronic metabolic energy quantum.

Comparison of Orch-OR hypothesis with the TGD point of view

Penrose-Hameroff (P-H) model and its variants such as Diosi-Penrose (D-P) model have been leading candidates for a quantum theory of consciousness. In light of recent experiments and theoretical arguments, the D-P model looks highly implausible. The key problem is energy conservation, which is actually the central problem of general relativity and caused by loss of Poincare invariance. The basic idea of Penrose about quantum gravitational superposition is almost a must but in the framework of general relativity its mathematical realization is not possible.

TGD provides an alternative view based on the identification of space-times as 4-surfaces in $M^4 \times CP_2$ related by $M^8 - H$ duality to 4-surfaces in M^8. In this approach Poincare invariance is exact. In the TGD framework the hierarchy of Planck constants $h_{eff} = nh_0$ includes also gravitational Planck constant $h_{gr} = GMm/v_0$ introduced first by Nottale. This makes it possible to realize quantum coherence (in particular, gravitational one) in arbitrarily long spatial and temporal scales.

In this article P-H and P-P models are compared with the TGD point of view. In TGD, the generation of quantum gravitational binding energy liberates energy and provides the basic mechanism of metabolism and a direct connection with quantum biochemistry emerges. The gravitational magnetic bodies (MBs) of Earth and Sun are in an essential role. Could one invent a mechanism involving only self-gravitational interaction energies of the living body itself? The large gravitational Compton length $\Lambda_{gr} = GM/v_0$ requires the presence of a large mass, say star, which would serve as basic metabolic energy source but the presence of a planet is not necessary in the prebiotic stage.

There are strong indications that water is a quantum critical system at the physiological temperature range. This suggests that scaled variants of magnetic bodies of water blobs as candidates for proto cells appear in quantum superposition with values of the parameter v_0. This would induce large density fluctuations at the level of the ordinary biomatter. State function reduction would induce a phase transition to a scaled-up state in the presence of energy feed. The return to the original state would liberate the gravitational energy as metabolic energy. Note that there are also indications for the quantum (gravitational) criticality of microtubules so that they would be very special from the point of view of life and neuron level consciousness.

The gravitational self-interaction energy for water blobs with Planck mass corresponds to an energy scale of 3.5 meV identifiable as the energy difference between two opposite membrane potentials. Could gravitational metabolic energy make possible the action potential of proto cells observed even for monocellulars?

New Results about Microtubules as Quantum Systems

Around 2014, the latest hot news in quantum biology was the observation by the group led by Anirban Bandyopadhyay about detection of quantum vibration in microtubule scale - their lengths vary up to 50 μm. If this observation can be replicated, one can speak about breakthrough in quantum consciousness.

The findings reported in an earlier talk of Bandyopadhyay give support for the general TGD inspired view about topological quantum computation (TQC) and allow for a rather detailed model in the case of microtubules. The idea is that flux tubes form a 2-D coordinate grid consisting of parallel flux tubes in two different directions. Crossing points would be associated with tubulins and the conformational state of tubulin could define a bit coding whether the braid strands defining coordinate lines are braided or not (swap or not). In this manner any bit pattern at microtubule defines a particular TQC program. If also conformations are quantum superposed, one would have "quantum-quantum computation". It however seems that conformation change is irreversible chemical reaction so that this option is not feasible.

The TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks rather natural. Coordinate grids can be fixed on basis of the experimental findings and there are 8 of them. The interpretation is in terms of different resolutions. The grids for A and B type lattices are related by 2π twist for the second end of the basic 13-unit for microtubule. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence, which is a strong objection against Penrose-Hameroff model.

TGD suggests also a generalization of the very notion of TQC to 2-braid TQC with 2-D string world sheets becoming knotted in 4-D space-time. Now qubits (or their generalizations) could correspond to states of flux tubes defining braid strands as Penrose and Hameroff seem to suggest and the emergence of MTs could be seen as an evolutionary leap due to the emergence of a new abstraction level in cognitive processing.

About 10 years later (2024), Babcock et al reported of the evidence for a mesoscale quantum coherents consisting of microtubules, and this finding seems to be taken rather seriously also by the mainstream. During these 10 years, the TGD inspired quantum biology has developed considerably and in this article I combine the recent TGD based view of the findings of Bandyopadhyay and of Babcock et al.

A Possible Explanation of Shnoll Effect

Shnoll and collaborators have discovered strange repeating patterns of random fluctuations of physical observables such as the number n of nuclear decays in a given time interval. Periodically occurring peaks for the distribution of the number $N(n)$ of measurements producing n events in a series of measurements as a function of n is observed instead of a single peak. The positions of the peaks are not random and the patterns depend on position and time varying periodically in time scales possibly assignable to Earth-Sun and Earth-Moon gravitational interaction.

These observations suggest a modification of the expected probability distributions but it is very difficult to imagine any physical mechanism in the standard physics framework. Rather, a universal deformation of predicted probability distributions could be in question requiring something analogous to the transition from classical physics to quantum physics.

TGD gives hints about the nature of the modification.

1. TGD inspired quantum measurement theory proposes a description of the notion of finite measurement resolution in terms of inclusions of so called hyper-finite factors of type II_1 (HFFs) and closely related quantum groups parameterized by quantum phase $q_m = exp(i\pi/m)$. Canonical identification mapping p-adic integers to to their real counterparts is central element of TGD. For $m = p$ one can consider also the quantum variant of p-adic integer n mapped to n_R by canonical identification. There are 2 candidates for quantum-p-adics depending on whether the pinary digits are interpreted as quantum integers as such or mapped to a product of quantum counterparts of their prime factors.

2. Adelic physics provides a possible unification of real number based physics as physics of sensory experience and various p-adics physics as physics of cognition and predicts a hierarchy of Planck constants $h_{eff} = nh_0$ and suggests the identification of preferred p-adic prime p as a ramified prime of extension of rationals associated with the adele.

   p-Adicization or perhaps even quantum-padicization could explain the findings of Shnoll.

1. The universality of the modified distribution $P(n)$ would reduce to the interpretation of the integer n in the distribution $P(n|\lambda)$ of counts as a p-adic integer or its counterpart mapped by canonical identification to a real number n_R appearing as argument of $P(n|\lambda)$. Same can be applied to $n!$. The fractality implied by the quantum criticality of TGD Universe suggests that $P(n)$ should be approximately scaling invariant under $n \to p^k n$.

2. TGD can be regarded formally as complex square root of thermodynamics, which suggest the representation $P(n) = |\Psi(n)|^2$, where $\Psi(n)$ would be wave function in the space of counts expressible as product of classical part and "quantum factor". One could have wave functions in the space of counts n expressible as superpositions of "plane waves" q_m^{kn}, with k playing the role of momentum.

   A more concrete model relies on wave function proportional to $(kn)_{q_p} \propto q_m^{kn} + q_m^{-kn}$ - analog to a superposition of plane waves with momenta k propagating to opposite directions in the space of counts reduced effectively to a box $0 \leq n < p = m$ representing modulo p counter. One would have effectively wave functions in finite field G_p. The symmetries of quantum factor would correspond to a multiplication or shift of k by element r of F_p.

   Various additional rational-valued parameters characterizing the probability distribution can be mapped to (possibly quantum-) p-adics mapped to reals by canonical identification. The parameters taking care of the converge such as the parameter λ in Poisson distribution must be mapped to a power of p in p-adic context.

   The model can be applied to explain the findings of Shnoll.

1. The model makes rather detailed predictions about the periodically occurring positions of the peaks of $P(n)$ as function of p based on number theoretical considerations and in principle allows to determine these parameters for given distribution. There is p-periodicity due to the fact that the lowest pinary digit of n_R gives first approximation to n_R.

2. The slow variation of the p-adic prime p and integer $m = p$ characterizing quantum integers could explain the slow variation of the distributions with position and time. The periodic variations occurring with both solar and sidereal periods could be understood in two manners.

   The value of p could be characterized by the sum a_{net} of gravitational accelerations assignable to Earth-Sun and Earth-Moon systems and could vary. If the value of p is outcome of state function process, it is not determined by deterministic dynamics but should have a distribution. If this distribution is peaked around one particular value, one can understand the findings of Shnoll.

3. An alternative explanation would be based on slow dependence of quantum factor of $\Psi(n)$ on gravitational parameters and on time. For instance, the momentum k defining the standing wave in the space of counts modulo p could change so that the peaks of the diffraction pattern would be permuted.

1.3.2 PART II: MORPHOGENESIS

TGD view of Michael Levin's work

In this chapter, I will discuss the findings of Michael Levin's group related to morphogenesis and also the general ideas inspired by this work. The findings demonstrate that the hypothesis that genotype fixes the phenotype apart from adaptations is wrong. Already epigenesis challenges genetic determinism and the view emerging from the experiments is that the patterns of membrane potentials of cells of early embryo determine patterns of electric fields in multicellular length scales

and that code for the outcome of the morphogenesis. One can say that these patterns code for the goal directed behavior and have the basic properties of memory. The manipulations of these patterns in the early embryonic stage can modify the outcome of the morphogenesis so that one can speak of a novel organism. Also the manipulations of say gut cells can produce organs such as ectopic eye.

One can regard multicellular systems as predecessors of neural systems. Ion channels and pumps are present in both systems. In nervous systems synaptic contacts replace the gap junctions. Nerve pulse patterns are replaced by waves associated with gap-junction connected multicellular systems.

Levin introduces notions like cognition, intelligence and self not usually used in the description of morphogenesis and represents a vision about medical applications of the new view

The TGD view of morphogenesis is compared with Levin's vision. The basic picture relies on the notions of magnetic and electric bodies, to the phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$ behaving like dark matter and making possible macroscopic quantum coherence, and to zero energy ontology (ZEO) providing a quantum measurement theory free of the basic paradox. ZEO is implied by almost deterministic holography forced by general coordinate invariance. Holography implies that structure is almost equivalent to function.

This framework explains the basic finding that the goal of the morphogenesis is determined by the patterns of electric fields during the early embryo period. TGD also suggests the universality of the genetic code and several variants of the genetic code. Morphogenetic code might reduce to a variant of genetic code realized by cell membranes and larger structures instead of ordinary DNA. TGD predicts the analog of nerve pulse with the increment of membrane potential in mV range. These patterns would play a key role also in neural systems.

TGD View about Water Memory and the Notion of Morphogenetic Field

Besides general problems, which might be regarded as philosophical, the anomalies of the physicalistic world view have served as the source of inspiration. Several poorly understood phenomena have played a central role in the "Poiroting-like" process leading to the development of TGD based views about quantum biology. Mention only the effects of ELF em fields on vertebrate brain, biophotons, water memory, Pollack effect, and Comorosan effect. The notion of syntropy by Fantappie, which challenges the belief that the arrow of time is not always the same in living systems, has been also inspiring.

In this article I will discuss the TGD based vision and the above listed phenomena, which are often forgotten. I will also compare the TGD based view with the proposed interpretation of morphogenetic field as em field generated by DNA and realizing genetic code discussed in the articles of Savelev et al, and compare it with the TGD based models of genetic code realized in terms of dark nucleons and dark photons. The findings described in these articles and in the articles of Yolene Thomas about water memory also provide new tests for the TGD based view. As always, this kind of process led to some new ideas and insights.

The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?

During almost two decades I have returned repeatedly to the fascinating but unfortunately unrecognized work of Roschin and Godin about rotating magnetic systems. With the recent advances in TGD it has become clear that the reported strange effects such as the change of weight proportional to the rotation velocity of rollers taking place above 3.3 Hz rotation frequency and rapid acceleration above 9.2 Hz up to frequency 10 Hz could provide clues for developing a general vision about morphogenesis of magnetic body, whose flux quanta can carry Bose-Einstein condensates of dark charged ions with given mass and charge if the hypothesis $h_{eff} = n \times h = h_{gr}$ identifying dark matter as phases with non-standard value of Planck constant holds true.

The generalization of Chladni mechanism would provide a general model for how magnetic flux tubes carrying charged particles with given mass at given flux tube drift to the nodal surfaces giving rise to magnetic walls in the field of standing or even propagating waves assignable to "topological light rays" (MEs). Ordinary matter would in turn condense around these dark magnetic

structures so that Chladni mechanism would serve as a general mechanism of morphogenesis. This mechanism could be universal and work even in astrophysical systems (formation of planets).

The change of weight correlating with the direction of rotation (parity breaking) and rapid acceleration could be understood in terms of momentum and angular momentum transfer by dark photons liberated in the quantum phase transition of many-particle states of dark charged particles to from cyclotron Bose-Einstein condensates giving rise to analogs of superconductivity and spontaneous magnetization.

There is also evidence that the presence of light source below massive object affects its weight by about .1 per cent. This effect could be explained along the same lines. Zero Energy Ontology and the proposed mechanism remote metabolism at the level of dark matter is however needed and this would force to modify dramatically the views about basic interactions at the level of dark matter.

An increase of weight $\Delta g/g \simeq 2\times 10^{-4}$ is observed for electrets: this number has appeared in TGD already earlier and in TGD framework could have interpretatation in terms of dark matter layer with mass $M^D \simeq 2 \times 10^{-4} M_E$ at distance of Moon. More generally, any living system could be accompanied by a magnetic body with this mass fraction and lose it in biological death. Amusingly, this change of weight happens to consistent with the "weight of soul" claimed to be 21 g.

1.3.3 PART III: ZERO ENERGY ONTOLOGY AND BIOLOGY

Zero Energy Ontology

Zero energy ontology (ZEO) has become gradually one of the corner stones of quantum TGD. This motivates the collection of material related to ZEO in a single chapter providing an overall view about the development of ideas. The sections are independent and reflect different views about ZEO.

The following gives a brief summary of the most recent view (2021) of ZEO.

1. The notion of a causal diamond (CD) is a central concept. Its little cousin "cd" can be identified as a union of two half-cones of M^4 glued together along their bottoms (3-D balls). The half-cones are mirror images of each other. CD=$cd \times CP_2$ is the Cartesian product of cd with CP_2 and obtained by replacing the points of cd with CP_2. The notion of CD emerges naturally in the number theoretic vision of TGD (adelic physics via the $M^8 - H$ duality.

2. In ZEO, quantum states are not 3-dimensional if the determinism does not fail as it actually does, but superpositions of 4-dimensional deterministic time evolutions connecting ordinary 3-dimensional states. For the strongest form of holography implied by general coordinate invariance (GCI), the time evolutions are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution.

   The failure of determinism probably implies that a given 3-surface at the passive boundary of CD (PB) corresponds to a finite number of 4-D minimal surfaces and that the minimal surface can be regarded as an analog of soap film spanned by a frame having fixed parts at the boundaries of CD and dynamically generated parts in the interior of CD. The frame can be identified as a topological analog of a Feynman diagram.

3. Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced by a new superposition. The classical determinism of individual time evolution is not violated. This solves the basic paradox of quantum measurement theory. There are two kinds of SFRs: BSFRs (counterparts of ordinary SFRs) changing the arrow of time (AT) and SSFRs (analogs of "weak" measurements) preserving the arrow of time that give rise to an analog of the Zeno effect. The findings of Minev et al provide strong support for ZEO.

About the Number Theoretic Aspects of ZEO

The interaction between number theoretic vision, ZEO, and the TGD view DNA enriches all of them. In this article the recent view about quantum measurements is discussed in light of the recent progress in the understanding of the number theoretic aspects of TGD.

By $M^8 - H$ duality space-time regions would be determined by polynomials whose roots define in $M^4 \subset M^8$ 3-D mass shells providing the data for holography fixing the space-time surfaces. Whether product polynomials besides irreducible polynomials should be allowed has been an open question. The product polynomials could naturally correspond to free states unable to entangle. The functional composition was earlier interpreted as formation of many-particle states but perhaps a more natural interpretation is as a generation of sheets of the many-sheeted space-time with interactions having wormhole contacts as geometric correlates.

This modified picture leads to a re-analysis of state function reduction (SFR), in particular the notions of "big" SFR and "small" SFR from a number theoretic perspective. This leads to a more precise view about the notion of time and time evolution. The emerging picture can be applied to TGD inspired theory of consciousness, in particular various aspects related to the notion of time and memory.

New results about causal diamonds from the TGD point of view

This chapter was inspired by two interesting results related to the notion of causal diamond (CD) playing a central role in quantum TGD. One interpretation is as a quantization volume and the second interpretation is as a geometric representation of the perceptive field of conscious entity. CDs can be said to define the backbone of the "world of classical worlds" (WCW) central for quantum TGD.

For these reasons it is interesting to ask the precise mathematical definition of the moduli space of CDs. TGD suggests a definition as the semidirect product $D \rtimes P/SO(3)$ of scaling group and Poincare group divided by $SO(3)$ subgroup leaving the CD invariant: this gives 8-D space. The definition that inspired this article is based on conformal group and gives also 8-D space $SO(2,4)/SO(1,3) \times SO(1,1)$. The metric signature is $(4,4)$ for both spaces and they could be identical. These definitions are compared and one can consider the conditions under which both identification can give rise to representations of the Poincare group as expected with the scaling group reduced to a discrete subgroup.

Second result relates to the finding that special conformal transformations in the time direction defined by CD leave CD invariant. The corresponding hyperbolic flows correspond to a motion with constant acceleration to which the so-called Unruh effect is associated. One can consider an SL(2,R) algebra assignable to a conformal quantum mechanics and assign a hyperbolic time evolution operator to this flow. The conformal 2-point functions associated with this operator correspond to thermal partition functions with thermal mass defined by the temperature which is essentially the inverse of the CD scale.

Holography does not allow us to consider these flows for the space-time surfaces insid CD but the action of the hyperbolic evolution operator on quantum states at the boundaries of CD is well-defined. This also raises interesting questions related to TGD inspired consciousness, where subsequent scalings of CD in state function reductions (SFRs) give rise to the correlation of subjective time and geometric time defined as the distance between the tips of CD. The SFRs associated with the hyperbolic time evolution operator would not affect CD and would correspond to "timeless" state of consciousness. One cannot avoid reconsidering the details of "small" SSFRs defining the subjective time flow correlating with the flow of geometric time assigned with the increase of CD.

About concrete realization of remote metabolism

The idea of "remote metabolism" (or quantum credit card, as I have also called it) emerged more than a decade ago - and zero energy ontology (ZEO) provides the justification for it. The idea is that the system needing energy sends negative energy to a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal metabolic mechanism with magnetic

body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling's theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from "large" magnetic bodies.

The model identifies Josephson frequency with the subharmonic of the frequency characterizing the periodicity of a periodic voltage perturbation assumed to correspond to cyclotron frequency in biological applications. Together with quantization conditions for charge and effective Planck constant it leads to precise quantitative predictions for capacitor-like systems acting as dark capacitors. Also a relationship between the magnetic field at the magnetic body of the system and the voltage of the capacitor-like Josephson junction emerges.

The predictions allow new quantitative insights about biological evolution as emergence of Josephson junctions realized as capacitor-like systems both at the level of cell, DNA and proteins, and brain. h_{eff} can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters. h_{eff} serves as a kind of intelligence quotient and its maximization requires the maximization of both the voltage and area of the membrane-like capacitor system involved. This is what has happened during evolution. Indeed, the internal cell membranes, cortical layers and DNA double strand in chromosomes are strongly folded, and the value of membrane electric field is roughly twice the value of the electric field for which di-electric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

The claimed properties of Tesla's "cold electricity" strongly suggest interpretation in terms of dark matter in TGD sense. This leads to a proposal that a transition to dark phase occurs when the value of voltage equals the rest mass of charged particle involved. This criterion generalizes to the case of cell membrane and relates the values of h_{eff}, p-adic prime p, and threshold potential for various charged particles to each other. The idea that nerve pulse corresponds to the breakdown of super-conductivity as a transition from dark to ordinary phase receives additional support. The resulting picture conforms surprisingly well with the earlier speculations involving dark matter and p-adically scaled variants of weak and color interactions in biologically relevant length scales. An extremely simple mechanism producing ATP involving only the kicking of two protonic Cooper pairs through the cell membrane by Josephson photon as a basic step is proposed. Also the proposal that neutrino Cooper pairs could be highly relevant not only for cognition and but also metabolism finds support.

Homeostasis as self-organized quantum criticality?

This chapter was originally motivated as an attempt to understand the properties of cold shock - and heat shock proteins (CSPs and HSPs). As a matter of fact , these proteins are similar and have much more general functions and it is better to talk about stress proteins (SPs) having two different modes of operation.

Soon it became clear that this problem is only one particular facet of a much bigger problem: how self-organized quantum criticality (SOQC) is possible? Note that the self-organized criticality (SOC) is generalized to SOQC. Criticality means by definition instability but SOQC is stable, which seems to be in conflict with the standard thermodynamics. In fact, living systems as a whole are quantum critical and manage to stay near criticality, which means SOQC and SPQC is nothing but homeostasis.

Zero energy ontology (ZEO) forming the basics of TGD inspired quantum measurement theory extends to a quantum theory of consciousness and of living systems and predicts that the arrow of time changes in ordinary ("big") state function reductions. ZEO leads to a theory of quantum self-organization and time reversal means that dissipation in reversed direction looks like extraction of energy from the environment for the observer with standard time direction. The change of the arrow of time tranforms critical states from repellers to attractors and makes possible SOQC.

Aging from TGD point of view

This chapter written together with Reza Rastmanesh was inspired by the book "Lifespan" by Sinclair and LaPlante. The books proposed that aging is basically caused by the approach to epigenetic chaos. The book also proposesthat bio-information is not only associated with DNA and genetic code but the conformational degrees of DNA and these are crucial in epigenesis. This vision serves as the starting point of TGD (Topological Geometrodynamics) inspired view.

Negentropy Maximization principle replacing in adelic physics second law but implying it for ordinary matter is the first key notion. Magnetic body (MB)carrying dark matter as $h_{eff} = nh_0$ phases of ordinary matter implying quantum coherence in the scale characterized by h_{eff} represents the second key notion. MB is the controller of the dynamics and its quantum coherence induces the coherence of ordinary biomatter as forced coherence rather than quantum coherence.

Zero energy ontology (ZEO) predicting the occurrence of time reversal in "big" (ordinary) state function reductions is the third key notion. Time reversal forces generalization of thermodynamics and dissipation of a subsystem with a reversed arrow of time looks like self-organization from the point of view of the system. Also self-organized quantum criticality difficult to understand in ordinary thermodynamics becomes possible.

The basic idea is that at birth the MBs of information molecules are at very low temperature and gradually approach the physiological temperature, which is near to Hagedorn temperature defining the maximal temperature of MB. This thermalization leads to epigenetic chaos implying that the flux tubes carrying dark DNA and therefore also DNA become loopy. Also the control of methylation and other modifications and their reversals crucial for epigenesis is lost. In particular, demethylation fails and leads to hyper-methylation of the promoter regions of genes. This leads to the failure of the control of genes coding for housekeeping proteins and eventually the system suffers a crash down.

Part I

QUANTUM GRAVITATION AND BIOLOGY

Chapter 2

Quantum gravitation and quantum biology in TGD Universe

2.1 Introduction

This article summarizes the recent understanding about the biological role of quantum gravitation in the TGD Universe.

2.1.1 The role of quantum gravitation in TGD inspired quantum biology

In this article several new ideas related to quantum gravitation in the sense of TGD are introduced. The notion of quantum gravitational magnetic body (MB) leads to a considerably sharpening of the existing picture and provides an improved understanding of the real nature and role of biologically important dark ions.

1. The notion of magnetic body (MB) carrying ordinary matter as phases with effective Planck constant $h_{eff} = nh_0$ suggests that MB acts as a master and ordinary matter is at the bottom of the slaving hierarchy. There are reasons to believe that gravitational flux tubes with very large value $h_{eff} = h_{gr}GMm/v_0$ of gravitational Planck constant [E1] [**?**, K77] [L139, L125] are of special importance and correspond to the very high level in the hierarchy and to scales of order Earth scale. One could say that quantum gravity would transform chemistry to biochemistry and distinguish between the chemistries in *vivo* and in *vitro*.

2. Gravitational MB, which consists of very long loop-like flux tubes with gravitational Planck constant introduced by Nottale [E1] explains the findings of Blackman and others [J8], is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs). Due to delocalization of the proton, hydrogen would be effectively negatively ionized.

   Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds (VBs) connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide H_2O_2). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

   A correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton HB becomes ordinary is obtained. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.

3. One obtains a correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton HB becomes ordinary. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential of about .4 meV. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.

4. Also the gravitational MB of Sun could be involved and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies so that photosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as a metabolic energy storage. Remarkably, the photosphere has temperature in thermal energy in the range [.4,.6] eV which corresponds to metabolic energy quantum.

5. This picture about dark HB leads to a rather detailed model of the role of phosphate in metabolism. Electronic metabolism could solve the problem due the lack of ATP machinery inside cilium and near it. Spikes having the same scale as miniature potentials observed in neurons could also appear in plants. For the recently observed spike sequences in fungi, the voltage spike has an amplitude with order of magnitude roughly consistent with the electronic metabolic energy quantum [I21].

6. A detailed model for the pairing of DNA and dark DNA (DDNA) emerges and forces to modify the earlier model somewhat. The HBs associated with base pairs could transform to gravitational HBs either by reconnecting directly with gravitational flux tubes or by double reconnection with gravitational HBs assignable to phosphate of the DNA nucleotide. This process could make possible the splitting of these HBs occurring in the replication and transcription. The very weak dependence of DNA properties on various salt concentrations in vivo is in sharp contrast to the strong dependence in vitro. This difference can be understood.

2.1.2 TGD based view of nerve pulse

The proposed model starts from the existing TGD based view about nerve pulse but the new quantum gravitational view about metabolism leads to a sharpening of the understanding of the role of biologically important ions in nerve pulse conduction.

1. TGD leads to a quantum view [K85, K40, K86] [L120, L125] about cell membrane as a generalized Josephson junction consisting of Josephson junctions defined by membrane proteins and to the proposal that soliton sequences analogous to a sequence of rotating penduli with phase difference increasing along the axon, define the resting states of the membrane.

   Nerve pulse would be induced by a perturbation transforming rotation to vibration locally, this propagating perturbation could be called pre-nerve pulse. Also the variant, in which rotation is replaced by oscillation - one would have an "oscillon" sequence - so that perturbation would generate a propagating soliton, can be considered. Note however that one cannot associate a definite rotation direction to an oscillon. The criticality against the generation of nerve pulse has remained poorly understood.

2. TGD also leads to a speculative view about the function of nerve pulse patterns. Usually they are considered to serve as signals inside the brain. An alternative view [L120] is that they 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 the brain (or even MB) and sensory organs and the building of standardized sensory inputs and standardized mental images by using a virtual sensory input from the brain or MB. Essentially pattern completion and recognition would be in question. Sensory perception would be an artwork rather than

photograph. Nerve pulses could also send sensory information from the neuronal membrane to MB.

3. Could the meridian system serve as a precedessor 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.

The quantum gravitational view about metabolism leads to a modification of the views of nerve pulse conduction.

1. In the earlier 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 pendulums as a mechanical analog. Action potential corresponds to a soliton (or several solitons) with opposite direction of rotation.

2. In the updated 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 HBs 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.

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 is 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 [K73]. Their precise role 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 involves the change of HB to gravitational HB and vice versa changing the local membrane potential. Therefore MT dynamics makes possible the propagation of the perturbation of the membrane potential in unmyelinated portions of the axon. The effect of anesthetics can be understood in terms of a reduced density of HBs preventing the formation of gravitational HBs so that MTs and the axonal potential freeze.

The findings about multicellular animals of Prakash et al [I94, I92, I93], which have no nervous system but behave as if they had brain, provide valuable hints in attempts to understand the role of MTs. 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.

2.2 Update of the general ideas of TGD inspired quantum biology

In the sequel I develop a TGD based interpretation of findings in the conceptualization provided by TGD. I will proceed from general to specific and use cilia as example to illustrate the general ideas.

2.2.1 Basic motion patterns as analogs of Bohr orbits

Prakash *et al* identify a small number of basic motion patterns of cilium [I94, I92, I93]. More complex motion patterns of cell can be constructed as combinations of from these using simple rules.

For a general mechanical determiministic system 3-D initial values for generalized positions and velocities determine the time evolution and huge number of different time evolutions are possible. A chaotic behavior is much more plausible than the highly organized behavior analogous to that for organisms possessing central nervous system.

These findings resonate with the general TGD based classical description of classical physics in terms of the topology of space-time surfaces $X^4 \subset M^4 \times CP_2$ as preferred extermals (PEs) of the basic action principle [L136].

1. In the TGD framework, space-time as a 4-surface in $H = M^4 \times CP_2$ is topologically non-trivial in all scales and various shapes of matter, usually assigned to matter in almost flat and topologically trivial space-time of general relativity, correspond directly to the topology of the space-time surface.

2. From the general coordinate invariance, space-time surface is a preferred extremal (PE) of a general coordinate invariance action principle, which realizes holography in the sense that 3-surface as boundary values determines almost completely the 4-surface, which is therefore analogous to Bohr orbit. There is however a small failure of determinism localizable at the singularities where minimal surface property fails. PEs are minimal surfaces with singularities analogous to frames of ordinary soap films [L141].

3. The space-time counterparts of all biological and neurological functions (this includes the development of mechanical and electromagnetic patterns such as nerve pulse patters) correspond to PEs. PEs are also analogous to the modules of computer programs. A small failure of quantum determinism corresponds to a selection of sub-modules in branching points and correspond to the non-determinism of soap films with frames.

4. Zero energy ontology of TGD which predicts that quantum states of a system are superpositions of space-time surfaces as preferred extremals (PEs) of action. "Small" state function reductions (SSFRs) as the TGD counterparts of "weak" measurements would select between different variants of space-time surface with same singularities (frames of soap film) and BSFRs would correspond to big changes.

   The small repertoire of different motion patterns would correspond to a collection of PEs. From these patterns for cilia more complex patterns would be constructed for the motion patterns for a cell would emerge. From the patterns for cell motion the patterns for a multi-cellular system would emerge. There would be a hierarchy of complexity reducing to a hierarchy of extensions of rationals at fundamental level.

2.2.2 Quantum criticality

Also cilium and a ciliary system could be near quantum criticality and this could be essential for the changes of the state of the motion of cilia.

The motions of microtubules inside cilia force the bending of cilia. The beating waves with frequency 4-10 Hz propagating along cilia and having constant phase along a 1-D section curve of the 2-D transverse section of transversal plane of cilium are known to induce the motions of a single cilium. In multicilium system these motions are in the same phase and induce coherent motion

When the height h, the orientation of cilium, and the beating frequency f are near criticality, a BSFR would occur and induce a sudden change in the motion of cilium. The criticality of the beating frequency could mean resonance between the microtubuli inside cilium and BSFR would induce the shortening of the flux tube pair connecting them. This would induce the bending of the flux tube.

The presence of 3 parameters suggests a catastrophe theoretic description using Thom's catastrophe theory based on a butterfly catastrophe with 3 control parameters.

2.2.3 Excitable systems in zero energy ontology

In the TGD framework, the idea that excitable systems as systems making "big" state function reductions (BSFRs) as counterparts of ordinary SFRs in macroscopic spatial and temporal scales is suggestive. In BSFR the arrow of time changes and after BSFR the dissipative development occurs in reverse time direction and looks to the observer with the standard arrow of time like self-organization and generation of patterns. This BSFR is followed by second BSFR re-establishing the original arrow of time.

In quantum critical systems, the value of h_{eff} would be fluctuating and the change of h_{eff} could happen in BSFR. The dynamics of microtubules (MTs) could be quantum critical since it involves continual growth and decay of MTs, which would correspond to a sequence of BSFRS. During mitosis (cell replication) the expansion and contraction of MTs involving change of h_{eff} and BSFR would play a key role role.

Bio-catalysis is another example [L196]. The reactants would be brought near each other by a contraction of the flux tube pairs connecting them. The flux tubes pairs would be formed by a reconnection of U-shaped flux tubes of reactants acting as tentacles if there is cyclotron frequency resonance (the thicknesses of the U-shape flux tubes are identicals). The BSFR involving a contraction due to the reduction of h_{eff}. After reaction h_{eff} could reduce to its original value in second BSFR.

2.2.4 The notions of magnetic and electric body

The notions of magnetic body and electric body are central in TGD inspired quantum biology but their precise definition has been far from clear. The intuitive notion is that MB consists of U-shaped monopole flux tubes extending from the system considered and serving as kinds of tentacles. These flux tubes for two systems can reconnectand form a pair of flux tubes connecting the system if the cyclotron frequencies of the tubes are the same so that cyclotron resonance becomes possible.

MB is characterized by the value of the effective Planck constant $h_{eff} = nh_0$, where n corresponds to the dimension of the extension of rationals assignable to the space-time regions by $M^8 - H$ duality [L104, L105]. One can assign MB to flux tubes mediating electromagnetic, gravitational and even weak and color interactions, and the scale of MB correlates with the screening length of these interactions. For gravitation there is no screening and the values of $h_{eff} = h_{gr}$ can be very large. The large value of $h_{gr} = GMm/v_0$ [E1] implies that the dark cyclotron radiation in the EEG range would correspond to visible and UV energies.

In the TGD framework magnetic body (MB) would serve as the controlling agent receiving sensory information as a frequency modulated dark Josephson radiation and controlling the cell by using dark cyclotron radiation coming as pulses corresponding to resonant receival of Josephson radiation.

What could be the electric counterpart of the magnetic body? Magnetic flux tubes can also be dynamical and locally orthogonal helical magnetic and electric fields are possible. Electric body should be something different. Various membrane-like structures populate the Universe and they could correspond to electric bodies.

1. The 4-surfaces X^4 with 1-D CP_2 projection and 3-D M^4 projection having 2-D membrane as E^3 projection are good candidates for various membrane objects in TGD Universe [L141]. The E^3 projection is not a minimal surface although X^4 is, and this possible if the 1-D CP_2 projection is dynamical. The flux tubes of MB should be assignable to kind of membrane-like surface.

2. The gravitational MB, it it exist, could be a layered structure containing the Bohr orbits with Bohr radii $r_n \propto n^2$ of particles in the gravitational field of Earth. Particles with different masses would concentrate at the same orbits. One would have the shell structure of the ordinary atom. This notion generalizes also to other interactions and for them the values of h_{eff} would be much smaller.

3. Flux sheets with a cylindrical rotational symmetry containing the orbits can be considered. These surfaces should be realized as preferred extremals of the action and should be minimal surfaces in $H = M^4 \times CP_2$. As closed surfaces they cannot define minimal surfaces of the

Euclidean 3-space E^3. Indeed, soap bubbles are not minimal surfaces but require a constant pressure difference between interior and exterior.

The analog of the pressure difference would be non-trivial and dynamic 1-D projection of 4-D surface to CP_2 [L141]. The liberation of metabolic energy quantum would be analogous to a transition of hydrogen atom to a lower energy state.

2.2.5 The notion of gravitational magnetic body

The notion of gravitational MB turns out to be crucial for the understanding of the role of quantum gravitation in TGD inspired quantum biology.

Gravitational magnetic body as a controlling agent and the prediction of two metabolic energy quanta

In the TGD framework magnetic body (MB) would serve as the controlling agent receiving sensory information as a frequency modulated dark Josephson radiation and controlling the cell by using dark cyclotron radiation coming as pulses corresponding to resonant receival of Josephson radiation.

The large value of $h_{eff} = h_{gr} = GMm/v_0$ [E1] implies that the dark cyclotron radiation in the EEG range would correspond to visible and UV energies.

The intuitive notion is that MB consists of U-shaped monopole flux tubes extending from the system considered and serving as kinds of tentacles. These flux tubes for two systems can reconnect and form a pair of flux tubes connecting the system if the cyclotron frequencies of the tubes are the same so that cyclotron resonance becomes possible.

In [L148], the question of what the notion of gravitational MB does mean, was considered.

1. The dark flux tube would be "gravitational" with $h_{eff} = h_{gr}$. Gravitational flux tubes carry Kähler monopole flux but no gravitational flux. This would be in conflict with the irrotational nature of gravitational field at Newtonian limit. The monopole flux could however have interpretation as gravimagnetic flux. The attribute "gravitational" is motivated by the assumption that one has $h_{eff} = h_{gr}$. The ordinary, short, MB reconnects atoms A and B.

   Gravitational flux tubes have lengths, which can be of the order of Earth size scale and the radii of gravitational Bohr orbits define a natural scale form them. Gravitational flux tubes are closed flux tubes with the shape of a highly flattened triangle with a long side in the vertical direction and having length of order Earth size scale and short side of order interatomic distance for the atoms A and B connected by HB.

   This inspires a rather concrete vision about the structure of gravitational MB as a forest of gravitational flux tubes analogous to trees. This applies also to non- gravitational flux tubes with smaller values of h_{eff}. One would have a full magnetic flora. The larger the value of h_{eff}, the more complex the magnetic plant would be. MB would be like a fractally scaled-up variant of the ordinary forest. Reconnections would make possible transfer of gravitational flux tubes so that also magnetic fauna would be present.

2. One obtains gravitationally dark hydrogen bond (HB) from an ordinary HB when a HB from A to B reconnects with a pre-existing long gravitational flux tube to create a very long gravitational flux tube from A to B. Proton is delocalized as a gravitationally dark proton and its gravitational potential energy is reduced so that the flux tube stores metabolic energy. In the reverse process a reverse reconnection takes place and this metabolic energy is liberated.

   The reconnection process requires a feed of energy: for instance solar radiation can provide it in photosynthesis. A similar description applies in the case of valence bonds (VBs). Note that the transformation of an ordinary, short HB to a long gravitational HB is not a realistic option since this would require a lot of energy since magnetic energy would be created.

3. The elongated gravitational flux tubes could correspond to either hydrogen bonds (HBs) or valence bonds (VBs). The loop-like bond could connect nearby atoms just like the ordinary bond. The delocalization of the charge to the flux tube leads to an effectively ionized donor atom.

4. All values of h_{eff} are possible. For electromagnetic flux tubes the values of h_{eff}/h are not very large. This picture leads to a view about hydrogen and VBs as bonds having $h_{eff}/h > 1$ [L56]. Also gravitational variants of hydrogen and VBs are possible. In this case, the proton or electron would be vertically delocalized in the Earth scale so that the donor atom would be effectively ionized. For instance, a phosphate ion could be an effective ion having a gravitational hydrogen bond with the hydrogen of a water molecule.

5. A gravitational VB, connecting a metal atom with an atom with an opposite valence, would lead to effective ionization of the metal atom. For instance, biologically important bosonic ions such as Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++} associated with their oxides could correspond to effective ions like this.

   The signature would be a pairing with a neutral oxygen atom by a gravitational VB. I have introduced the notion of dark ion to explain the findings of Blackman [J8] and others and dark ion could correspond to this kind of pair. Note that the original variant of the model assumed that the entire ion is dark, the later version assumed that the valence electron of free atom is dark, and the model considered here assumes that darkness is a property of bond.

6. The effective ionization requires energy ΔE to compensate the increment of the gravitational potential energy given by $\Delta E_{gr} = (\langle V_{gr}(R)\rangle - V_{gr}(R_E))$. Here $E_{gr}(R)$ is gravitational potential energy proton or electron, and R_E denotes the radius of Earth, and R is the distance of the point of flux tube from the center of Earth.

   Classical energy conservation suggests that the value of vertical kinetic energy at the surface of Earth is equal to the increment of the gravitational potential energy at the top of the loop. From energy conservation one can estimate the metabolic energy quantum as a liberated kinetic energy in the normal direction equal to the increase of gravitational potential energy. Hence the naive guess could be correct.

7. The maximal value for ΔE_{max} for electron Cooper pair (dark Cooper pair is at infinite distance) corresponds to $V_{gr}(R_E) = .36$ meV to be compared with the energy scale .3 meV defined by the temperature of 3 K microwave background and to the value .4 meV of the miniature potential. This suggests that, in the case of the electron, the reduction of kinetic energy contributes more than 10 per cent to the ΔE.

   For a single dark proton one has $V_{gr}(R_E) \simeq .34$ eV, which is below the nominal value of the metabolic energy currency about .5 eV.

8. The condition that the end of the vertical gravitational loop travels along a stationary orbit parallel to the plane of rotation of Earth such that the normal velocity of the dark particle vanishes at the top, implies for the tangential velocity v_T the condition $v_T^2 = \omega^2 R^2 = GM/R$ allowing to determine the radius of the orbit as

$$\frac{R}{R_E} = (\frac{r_{s,E}c^2}{2\omega^2})^{1/3} \times \frac{1}{R_E} \simeq 3.1 \ .$$

   The change of the gravitational potential energy in the transition to an ordinary proton would be $\Delta E = \Delta E_{gr} = .68 \times V_{gr}(R_E)$, which would give $\Delta E = .18$ eV. In the dark genetic codons hydrogen bonds appear as triplets. 3 dark protons would give metabolic energy quantum .55 eV. Interestingly, a translocation of 3 protons fuels synthesis of ATP!

9. For an electron Cooper pair the upper bound for the metabolic energy quantum would be $\Delta E_{max} = .33$ meV, which is below the miniature potential .4 meV. For the stationary flux tubes one obtains $\Delta E = .17$ meV. Later the evidence for the 'spikes' in fungi [I21] discovered by Adamatsky will be discussed: their amplitude is reported to be in the range .03-2.1 meV which contains ΔE.

   For an electron Cooper pair triplet one would have $\Delta E = .51$ meV consistent with the miniature potential .4 meV. Should one take this seriously? Could also dark electron Cooper pairs organize into triplets like dark protons would do and in this manner define dark genetic

code? TGD predicts that genetic code is universal: could also dark electron Cooper pairs define a dark variant of the genetic code?

Posner molecules $[(PO_4)^{-3})]_6Ca_9^{+2}$, to be discussed in the sequel, consists of 3 $[(PO_4)^{-3})]_2Ca_3^{+2}$ acting as a basic unit. This unit could contain 3 electronic Cooper pairs with electronic metabolic energy quantum $\Delta E = .51$ meV. In principle, Cooper pairs can have spin 1 or spin state giving 4 states altogether. Could these states define letters of a dark genetic codon so that the basic unit would define a genetic codon and Posner molecule could correspond to a triplet of genetic codons?

The TGD view about formation of bound states as Galois singlets [L162] allows us to consider this possibility. For an extension of extensions of ... the Galois group would decompose to a hierarchy of Galois groups actings as normal subgroups. Codons as triplets would be Z_3 singlets in both the ordinary and the electronic genetic code. Genes would correspond to larger Galois groups decomposing to normal subgroups. Codon doublets of DNA double strands would be Z_2 singlets and triplets of triplets of Posner molecules would be Z_3 singlets.

10. A proper treatment of the situation would require Schrödinger equation for the dark particle at the flux loop. The situation is analogous to a quantum model of the fountain effect of super-fluidity discussed in [K34, K35, K36, **?**] in a situation when the gravitational potential can be linearized (WKB approximation).

    One can consider Schödinger equation for h_{gr} idealizing the loop with a 1-D box with gravitational potential GMm/r. The Schrödinger equation reduces in dimensionless variable $u = (m/\hbar_{gr})z = 2\beta_0(z/r_s)$, $r_s = 2GM$ to

$$(-\frac{\partial_u^2}{2} - \frac{\beta_0}{u})\Psi = \frac{E}{m}\Psi \equiv \epsilon\Psi \quad .$$

    A possible condition is that the vertical derivative $\partial_z\Psi$ vanishes at the top of the loop. The metabolic energy quantum equals $(GM/R_E - \epsilon(v))m$ and is quantized. The height of the loop could be quantized using the condition that the loop end is stationary with respect to Earth.

If this speculative picture makes sense, quantum gravitation would play a key role in metabolism and genetic code.

1. The transformation of electrons and protons between ordinary and gravitationally dark states would be a key process of metabolism and biocatalysis. This conforms with the fact that proton and electron exchanges play a key role in biology. For instance, phosphorylation means that the receiving molecule gains phosphate, which can form gravitationally a dark hydrogen bond so that the system becomes metabolically active. This would correspond to the activation in bio-catalysis.

2. In the same way, in a redox reaction, the electron donor is oxidized and the electron receiver is reduced. Reduced molecule gains the ability to have a gravitationally dark electron, and therefore becomes metabolically active in the electronic sense. Redox reaction would be the electronic counterpart for phosphorylation.

The role of solar gravitational field in metabolism

Also the gravitational field of the Sun could be important in metabolism.

1. At the distance of 1 AU of the Earth, the counterpart of single proton metabolic energy quantum .18 eV would be 2.6 eV, which is in the visible range. For a proton triplet, the energy would be 7.8 eV and in the UV range. This quantum would be realized as a long flux tube directed away from the Sun in the plane of the Earth's orbit and orthogonal to the orbit.

2. Could the visible solar radiation kick protons to solar gravitational flux tubes and the radiation of photosphere having energy range [.4,.6] eV to the gravitational flux tubes of Earth in photosynthesis? Could the solar part of dark gravitational energy for protons be transformed to ordinary metabolic quanta in metabolism? Note that the feed of the solar radiation energy to flux tubes suggests a modification of the proposed simple model involving only gravitation.

3. This picture would be true for all Sun-like stars and for planets at the distance of Earth and supports the view that Earth-like planets for Sun-like stars are favourable for life.

Metabolic energy depends on gravitational environment

According to the proposed simple model, bio-chemistry would strongly depend on the local gravitational environment.

1. For an object with mass M and radius R, the estimated maximal gravitational metabolic energy quantum E_{max} is scaled up by factor is scaled up by a factor $z = (M/M_E) \times (R_E/R)$. The values of z for Mercury, Venus, Mars, and Moon are (.2,.14,.86,.04). For Venus, which is called the sister planet of Earth, z is not too far from unity.

   For the stationary orbits around an object with radius R_1, mass M_1, and rotation frequency ω_1 the ratio $\Delta E_1/\Delta E_E$ of metabolic energy quantum to that for Earth satisfies the scaling formula

$$\begin{array}{lll} \frac{\Delta E_1}{\Delta E_E} = \frac{R_E}{R_1} \times (1 - x_1 x_2 x_3) & & , \\ x_1 = (\frac{M_1}{M_E})^{1/3} \; per, & x_2 = \times (\frac{\omega_E}{\omega_1})^{2/3} \quad , & x_3 = \frac{R_E}{R_1} \end{array}$$

2. In the case of the Moon, E_{max} would be by a factor $z = R_E/R_{Moon} = .017$ smaller than at the surface of Earth. The stationarity condition would require a flux tube orbit radius smaller than the Moon radius. In the case of Venus, the sidereal rotation period is -243.0 days (retrograde): also now the orbit of stationary radius would be smaller than the radius of Venus. This suggests that only the metabolism utilizing the solar gravitational field photosynthesis is possible and would be essentially the same as at the surface of Earth.

3. In the case of Mars one has $\omega_1/\omega_E \simeq 1$, $M_1/M_E = .1$, $R_1/R_E = .533$. This gives $\Delta E = .24\Delta E_E$, which for the proton Cooper pair would give .13 eV. Could the solar gravitational field save the space traveller in case of Moon and Mars? The largest distance from Earth is about 1.7 AU and at this distance the maximal value of the solar metabolic energy quantum is scaled down by a factor .59.

Jupiter's (`https://cutt.ly/CF8bteR`) moon Europa (`https://cutt.ly/HF8buAp`) is one of the most promising candidates for a seat of life since it contains water in the form of ice. Is quantum gravitational metabolism based on the solar and Jovian gravitational fields consistent with Earth-like metabolism?

For the Jupiter's gravitational field, the gravitational potential energy at the surface of Europa is $V_{gr} = GM_J m/R_{Eu}$ and defines the maximal value ΔE_{max} of the metabolic energy quantum for a flux loop defining dark gravitational HB oriented radially outwards along A line connecting Europa and Jupiter. The mean distance d_{Eu} from Jupiter is $d_{Eu} = 105.3 \times R_E$ to be compared with the radius $R_J = 10.97R_E$ of Jupiter. The mass of Jupiter is $M_J = 317.8M_E$. This gives $\Delta E_{max,Eu}/\Delta E_{max,E} = V_{gr,J}/V_{gr,E} = (M_J/M_E) \times (R_E/d_{Eu}) \simeq 3.0$.

For a single gravitationally dark proton, the maximal metabolic energy gain would be .99 eV, which is twice the metabolic energy quantum. Standard metabolic energy quantum .5 eV corresponds to a radially oriented loop with height $h = d_{Eu}$. If a proton triplet defines the metabolic energy quantum, one would have $h = (1/5)R_{Eu}$.

Solar radiation should provide metabolic energy. The average distance d_J of Jupiter from Sun varies between 5.0AU and 5.4AU so that the gravitational metabolic energy quantum has upper bound $\Delta E_{gr,Sun,J} \leq \Delta E_{gr,Sun,E}/5 \simeq .5$ eV, which corresponds to metabolic energy quantum. Photosphere produces IR radiation with energies in the range .4-.6 eV. Therefore Europa seems to satisfy the conditions from quantum gravitational metabolism.

Just for fun, one can also look at the situation at the surface of Sun.

1. At the surface of the Sun, one has $z \simeq 3.0 \times 10^2$ and the metabolic energy quantum .55 eV for dark proton triplet scales to $\Delta E_{Sun} \sim .16$ keV: this is below the threshold for the nuclear fusion and below the temperature of $\sim .23$ keV of the solar corona. An interesting question is whether the X-ray radiation arriving to Earth could have some, perhaps even biological, function. TGD indeed predicts that nuclei have excitations in the keV range [K67].

2. For a dark electron Cooper at solar surface, the upper bound is .08 eV. The temperature of the photosphere corresponds to photon energy of .4-.6 eV, which corresponds to the metabolic energy quantum associated with the Earth's gravitational flux tubes. Could the IR thermal radiation from the photosphere serve as a metabolic energy source?

How does this model relate to the TGD inspired model for Cambrian Explosion [L71] [L140] ?

1. The TGD explanation for the sudden emergence of new phyla in Cambrian Explosion is that the radius of Earth doubled in CE in rather short time. If the end of flux tube moves along stationary orbit, the scaling formula gives for the metabolic energy quantum before the transition for the dark proton triplet the value $\Delta E_{gr} = .38 \times \Delta E_{gr,max}$, which gives $\Delta E_{gr} = .3$ eV. This is considerably smaller than .55 eV.

2. According to Stephen Gould (see the book "Wonderful life" about Burgess Shale Fauna [I115]), a large number of the phyla suddenly disappeared. Could this mean that they were not able to adapt to the transition increasing the value of the metabolic energy quantum? On the other hand, a rapid evolution started. Could this relate to the increased sizes of the protonic and electronic metabolic energy quanta? Solar metabolic energy quanta would not have changed.

Do Moon travellers survive in TGD Universe?

3 dark protons give the nominal value of metabolic quantum. If the naive estimates are taken seriously, terrestrial life might not be possible on Mars and Moon. Humans have however successfully visited the Moon and it is not clear whether the solar gravitational field comes to rescue.

Rather than giving up the idea, it is better to ask what goes wrong with the simplest model. The quasiclassical estimate assumes that the dark charge at the top and bottom of the gravitational flux tube has the same kinetic energy. If the kinetic energy at the top is higher, the value of the metabolic energy quantum increases. This inspires the question whether the reduction of the kinetic energy in the metabolic energy quantum can be neglected.

1. The simplest model for the particle at gravitational VB is as a particle in a box with kinetic energies given by $E_n = n^2\hbar_{eff}^2/mL^2$, L the length of the loop. If L scales like h_{eff}, the kinetic energy does not depend on h_{eff}. Therefore the scale of kinetic contribution can be estimated in a molecular length scale.

2. Could the system adapt to a reduction of the maximal gravitational potential at the surface of the Moon, Mars, or Venus by increasing the average value of n in the superposition of the standing waves having maximum at the top of the valence loop? The system would adapt by increasing the localization of the dark charge at the top of the loop. The reduction of the bond length would mean reduction of the superposition to $n = 0$ wave so that the kinetic energy would be indeed liberated.

Dark gravitational bonds and high energy phosphate bond

How could the somewhat mysterious high energy phosphate bond (HEPB) associated with di-phospates (DP) and tri-phosphates (TP) relate to the gravitationally dark hydrogen bonds (HBs)?

1. HEPB (`https://cutt.ly/2FcLFJY`) is identified as the bond $... - -O - -...$ connecting two P atoms in ATP or ADP (`https://cutt.ly/HFcLKyk`). Hydrolysis involves also one H_2O molecule. The $-O - P$ bond splits inducing the splitting of ATP to ADP and P_1. One cannot assign HEPBs to the monophosphates (MPs) associated with DNA so that the splitting of the O-P bond must play an essential role..

2. It is best to start by listing the facts about $ATP \rightarrow ADP + P_i + 2H^+$ reaction for which the Wikipedia article (see `https://cutt.ly/xFbuDet`) gives both graphical representation and the overall formula for the reaction.

   In the initial state 4 O-atoms of ATP have a visible negative charge. The simplest assumption is that all ions O^- actually correspond to gravitationally hydrogen bonded $O...H$ pairs with a delocalized proton charge so one should use the notation $O^{"-"}$. O^- would be replaced with $O...H-O-H$ such that the HB carries a gravitationally dark proton delocalized in even astrophysical scale. The negative charge would be only effective and associated with $OH^{"-"}$ rather than being a real negative charge of O^-. The same assumption is natural also for ADP and AMP. This would define the meaning of organic phosphates. In the final state both P_i and ADP have visible charge -3 to give a total visible charge -6.

   $2H^+$ in the final state guarantees the conservation of the visible charge in the reaction.

3. The $P(O^{"-"})_2$ of the third phosphate transforms to an inorganic phosphate P_i. A natural interpretation is that the gravitationally dark protons become ordinary ones. This explains $2H^+$ in the final state. This reaction would liberate part of the metabolic energy.

4. One H_2O molecule is used in the reaction. The natural assumption is that one hydrogen of H_2O has a dark gravitational HB with the oxygen appearing in $O-P$ of $(O_2^{"-"}P = O)-O-P...$ so that it one has $O^{"-"}$ visible charge -1. The bond $...P-O-...H$ becomes the effective oxygen ion of $...P-O^{"-"}$ of P_i so that P_i would not be completely inorganic. The remaining OH of the water molecule becomes one $O^{"-"}$ of P of ADP. Also this reaction can liberate metabolic energy.

2.2.6 Gravitational magnetic body and the model of dark DNA

Dark DNA (DDNA) is identified in terms of dark proton triplets assigned with flux tubes parallel to DNA. Codons correspond in the original model to smaller circular flux tubes carrying the dark proton triplets. This model is modified by replacing the circular flux tubes with long U-shaped gravitational HBs. In order to avoid confusion, one must make clear that this realization of DDNA differs from that discussed in [L162] and one must check whether they are consistent and what new predictions follow from the recent, much more specific, model.

Original model of DDNA

The original proposal for DDNA was that the dark proton charge screens the negative charge of phosphates so that the charge associated with the DDNA codon would be +3. If one has dark nucleons (proton and neutron), also other charges than +3 are possible in the proposed model and would be needed for amino acid polymers (AAs) [L162].

The most recent model discussed in [L162] made the following assumptions.

1. Dark nucleotides correspond to closed loops containing a dark nucleon: both dark protons and possibly effectively dark neutrons are possible so that dark nucleon has spin and strong isopin corresponding to 4 letters of the genetic code. A dark neutron could be only effectively a neutron and could be formed from a dark proton, which has transferred its charge to a flux tube connecting it with the neighboring dark proton.

   The total charge is that for dark protons as required by the condition dark DNA charge is neutralized. This conforms with the model for the formation of dark protons by Pollack effect [I63, L27, I128, I99] as transfer of ordinary protons to dark protons at flux tubes possibly forming dark codons as dark proton triplets [L27].

   The flux tube could be regarded as analogous to dark π^0/π^- or dark Z^0/W^-. These two options could be dual descriptions as the conserved vector current and partially axial current hypothesis of old fashioned hadron physics suggest.

2. The loop carries angular momentum and the angular momenta of dark protons and dark nuclei sum up. The tensor product decomposition of the states obtained in this manner gives DDNA, DRNA, DtRNA, and DAA therefore unifying the counterparts of the basic biomolecules at the dark level.

3. A natural expectation is that $h_{eff} = nh$ forms the unit of angular momentum, in particular spin. This gives a very strong condition and strongly suggests that dark particle corresponds to n-particle as analog of Bose-Einstein condensate: dark 3N-protons and dark 3N-photons as representations of genes with N-codons have been indeed suggested to play a key role in TGD inspired quantum biology. Dark photons with energy of $E = h_{eff}f$ would correspond to $n_{eff} = h_{eff}/h$ dark photons forming an analog of BE-condensate.

   Dark space-time sheets X^4 correspond to n-sheeted structures with Galois group of n-D extension of rationals. Many-sheetedness could correspond to many-valuedness of X^4 as a map $M^4 \to CP_2$ or vice versa and one can have also have n_1- and n_2 valuedness with $n = n_1 n_2$. In fact, one has a natural factorization of the order of the Galois group to a product of integers corresponding to its decomposition to normal subgroups so that $n = n_1 n_2 ... n_k$ is the general proposal. n_{gr} (assigned to h_{gr}), n_{em} , n_{weak}, n_{color} can have further decompositions. n-sheetedness with respect to CP_2 would correspond to n copies of a space-time sheet in M^4, for instance parallel flux tubes forming a quantum coherent structure. For $\hbar_{gr}$ this would be the natural option and for $n_{gr} = \hbar_{gr}/\hbar = n_{gr} \sim 10^{14}$. In this case, N-codon interpretation is not appropriate not natural, rather n_{gr} gravitationally dark DNA flux tubes could integrate to a quantum coherent parallel structure with a size about 1 mm.

The revised model of DDNA

In the model of DDNA-DNA considered here gravitationally dark HBs would define the dark codons.

1. The earlier model is modified by replacing the closed flux tubes associated with the dark nucleons with gravitationally dark HBs.

2. There is no screening now, and the negative charge of phosphates is only effective and assignable to water molecules surrounding DNA rather than phosphates directly so that DNA stability would be achieved also now.

3. Dark DNA has still effective charge -1 per codon and the dark proton charge would be delocalized at the dark gravitational flux tubes and thus invisible. DDNAs would be connected by quantum numbers of loopy flux tube pairs with quantum numbers π^0 or π^- connecting dark nucleons of dark DNA. A dark proton at the strong flux tubes would transform to an effective dark neutron in the case of π^-. The value of h_{eff} for these would most naturally correspond to h_{color}.

   I have proposed that even the nucleons of ordinary nuclei can have dark flux tubes, which emanate from nuclei of nuclei and carry quantum numbers of pions and having size of even atomic scale. This could relate to the observed discrepancy of the radius of protons. As a matter of fact, this would mean the counterpart of dark HBs at the level of strong interactions.

4. What is new as compared to the earlier model is that there would be a composite of n_{gr} more or less parallel DNA flux tubes assignable to a volume of order 1 mm and each having a length proportional to $\hbar_{gr}$. Also single flux tube visiting through all the DNAs can be considered. One would have a flux tube spaghetti also assumed to be generated in the formation of astrophysical objects [L84, L94, L137].

Could the HBs associated with the base pairs of DNA become gravitationally dark?

DNA base pairs are connected by 2 (A-T) or 3 (G-C) HBs: what could this mean from the point of view of DNA energy metabolism?

1. If these strands can appear as dark gravitational strands, the maximum of 2 (3) metabolic quanta could be liberated in A-T (G-C) pairs via a transformation to ordinary HBs. Could this serve as a yet-unidentified source of metabolic energy in the replication and transcription?

2. Could the dark/organic mono-phosphates of the double DNA strand serve as a source of metabolic energy for DNA transferred to the HBs connecting base pairs?

3. Suppose that the DDNA parallel to DNA corresponds to a sequence of gravitational HBs B_{gr} as loops associated with the organic phosphates. Codon would correspond to a bound state of dark protons associated with three dark gravitational HBs.

   Consider an ordinary HB A_o associated with a base pair and B_{gr} associated with the corresponding dark/organic phosphate. Can one transform A_o to A_{gr} to achieve the transfer of metabolic energy?

   Two reconnections for a HB pair (A_o, B_{gr}) can transform the pair to (A_{gr}, B_o). The gravitationally dark proton and metabolic energy would be transferred to basepair from the organic phosphate, which itself would become an organic phosphate ion P_1^-.

   Note: Also the phospholipids of the cell membrane are accompanied by a monophosphate group. Also microtubules are accompanied by GMPs. Could they serve as metabolic energy sources in the cell membrane using the above described mechanism?

A quantum gravitational mechanism for the splitting of HBs associated with base pairs

The splitting of HBs associated with base pairs [**?**]`https://cutt.ly/9FmJywe`) plays a fundamental role in DNA opening necessary for DNA replication and transcription. These HBs must split during replication and transcription and many other processes such as selective recognition of DNA by proteins, regulation of RNA cleavage by site-specific mutations, and intermolecular interaction of proteins with their target DNA or RNA. Could the notion of gravitational HB provide insights about the process?

1. As the figures of (`https://cutt.ly/PFmJaFr`) illustrate, the base pairs of the double DNA/RNA strand have 2 or 3 HBs. HBs of type $N-H...O$ and $H-N...O$ and $N-H...N$ (called imino HB) are possible. Imino HB appears for both A-T with 2 HBs and G-C with 3 HBs.

   Since the hydrogen of $X-H...Y$ is nearer to Y than X, the splitting is expected to give $X+H-Y$, $X, Y \in \{N, O\}$. This is indeed the case when X and Y are different. However, the imino HB $N-H...N$ actually splits to $N-H+N$ rather than the expected $N+H-N$. An exchange of a hydrogen atom is said to occur.

2. The temporary formation of a gravitationally dark HB could explain how this is possible. The gravitationally dark proton is at a large distance from the N atoms so that they are in a symmetric position and both outcomes for the splitting are equally probable so that the exchange rate increases.

3. This requires a temporary transformation of $N-H...N$ HB to a gravitationally dark HB. Could double reconnection transform the pair $(A_o, B_{gr}$ formed by $N-H...N$ HB and dark HB of phosphate bond to (A_{gr}, B_o), which then splits?

Quantum gravitational explanation for the different chemistries in vivo and in vitro

If gravitationally dark hydrogen and VBs are relevant to biology, their effects should distinguish between matter in vivo, gel phase and matter in vitro. The difference should be especially clear at physiological temperatures. Is there any empirical evidence for the deviations from what is inspected on the basis of the standard biochemical intuition?

The interactions between DNA metal ions present living matter could serve as a test for the proposal. In the TGD framework, both metal ions and DNA could be gravitationally dark (in vivo or gel phase) or ordinary (in vitro phase).

1. For the DNA and metal ions as they are usually understood, the phosphate ions $(PO_4)^-$ of DNA should have interactions with metal ions and the concentrations should affect the properties of DNA. This should be true both in vivo and in vitro.

2. In the TGD framework, DNA strand in vivo and in gel phase would be accompanied by a dark DNA strand. The phosphate ions $(PO_4)^-$ would be actually pseudo-ion $(PO_4)^{"-"}$, in the sense that the ion O^- would be replaced with a gravitationally hydrogen bonded structure $O...H-O-H$ such that the HB carries a gravitationally dark proton delocalized in a very long scale. The effective negative charge would be associated with $OH^{"-"}$ pseudo ion rather than being a real negative charge assignable to O.

   Outside the physiological temperature range and in vitro, the oxygen ion would be real and the situation would be as in the standard chemistry apart from the possible effects of darkness of metal ions. The simplest assumption is that both metal ions and DNA are dark at the same temperature range only.

3. (Gravitationally) dark metal ions of type X^{++} would also have a dark valence electron at flux tube. One can speak of dark salt since flux tube bonds would connect X with H_2O_2. Same applies to Cooper pairs of dark ions X^+.

   The phosphate of DDNA-DNA pair has Coulomb interaction with neither ordinary nor dark ions but the metal ion would interact with $OH^{"-"}$. This suggests that the presence of metal ions does, and ions in general, has no strong effect on the DNA properties in vivo. Besides realizing genetic code, dark DNA would shield the system from the perturbations caused by various ions.

4. Experimentally this seems to be the case. Most interactions between DNA and ions are modelled and studied experimentally in dilute water solutions. According to [I46] (`https://cutt.ly/bFQ1Gla`), under these conditions the DNA interaction with charged ligands, the helix-coil transition temperature, and other DNA properties are strongly dependent on the low-molecular-weight salt concentration, see [I46] and references therein. However, for condensed DNA states (fibers, gels) or in vivo, similar characteristics are often independent of or only slightly dependent on the ionic composition of the solvent.

What about amino-acids (AAs)? The proposal is that also DAA-AA pairing realizes dark genetic code. If this code is realized in terms of gravitationally dark HBs, one expects that the same should be true for AAs.

Dark proteins and quantum gravitation

What about dark proteins in the recent situation?

1. In the case of AA of a protein, the effective charge is assignable to the donor atom, which could be either atom of peptide backbone or of water molecule. Can one assign to a given amino acid (AA) of protein (`https://cutt.ly/sFRYlWA`) 3 gravitational HBs carrying a dark proton each?

2. In the formation of AA sequence, peptide bonding occurs, which means that $(C=0)-(OH)$ is replaced with C=O and NH_2 is replaced with $N-H$. $(N-H)-(C-H)-(C=O)$ is the unit of peptide backbone (`https://cutt.ly/nFRYnu4`).

   The H atom of $N-H$ could form a gravitationally dark HB to O atom of water molecule, which would give $N^{"-"}$. Also N could form HB with H of water molecule: this would give $OH^{"-"}$. $C=O$ could form a dark HB with the H of the water molecule so that $OH^{"-"}$ is generated but $=O$ remains neutral. As in the case of DDNA-DNA pair, an effective negative charge of -3 units would be generated if one counts also the $COH^{"-"}$ as part of the peptide backbone.

2.2.7 Living systems as analogs of topological quantum computers

Topological quantum computation (TQC) has in the TGD framework a realization in terms of braids realized as magnetic flux tubes connecting subsystems [K6, K5, K110]. The flux tubes carry $h_{eff} = nh_0$ phases of ordinary matter behaving in many respects like dark matter. In living matter TQC-like activities would be realized in several scales associated with the hierarchy defined by the levels of MB and one can even speculate that TGD is the basic function of living matter. This motivates a brief comparison of TGD based view about quantum computation (QC) and TQC with the standard view.

Basic distinctions from the standard view

The TGD based view about quantum computation (QC) [K6, K5, K110] differs in several aspects from the standard view.

1. The hierarchy of Planck constants makes it possible scal the time and spatial scales of QC by realizing it using dark matter as $h_{eff} = nh_0$ as phases for ordinary matter. This is possible at quantum criticality in which long range correlations associated with quantum fluctuations are realized as $h_{eff} = nh_0$ phases, which play a crucial role in the living matter. What is favorable for QC is that for large values of h_{eff} dissipation rate is small.

2. The fragility of quantum entanglement is a basic problem of standard QCD. Partially it is due to the smallness of Planck constant. Number theoretic vision predicts that one can assign to quantum entanglement ordinary entanglement entropy and also p-adic entanglement entropy which is possible if entanglement probabilities belong to the extension of rationals assigned to the space-time region considered. $h_{eff}/h_0 = n$ corresponds to the dimension of extension associated with the space-time surface and is determined by the degree of the polynomial determining it at the level of $M^9 8$ ($M^8 - H$ duality). Negentropy Maximization Principle (NMP) is the basic principle of TGD inspired theory of consciousness as a generalization of quantum measurement theory based on zero energy ontology (ZEO).

   The prediction is that the quantum entanglement associated with entanglement with positive p-adic entanglement negentropies is very stable and the negentropy of the entire system tends to increase. This implies evolution as an increase of algebraic complexity accompanied by the increase of h_{eff} and quantum coherence scales.

3. Negentropic quantum entanglement favored by NMP satisfies strong constraints. In particular, the entanglement probabilities are rational numbers. Therefore this kind of entanglement is very rare. This solves a second basic problem of QC: there are quite too many possible quantum entanglements so that combinatorial explosion is unavoidable.

4. ZEO [L96, L132] [K117] allows also QCs in both time directions. In "big" state function reduction (BSFR) the computation halts and the arrow of time is changed and QC in the opposite time direction begins. At the human level the wake-sleep cycle corresponds to the periods separated by BSFRs. The saying that problems are solved, by sleeping over night, makes sense at a deeper level. During this period dissipation looks like self-organization and regeneration of structures, healing, and biological systems would apply this mechanism in all scales in order to fight against second law. One can also ask whether QC forth-and-back in time could make QC much faster.

TQC in the TGD framework

TQC is a very natural option in the TGD framework [K6, K5, K110]. The basic notions are magnetic body (MB) having magnetic flux tubes and flux sheets as body parts and dark matter residing at MB.

1. ZEO replaces 3-D quantum states with superpositions of deterministic time evolutions as preferred extremals (PEs) of the basic action principle, and are analogous to Bohr orbits and realize almost ideal holography - required by the realization of general coordinate invariance, in the sense that 3-D data fix the entire 4-surface. PEs are analogous to biological functions,

behavior patterns in neuroscience, and computer programs in computer science. SFRs as acts of free will replaced these programs with new ones.

PEs would be 4-D minimal surfaces with singularities of lower dimension. PE is analogous to soap film spanned by frames defining the singularities. As in the case of soap films, the frames give rise to a finite failure of strict determinism and ideal holography. This failure would be a classical space-time correlate for quantum non-determinism, or at least what I have called cognitive non-determinism as a correlate for imagination.

In purely classical physics holography is not realized. It is easy to understand this by thinking in terms of a point-like particle (for which 3-surface is a generalization). A particle at a given point can go in any direction with any velocity. By ideal holography only single direction and unique velocity is allowed.

2. Magnetic flux tubes connecting 3-surfaces give rise to networks. 3-surfaces appear as nodes of this network. An interesting possibility is that these 3-surfaces have as a good approximation 2-D projection to 3-space and therefore define membrane-like objects. All membrane like objects, such as cell membrane could be associated with this kind of 4-surfaces.

   The flux tube connections are a new element not present in the standard physics. The flux tubes can be idealized as string-like entities. In 3-D space the flux tubes can get knotted and linked with each other and define in this way braids - or rather, generalizations of braids. They would define the topological space-time correlate for a TQC program,

3. Fermionic degrees of freedom (quarks at fundamental level giving rise to all elementary particles including bosons and also leptons as the bound states) define the fermionic part of TQC. Fermionic states reside at the ends of braids at the nodes of the network and more generally at the 3-surfaces from which the flux tubes begin.

   An important delicacy, forced by the fact that flux tubes carry monopole flux, is that flux tubes associated with a 3-surface are tentacle-like U-shaped flux loops, and their reconnection builds flux tube pairs connecting 3-surfaces.

4. Reconnection for U-shaped flux tubes for a pair A,B of nodes forms a flux tube pair connecting A and B. The reversal of this process destroys the flux tube connection. If all flux tube connections from subsystem A to the environment disappear, A de-entangles. Thus it seems that the presence of flux tube pairs makes possible entanglement. The change of entanglement in turn has braiding as a space-time correlate.

   The halting of TQC assignable to subsystems could correspond to the de-reconnection process for a subsystem. Partial de-reconnection is also possible and the notion of partial halting might make sense.

   The braids are effectively 1-D and their time evolution defines effectively 2-D surfaces inside a 4-D space-time surface. They can form 2-knots as a generalization of ordinary knots which are 1-knots. The reconnection processes define the topology of these 2-knots. For higher-D space-time surface 2-knotting is not possible so that from the point of view of TQC, the dimension D=4 for the space-time is completely unique as also the dimension D=3 for 3-space.

5. Dance metaphor [K6, K5, K110] is a highly useful way to see TQC in the TGD framework. One can think that the nodes of the network are like dances connected to each other by thin threads. Dancers change their partners and define a complex pattern on the dance floor. At the space-time level this defines braiding of the time-lines of the dancers. One can speak of a time-like braid.

   Also the threads connecting the dancers are braided and form space-like braind determined completely by the time-like braiding once the initial state of the space-like braid is fixed. This is not quite the case if reconnections splitting or creating threads between dancers take place. One can say that the space-like braiding records the history of the dance hall as analog of akashic records. One can also speak of topological memory.

6. The evolution of the entire TGD Universe can be regarded as a fractal hierarchy of TQCs based on the fractal hierarchy of magnetic flux tubes characterized by algebraic extensions of rationals to which one can assign p-adic primes as maximal ramified primes. These in term define p-adic length scales assignable to the flux tubes. The braiding of flux tubes takes place in all scales. For instance, while moving around, we contribute to a generation of this kind of braids defining analogs of TQCs.

Biochemistry could represent especially refined analog of TQC. The basic notions of biochemistry interpreted in TGD framework correspond to those of TQC according to TGD as described above but also some new elements emerge.

1. Consider the TGD inspired view about bio-catalysis [L196]. Reconnection is the basic mechanism of bio-catalysis. According to the TGD based view about bio-catalysis, reactants find each other by using as tentacles U-shaped flux tubes and resonance mechanism.

   Flux tubes can touch but this is not enough. There must be a resonance. This occurs if the cyclotron frequencies associated with the flux tubes are identical. This is possible if the flux tubes have the same radius and therefore identical magnetic field strengths and cyclotron frequencies.

   If the value of h_{eff} associated with the flux tubes is reduced, the pair is shortened and forces the reactants near each other. The reduction of h_{eff} liberates energy, which in turn makes it possible to overcome the potential wall, which otherwise prevents the reaction from occurring. After the reaction the energy needed to overcome the wall is liberated and can bring U-shaped flux tubes to its original size. Note that the values of h_{eff} tend to be reduced and metabolic energy feed is to provide the energy needed to preserve the distribution of h_{eff} values.

   Since reconnection takes place and reaction can produce new nodes, biochemical reactions do not reduce to the notion of gate in the generalized view of TQC.

2. Besides reconnection, the notion of tuning is also fundamental and brings a new element to TQC according to TGD. The change of the thickness of the flux tube as the basic motor action of the flux tube (besides reconnection and contraction) changes the cyclotron frequency. The frequency modulation makes it possible for flux tubes to search whether some objects are present in the environment. This would be the basic operation of the immune system at quantum level [K50] [L160]. The tuning of the flux tubes of MBs of the water clusters makes it possible for them to mimic the cyclotron spectrum of invader molecules and this ability explains water memory.

3. Bioharmony [L24] [L111, L128, L162] is a further TGD based notion. The proposal is that genetic code has two quantum realizations. The first one is based on dark nucleon sequences with a dark codon realized as a nucleon triplet. For the second realization codon corresponds to dark photon triplet. These triplets behave like quantum coherent units and are analogous to quarks as 3-quark bound states.

   The binding mechanism is purely number theoretic and universal. Also genes can be regarded as dark 3N-nucleons or 3N-photons. The states of dark proton triplets correspond to all basic biomolecules DNA- ,RNA-, and tRNA-codons, as wella s amino acids (AAs).

   Bioharmony defines the dark photon realization of genetic code. Communications occur by using 3-chords (or possibly even 3N-chords). The ordinary resonance between participants with the same value of h_{eff} is replaced with 3N-resonance. The allowed 64 3-chords define bio-harmony as a collection of allowed 3-chords. Music expresses and creates emotions and the natural interpretation is that bioharmony is assigned to variants of genetic code which correspond to different molecular moods. Also the energy resonant communications between dark and ordinary variants of codons must be possible and this poses extremely stringent conditions on the basic bio-molecules.

   Bioharmony realizes genetic code and would become the basic code of TQC. Codons or even their sequences would serve as addresses. The signal is a sequence of these 3-chords, analog for a piece of music, and is received by resonance mechanism only by receivers which correspond

to a sequence of dark nucleon triplets defining the same codons. Note that also partial resonance is possible in which case the number of possible receivers is higher. The principle is the same as in LISP. The message can be coded to the modulation of the frequency scale of chords. The cyclotron resonance peaks define a sequence of pulses making it possible to interpret the message. Nerve pulse pattern could be induced by this kind of pulse sequence.

2.3 Update of the TGD based view of nervous system

The existing TGD based view of the nervous system will be summarized first. After that the basic notions and the ideas about what happens in nerve pulse conduction are sharpened by using the quantum gravitational view about metabolism. Also the relationship between biochemistry and TGD view about quantum biology will be discussed and lead to highly non-trivial insights about the role of the basic biomolecules.

2.3.1 The recent TGD based view of nervous system

The proposal [K85, K40, K86, L120] is that the cell membrane possesses a pre-NS based on cell membranes acting as generalized Josephson junctions.

1. The oscillations of membrane potential induce Josephson oscillations as soliton sequences, which represent the ground state of the axon, and possibly also of cilium. A sequence of rotating mathematical penduli in different phases giving rise to a wave is a good analogy. Pre-nerve pulse would correspond to a perturbation of the soliton sequence in which some penduli oscillate instead of rotating, which propagates with the same velocity as the soliton sequence.

   One can also consider an alternative scenario in which the roles of rotation and oscillation are changed. The soliton sequence requires more metabolic energy than its oscillatory counterpart and one might argue that the latter is more favored for this reason.

2. Generalized Josephson radiation gives rise to sensory communications from the cell membrane to its MB using frequency modulated generalized Josephson radiation with generalized Josephson frequencies $f_J = E_c/h_{eff}$ (and their multiples), which correspond to the energies $E_J = \Delta E_c + ZeV$, where ΔE_c is the difference of cyclotron energies for flux tubes at different side of membrane, and ZeV is the usual Josephson energy. Z denotes the charge of a Cooper pair or bosonic ion. For $h_{eff} = h_{gr}$ the generalized frequencies are in EEG range and nerve pulses appear as frequency modulations of the generalized Josephson frequencies.

3. The frequency modulated generalized Josephson radiation is received at MB and induces pulse by cyclotron resonance defining the response of MB as a dark cyclotron radiation. The response of MB corresponds to a sequence of resonance peaks, which induce pre-nerve pulses as propagating perturbations of the soliton sequence. The perturbation would change the rotating motion of the effective gravitational pendulum to an oscillating motion.

   The pre-nerve pulse induces a nerve pulse if a quantum criticality condition stating that the magnitude of the resting potential is above the critical value is satisfied. Synaptic transmission builds a contact between pre- and postsynaptic cells and connects U-shaped flux tubes parallel to the dendrites and axon to a pair of flux tubes.

Which part of the neuron could receive the response of MB?

1. The original proposal [K85] was that the response of MB occurs directly at the level of the genome. This would require a network of flux tubes connecting cell nucleus and cell membrane transmitting the response from genome to cell membrane. This flux tube network would also make topological quantum computation-like processes possible [K5, K110].

2. One can also imagine a simpler scenario. The response would be received by the cell membrane and generate second messenger molecules, which carry a chemical signal to the cell nucleus. The response could be seen as a sensory communication with a reversed arrow of

time. The objection is that sensory and motor systems are different for vertebrates. One can however argue that the time reversal is for the combined system. If sensory and motor sub-systems have opposite arrows of time, only either of them contributes to "our" conscious experience at once.

Interestingly,in human EEG there is a clear division into quasi-stationary periods with a duration of about .3 seconds [L20] discussed from the TGD point of view in [L19]. The first half of the period looks ordered and the second half chaotic. I have proposed that these pieces are separated by BSFR at MB as a response of MB and correspond to different arrows of time.

Synaptic transmission is second key part of neural activity.

1. Synaptic transmission involves the transmission of a bag of neural transmitters implying that the pre- and post-synaptic cell membranes touch and fuse to a singly entity temporarily. This would imply also the fusion of the magnetic flux tubes assignable to pre- and postsynaptic axons to a single flux tube and make possible both the transfer of quantum coherence and the propagation of dark photon signals assignable to magnetic flux tubes acting as wave guides. The flux tubes could be called pre-axons.

2. The deeper function of neurotransmitters remains a mystery in the framework of the standard neuroscience but terms like reward and punishment are routinely used. In the TGD framework, these terms could be more than convenient metaphors.

   The neurotransmitters arriving in the synaptic contact could induce a change of the local bioharmony and thus a change of the local mood so that the heuristic terminology would be justified. At the level of the basic biomolecules the epigenetic regulation based on methylation could induce similar changes [L162]. The decision making of neurons would rely on emotions created by various synaptic inputs: this is the situation also at our level!

Axonal MTs could make the conduction of nerve pulses through the myelinated portions of the axon possible. Inside myelinated portions the transfer of ions between interior and exterior of the axonal membrane is not possible. The shortening of axonal MTs involves localization of delocalized protons and electrons at gravitational flux tubes and changes the charge of the axonal interior and this in turn can take the membrane potential below the critical value and make the conduction possible. Note however that the drop of electrons and protons would take place at Bohr orbit with Earth radius. A further localization to atomic level would liberate more energy.

2.3.2 Clarification of some basic concepts

In the following I try to further clarify the basic notions used in order to identify the weaknesses of the scenario.

About the notion of dark ion

The original view was that dark ion as a whole resides at the flux tube. Later this statement became more precices: dark ion is touches the , say gravitational, dark flux tube with $h_{eff} > h$. This applies also to both gravitational, electromagnetic, weak, and color flux tubes and ordinary bonds correspond to electromagnetic flux tubes with $h_{eff} = h_{em}$ [L56].

The entire dark ion touching the flux tube would have wave function in the magnetic field of flux tube having the touching point as argument. Cyclotron states are natural.

The more precise view considered already earlier is that one has effective ion: the dark elecron or Cooper pair resides at gravitational flux tube is not bound to the atom as effective ion. The predictions for dark cyclotron states are same as for the older picture and the predictions related to the dark electron or proton are new.

About the notion of electric flux quantum

What does one mean the flux tube parallel to axon?

1. I have talked assigned to axon a magnetic flux tube parallel to it and accompanied by magnetic flux tubes transversal to it. This would correspond to a 3-D network of flux tubes.

   The problem has been how to describe the membrane structure with electric field and electric flux orthogonal to the flux tube. This situation requires genuine electric flux quanta analogous to magnetic flux quanta and the time dependent deformations of the magnetic flux tube cannot give them. However, magnetic flux tubes allow very simple time dependent deformations allowing longitudinal electric flux along the tube.

2. Could electric flux quanta associated with a pair of lipid layers correspond to a pair of membrane-like objects having 1+2-D rather than 4-D M^4 projection connected by time-dependent deformations of transversal magnetic flux tubes carrying a longitudinal electric field?

3. Unfortunateluy, I did not have any candidate for an explicit solution of field equations describing 2-D membrane-like object such as cell body or axon. For some time ago I finally understood 2-D membrane-like objects in terms of 3+1-D minimal surfaces in $H = M^4 \times CP_2$.

   M^4 projection is 3-D and E^3 projection 2-D membrane. The basic problem is posed by the fact that 2-D closed minimal surfaces are not possible. For soap bubbles a pressure difference over the soap bubble is required and one loses minimal surface property. The solution of the problem was that the 1-D CP_2 projection of the surface is dynamical and allows 4-D minimal surface. The simplest option is that it represents rotating geodesic circle.

4. Therefore one can ask whether lipid bilayer could have pair of electric bodies (EBs) serving for them as a kind of template and connected by transversal elecric flux tubes carrying a longitudinal rather than transversal electric field.

2.3.3 Gravitationally dark effective ions

Besides organic molecules but also metal ions are fundamental for metabolism and bio-catalysis. This led to the TGD inspired proposal that they give rise to dark ions and the recent work gives further support for the view is that gravitationally dark electrons given them their special role

1. Various bosonic effective metal ions and their Cooper pairs can get paired by gravitational flux tube with atoms of opposite total valence. The distance between paired system can become due the relative motion of the atoms considered. Also reconnections of gravitational flux tubes could cause this.

   Correlations are predicted between the members of pairs. The presence of gravitational hydrogen- and valence bonds (VBs) implying the presence of effectiove ions could distinguish biochemistry from chemistry. Also electrolysis, and therefore organic chemistry in general, involves the ionization of atoms very difficult to understand without the notion of dark gravitational valence- and hydrogen bonds. Also the physics of water is full of thermodynamical anomalies suggesting the presence of these bonds.

2. According to standard chemistry, one has equilibrium $X(OH)_2 \leftrightarrow X^{++} + 2OH^-$ for X$\in$ {Ca, Mg, Fe} in water environment. Gravitational effective ionization effectively breaks charge conservation and one would obtain quantum correlated pairs formed from X^{++} connected by flux tubes H_2O_2. Gravitationally dark electrons would not be visible. This would mean apparent charge non-conservation, which could be tested as deviation of the concentrations from the prediction $n(X^{++}) = 2n(OH^-)$.

   This could happen also for water itself. $H_3O)^+$ and OH^- ions are present. OH is not stable but the pairing $2(H_3O)^+ + 2H_2O_2$ by gravitational hydrogen bonds is possible. Also H_2O + OH^- pairs with one dark gravitational proton are possible. The concentrations of $(H_3O)^+$ and OH^- would be different.

Signatures of dark effective ions

The ions X^{++}, X $\in$ {Ca,Mg, Fe,Z} and X $\in$ {Li, Na, K} would be actually effective ions with gravitationally dark VBs. Dark effective ions have special signatures, which allow to test the TGD view.

1. These effective ions effectively break charge conservation. Is the transformation of $X(OH)_2 \to X^{++} + H_2\,O_2$ rather than $X(OH)_2 \to X^{++} + 2OH^-$ in question as would be if electrons become gravitationally dark. Note that hydrogen peroxide $H_2\,O_2$ is a reactive oxygen species (ROS) (`https://cutt.ly/NFima6X`) playing a very important role in biology. ROS are produced in biological processes, in particular metabolic process such as respiration and photosynthesis. TGD view would mean that ROS are not a nuisance but an essential element of electron based metabolism.

   For X^+, X ∈ {Li, Na, K} the electrons of the Cooper pair are paired with two OHs. Two XOHs forms Cooper pair of X^+:s correlated hydrogen peroxide H_2O_2. This would represent new physics and effective charge non-conservation.

2. Quantum gravitational correlations between H_2O_2 and X^{++}, X ∈ {Ca, Mg, Fe, Zn} and between H_2O_2 and Cooper pars of X^+, X ∈ {Li, Na, K} are predicted and this prediction might be testable.

Some facts about Calcium ions

Basic facts about Ca ions allow to get idea about the implications of new metabolic quantum and the quantum gravitational realization of metabolic energy quanta.

1. Calcium ions (Ca^{++}) contribute to the physiology and biochemistry of organisms' cells. They play an important role in signal transduction pathways, where they act as a second messenger, in neurotransmitter release from neurons, in contraction of all muscle cell types, and in fertilization.

2. Calcium phosphate `https://cutt.ly/4FimgMc` appearing in bones combines effective ions possibly having gravitationally dark protons and electrons (Calcium phosphate is also considered in [L124]). Posner molecule $[(PO_4)^{-3})]_6Ca_9^{+2}$ made of 6 phosphate ions and 9 calcium ions would be the key player and has been proposed to play central role in consciousness theory [J31, J35] (`https://cutt.ly/bFimzit`). I already mentioned Posner molecules and a possible realization of genetic code using dark Cooper pairs of electrons. I have considered Posner molecules from the TGD point of view in [L38].

3. Ca^{++} currents initiate action potentials. Voltage gated Ca^{++} channels emerge first in the maturing of neuron and also in evolution of nervous system (already monocellular eukariotes generate action potentials). Na^+ channels emerge later. The action potentials pulses have a longer dead time for Ca^{++} than for Na^+.

   For instance, Ca^{++} initiates a contraction of muscle and helps to maintain the potential difference over cell membrane, which conforms with the proposed role in electronic metabolism.

4. Ca^{++} appears as a second messanger molecule. The TGD view about second messanger molecules is discussed in [L154]. Cell interior, in particular mitochondria and endoplasmic membranes contain storages of Ca^{++}. Mitochondria would thus involve both forms of metabolism.

Ca^{++} waves

Ca^{++} waves could be effective ions due to gravitationally dark Cooper pairs.

1. Ca^{++} waves are very important in biology and appear in cell interior and between cells. A calcium wave is defined as a localized increase in cytosolic Ca^{++} that is followed by a succession of similar events in a wave-like fashion. Ca^{++} waves can be restricted to one cell (intracellular) or transmitted to neighboring cells (intercellular).

2. Calcium waves are also associated with glial cells. Ca^{++} waves are of special importance in astrocytes and other glial cells [J34]. This should relate to electronic metabolism of the primary cilia associated with both neurons and glial cells.

   Calcium waves and miniature potentials would naturally relate to dark electron metabolism. Both glial cells [J29] and neurons [J28] have primary cilia acting as sensory receptors and since cilia cannot use ATP metabolis, electronic metabolism is natural.

2.3.4 About the model for the nerve pulse

Could one construct a simplified TGD based model for the nerve pulse [K85] using this kind of picture utilizing holography meaning that one can take the EBs as basic objects to which one can assign densities of various ions atoms and normal components of electric field as charge densities? Can one decompose these densities to various contribution assignable to ions or effective ions?

The basic physical picture would be as follows. The transformation of the pairs of metal atom with atoms with total valence equal to that of metal would generate gravitationally dark metal atoms, which are effective ions which correlate with the paired atoms. The valence charge of the metal atom effectively disappears and implies an effective charge non-conservation. In nerve pulse these effective ions would disappear and would look like charge non-conservation. Also effective ionic currents appear.

1. Josephson currents are assumed to flow along dark flux tubes connecting the two systems and electric field would be along them. Gravitationally dark protons and electrons reside at gravitational flux tubes as very long loops connecting cell interior and exterior. Dark ions are associated with these flux tubes (touch them).

2. What kind of dark Josephson currents could flow along them? If the two atoms are localized at the ends pf the dark gravitational valence- of hydrogen bond at the opposite sites of the membrane, the dark electron and proton Josephson currents can run along gravitational flux tube. Also effective dark ion currents can flow between interior and exterior since the gravitational VB with H_2O_2 can get stretched.

   Gravitational flux tubes assignable to valence and hydrogen would connect systems such as X^{++}, X$\in$ Ca, Mg, Fe and hydrogen peroxide H_2O_2, which is a reactive oxygen species (ROS). The currents would flow between systems containing these dark ions and molecules.

3. More than 100 miniature potentials induced by Ach vesicles are needed to initiate nerve pulse in synaptic contact. The miniature potential corresponds to a liberation gravitational electronic metabolic quantum as a transformation of gravitationally dark electron to ordinary one. This critical reduction of membrane potential would induce the reduction of the membrane potential below the critical value and induce the action potential. Also protonic metabolic quanta are involved and would relate to the ordinary metabolism based on ATP machinery.

The TGD picture challenges the Hodgkin-Huxley model of nerve pulse generation (`https://cutt.ly/FFiWTNA`). The model for the neuronal membrane assumes that ohmic currents flow through the ion channels. What happens when a Ca^{++} initiated action potential is generated?

1. The standard description using Hodgkin-Huxley model is in terms of a rush of Ca^{++} ions to the cell interior along Ca^{++} channels. The process occurs spontaneously since the cell interior is negatively charged and does not require metabolic energy. These currents would be ohmic and dissipative. This description could make sense only in the non-myelinated portions of the axons.

   Since only non-dissipative Josephson currents for dark Ca^{++} ions are possible, the rush of dark Ca^{++} dark ions does not seem plausible in the TGD picture. However, the delocalized electronic charge could end up to the hydrogen peroxide H_2O_2 paired with Ca and a genuine Ca_{++} ions would be created. The same applies to Cooper pairs of other dark metallic ions. In the myelinated portions of axon this kind of mechanism could work so that the Hodgkin-Huxley model would describe the situation.

   Inside the myelinated portions of the axon, the transformation of gravitationally dark protons to ordinary protons would reduce the associated effective negative charge and make membrane potential more positive and take it below the critical value for nerve pulse generation at non-myelinated portions.

   Also pairs of dark Ca^{++} ions and dark H_2O_2 pairs from $Ca(OH)_2$ can be created, perhaps by a double (effective) ionization creating pairs of dark Ca^{++} ions and dark H_2O_2 pairs from $Ca(OH)_2$ in an electric field in the cell interior. Also dark gravitational VBs associated

with Ca would be created in the cell interior and dark electron Josephson currents would be generated. The charge densities inside and/and outside the neuronal membrane would change and affect the membrane potential. This option could be realized in the non-myelinated sections of the axon in the resting state: nerve pulse would involve a transformation of dark ions to ordinary ones.

2. What looks very strange from the TGD point of view is that, although the generation of nerve pulse is spontaneous and is therefore expected to reduce the value h_{gr}, which in turn would liberate energy identified as a metabolic energy, just the opposite occurs. Can one conclude that a BSFR occurs at critical membrane potential and the arrow of time is changed. In this situation the process would be dissipative but in a reversed time direction. Later support for this interpretation will be found.

This raises a question considered from the TGD point of view in [K83]. Do the ion channels and pumps really act as channels for ionic currents or can only electronic, protonic and ionic Josephson currents flow through them?

1. The experimental work of Ling, Sachs and Qin [I66, I108] and other pioneers [I48, I32] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps.

2. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through the cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! This challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: an ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why is it so difficult to get the water out of it?

Membrane potential changes sign during the nerve pulse. The interpretation as a BSFR changing the arrow of time is suggestive and the above observation suggests the same?

1. If the action potential corresponds to two subsequent BSFRs as a kind of quantum tunneling event, the arrow of time temporarily changes at MB and changes the effective arrow of time at the level of the ordinary biomatter. Gel-sol phase transition in the neuron interior near neuronal membrane signals about the reduction of the quantum coherence scale.

2. The TGD based description for the change of the sign of the membrane potential is in terms of the model of nerve pulse describing the ground state as a soliton/oscillon sequence and mathematically equivalent to a sequence of gravitational penduli rotating/oscillating in synchrony. Can one choose between these options?

   Critical membrane potential would correspond to a situation in which the rotation changes to oscillation or vice versa. The fact that the membrane potential changes sign and has original magnitude, supports the soliton model. The rotation frequency would transform to a vibration frequency, decrease further, change sign and eventually transform to a negative rotation frequency. The arrow of time would have changed. The reverse of this process would correspond to the second BSFR leading to hyperpolarization.

2.3.5 Microtubular level

TGD predicts two forms of metabolism [L148]. The ordinary metabolism relies on gravitationally dark protons originating from hydrogen bonds. For the new form of metabolism dark protons are replaced with gravitationally dark electrons or their Cooper pairs originating from metal atoms. Both dark electrons and dark electron Cooper reside at gravitational Bohr orbits with the same spectrum of radii. When they transform back to ordinary particles, they become gravitational Bohr orbits at distance defined by Earth radius and therefore liberate energy.

This metabolic mechanism could be associated with cilia and flagella having no mitochondria in their interior and could be also important in the metabolism of axonal MTs.

Could the metabolism of cilia and flagella rely on gravitationally dark electrons?

The recent work in TGD has led to considerable progress in the understanding of metabolism [L148] already discussed in the section 2.2.5. The TGD based view about metabolism involves in an essential way quantum gravity.

The observation is that the gravitational binding energy of dark protons at Bohr orbits in Earth's gravitational field for $h_{eff} = h_{gr} = Gmm/v_0$ [E1] [K34, K35, K36, K37, K77] [L139, L125] can correspond to metabolic energy quantum in good approximation. The proposal is that the transformation of protons of hydrogen bonds possible for electronegative atoms and occurring at least for phosphate generates gravitationally dark protons. Their transformation would liberate metabolic energy quantum.

The prediction is that besides gravitationally dark protons also similar electrons define a metabolic energy currency relating to standard metabolic currency like cent to dollar. It is proposed that the electronic metabolic currency can be applied to the purely understood metabolism of cilia and flagella (`https://cutt.ly/WDkYZzx`). I attach the proposal below almost as such.

According to [I120] (`https://cutt.ly/EDkW2bu`) the recent measurements in sea urchin sperm (length ~ 50 μm long, diameter 0.2 μm) show that the energy consumed per flagellar beat corresponds to $\simeq 2 \times 10^5$ ATP molecules. There is no GTP inside cilium as in the case of axonal MTs (`https://cutt.ly/5DkYGB2`). It is difficult to understand how ATP machinery could provide the metabolic energy feed.

This motivates the question about whether local ciliary metabolism could rely on the transformation of valence electrons of some biologically important ions to dark electrons at the gravitational MB and vice versa? The reduction of h_{gr} for electrons would provide the metabolic energy related by a factor $m_e/m_p \simeq 2^{-11}$ to the ordinary. According [I120], about 4×10^8 gravitationally dark electrons would transform to ordinary ones in a single stroke of cilium.

Electronic metabolic energy quantum would relate like cent to dollar and make possible a more refined metabolism with fine tuning. Electronic metabolism could also be an essential part of ordinary metabolism.

Consider now the idea more quantitatively.

1. What could be the electronic analog of ATP machinery. All biologically important ions can be considered as effective ions with some valence electrons at gravitational MB. In particular, the bosonic ions Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++} could have Bose-Einstein condensates of gravitationally dark Cooper pairs at the gravitational MB.

   Ca^{++} waves play a key role in cellular biology, Fe^{++} is essential for oxygen based metabolism, and Mg^{++} and Zn^{++} are important in bio-catalysis: for instance, ATP must bind to Mg ions in order to become active.

2. What could be the mechanism transforming valence electrons to dark electrons? This should happen for positively charged biologically important ions, in particular for the bosonic ions Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++}. The consumption of metabolic energy would correspond to a de-ionization of dark ion Ca^{++} and this might make it possible to test the proposal. For instance, Ca^{++} could accompany ciliary waves.

   Where could the energy for ionization come from?

1. This question is also encountered in the chemistry of electrolytes [L56]. It is very difficult to understand how the external electromagnetic potentials, which give rise to extremely weak electric fields in atomic scales, could lead to ionization. The acceleration of electrons in the electric field along dark flux tubes involves very small dissipation and can easily give rise to electron energies making ionization possible.

2. MTs have a longitudinal electric field which by the generalization of Maxwell's equations to many-sheeted space-time (in stationary situation potential difference is same for paths along different space-time sheets) gives rise to an electric field along the magnetic flux tubes. These flux tubes need not be gravitational.

   By darkness, the dissipation rate is low. Could the acceleration along flux tubes, in particular MT flux tubes, lead to the ionization? Could the electret property of linear biomolecules

quite generally serve for the purpose of generating electronic metabolic energy storages in this way?

3. Assuming opposite charges $\pm Z_{MT}$ at the ends of dark magnetic flux tube associated with the MT, one obtains a rough estimate. The length of the cilium is $L \leq .5 \times 10^{-4}$ m and its radius is $R \sim 2 \times 10^{-7}$ m. The estimate for the energy gained by a unit charge e as it travels through the ciliary MT is $E \sim Z_{MT} e^2 L/R^2 \simeq Z_{MT} \times 2.85$ eV. The valence electron energy for atomic number Z with principal quantum number n (giving the row of the Periodic Table) is $E \simeq (Z/n)^2 \times 13.6$ eV. The ionization condition would be $Z_{MT} \geq (Z^2/n^2) \times 13.6/2.85$. For the double ionization in the case of Ca^{++} with $Z = 20$ and $n = 3$ this would give $Z_{MT} \geq 212$.

TGD based view about axonal and cellular microtubules

Axonal MTs and also subset of MTs in the cell body are highly dynamical critical systems changing their length continually. It seems that they are essential motor instruments of MB just like the MTs of motor cilia. Could the microtubular structures in cell soma are also analogous to supporting structures which can be rapidly deformed by making them unstable against the change of length.

1. Instability of axonal MTs and nerve pulse conduction

In the TGD framework, axonal MTs could make nerve pulse conduction in the myelinated portions of axons possible. The localization of dark proton charges in the shortening flux tube would change the charge of the MT interior and in this way affect the local membrane potential and bring it to criticality. Time reversal and BSFR could be associated with the change of the growth of the MT length to decrease or vice versa. The lengthening and shortening processes would be the same but have different arrows of time. The propagation of the wave at which arrow of time for MT changes would correlate with the conduction of nerve pulse.

The dynamic instability of the axonal and some cellular MTs (`https://cutt.ly/ADzx3re`) is not well-understood. Power stroke causing the decay of the MT at its end is the basic notion. Whether chemical action precedes the mechanical one or vice versa is not clear. Therefore an obvious question is whether chemistry and mechanics are enough. The following represent a possible TGD based view about the power stroke.

1. Gravitationally dark proton transforms to ordinary proton of a phosphate hydrogen bond in the transformation of GTP to GDP. This liberates metabolic energy quantum, serving as a power stroke. This localizes one unit of proton charge and in this manner affects membrane potential.

2. Assume that MT is associated with a cylindrical membrane, that is 4-D minimal surface with 3-D M^4 projection having no counterpart in GRT. M^4 projection would have the microtubular cylinder as an E^3 projection. Cylinder is not a minimal surface and the cylindrical analog of the soap bubble requires a pressure difference over the cylinder walls.

   In the TGD framework, CP_2 projection as a dynamical 1-D curve, say rotating geodesic line of CP_2 would give rise to the effective pressure difference [L141]. This analog of pressure difference would increase in the power stroke and locally expand the cylinder at the position of GDP. This would push tubulin protein outwards. These kinds of power strokes would force the MT to decay and shorten.

2. Energetics of the axonal transport

The transfer of material along the MT is the basic motor activity of MTs (`https://cutt.ly/TDzOePw`). The transfer of protein cargoes is a very slow process even on human time scales. Therefore these processes could involve electron (Cooper pair) based metabolism in an essential way. Note however that mitochondria are present also inside MTs.

If electronic metabolism is in question, these processes are predicted to be much slower than those induced by protonic metabolic currency since the work $F\Delta x$ done by the force corresponds to metabolic energy quantum and for Δx about tubulin size, F smaller by a factor m_e/m_p than in the case of protonic metabolic quantum.

Delayed luminescence for microtubules,quantum gravitation, and the mechanism of anesthesia

Jack Tuszynksi has reported very interesting findings in Science of Consciousness 2022 (https://cutt.ly/PF6OcxA). The findings are described in a popular article (https://cutt.ly/tF6OhWz).

A delayed luminescence in microtubules (MTs) irradiated by laser light has been observed. This can be seen as a support for the presence of quantum coherence at least in the scale of MTs. Also it was found that the application of anesthetics (such as noble gas Xenon expected to have very weak chemical effects) shortens the delay time. This suggests the reduction of quantum coherence by anesthetics so that quantum coherence in long scales should be crucial for consciousness. One of the challenges is to understand the reason for the reduction of quantum coherence.

Delayed luminescence has been associated with bio-photons a long time ago and DNA is proposed to serve as the seat of the delayed luminescence. In particular, the group involving also Tuszynski has studied the emission of mitochondrial biophotons and their effect on electrical activity of the membrane via MTs [J33] (https://cutt.ly/XF6OqLA). A TGD based view of biophotons as decay products of dark photons is discussed in [K19, K28].

To my opinion, the findings represented by Tuszynski provide support for quantum consciousness but not specifically for Orch-OR, which still remains a rather poorly defined approach since the statement that Planck scale quantum gravity effects are crucial for consciousness has no concrete content.

The TGD based interpretation of findings of Tuszynski would be as follows.

1. The laser beam serves as a metabolic energy feed increasing the value of h_{eff} and therefore the scale of quantum coherence. One can say that this metabolic energy feed creates or wakes up an analog of a conscious living organism: now at the level of microtubule MB. As it "dies" in "big" state function reduction (BSFR) involving the reduction of h_{eff} to a smaller value, not necessarily the normal value $h_{eff} = h$, the loaded metabolic energy is liberated.

   This would not apply only to MTs but quite generally. For instance, biophoton emission from cut leaves, would represent a similar decay process. Biophotons would be ordinary photons resulting as decay products of dark photon BE condensates and dark photons emitted with cyclotron Bose-Einstein condensates decay.

2. The delocalization mechanism associated with the formation of the gravitational variants of hydrogen- and valence bonds allows effective charge densities in short scales and could have dramatic implications for the model of nerve pulse. The nerve pulse need not correspond to a generation of ohmic currents through the membrane but to effective ionization or its reverse process due to the transformation of hydrogen and valence bonds to dark gravitational bonds.

3. MTs could play an important role since they involve GTPs as analogs of ATPs and are thus involved with metabolism. The conduction of nerve pulse in the sense of the Hodgkin-Huxley model through myelinated sections of axons is very difficult to understand. The new view would allow the shortening and lengthening of MTs to change the effective charge density of MTs so that membrane potential would change and nerve pulse conduction in the TGD sense would be possible.

How could one understand the effect of anesthetics? I have considered this problem earlier. First one should try to understand how the critical dynamics of MTs relates to nerve pulse conduction inside myelinated regions of the axon.

1. Certainly the membrane potential should become hyperpolarized to prevent nerve pulse condition so that consciousness would be lost. In myelinated portions of axons there is only propagating perturbation of membrane potential taking it below the threshold for nerve pulse generation so that nerve pulse is generated at unmyelinated portion. In the ground state one has propagating Sine-Gordon soliton (or oscillon sequence) visualizable as a sequence of rotating (oscillating) gravitational penduli.

   In the perturbation some penduli start to rotate in an opposite direction (or oscillation transforms to a rotation). Usually this would require flow of charge through the cell membrane as

Josephson current. Now the variation of the effective charge densities caused by the delocalization of protons inside the axon would induce an effective Josephson current. The effective charge inside the axonal interior becomes less negative and induces at non-myelinated portions of the axon a nerve pulse describable using the Hodgkin-Huxley model.

2. A couple of comments about the arrow of time are in order. Nerve pulse is induced by ~ 200 miniature potentials of amplitude about .4 meV which could be assigned to electron metabolic energy quantum. This corresponds to energy of .8 eV, roughly 2 protonic metabolic energy quanta. This supports an interpretation in terms of a time reversed process in which two metabolic energy quanta decay to ~ 200 miniature potentials. This conforms with the proposal that nerve pulse generation is BSFR inducing time reversal.

   The reconnection transforming HB (VB) to its gravitational variant or vice versa during nerve pulse propagation induces the transfer of proton (electron) to HB. Since the size scale of the gravitational bond is that of Earth, this would take time and could be too slow for protons. The problem disappears if the reconnection corresponds to BSFR changing the arrow of time. The BSFR occurs and the final state is what becomes the causal agent just as in the explanation of Libet's findings about active aspects of consciousness.

3. If the anesthetic induces the transformation of gravitationally dark HBs (VBs) to ordinary ones in the interior of the axon, the effective charge of the axon becomes more (less) negative and the axonal potential becomes more (less) negative. MTs have GTPs near their ends and GDPs in the intermediate region. Negative charges of GTPs and GDPs would naturally correspond to gravitational HBs.

   The variation of MT lengths involves a transformation of GTPs to GDPs and vice versa. This would change the effective charge density of the MTs and affect the membrane potential. If gravitational HBs become ordinary, metabolic energy is liberated and vice versa. Hyperpolarization would require a generation of reconnections and a local change of the MT lengths.

   The variation of the lengths of axonal MTs would induce effective negative charge near the growing end of MT. Could the moving depolarization front of the axonal membrane correspond to an increasing GDP region of an axonal MT?

4. The presence of soliton (oscillon) suggests periodic effective charge density waves in which the protons transform to gravitationally dark protons and vice versa in a periodic manner. Could this mean a periodic variation of the lengths of axonal MTs?

   Also the transformation of metallic valence bonds to their dark variants and vice versa could control the membrane potential. Ca^{++} waves would result in cell interior when valence electron pairs of Ca atoms or their salts become gravitationally dark. Could periodic rotation (oscillation) accompany dark electron metabolism with a much smaller energy cost?

How the presence of noble gas having very weak chemical interactions could affect the nerve pulse conduction inside the axon? One can proceed by making questions.

1. Could the anesthetic freeze the dynamics of MTs so that nerve pulse conduction would become impossible? The presence of an anesthetic should make the axonal interior more negative and induce hyperpolarization.

   Could the presence of the anesthetic stabilize the MTs by minimizing the length of their GDP region? Somehow the growth of MT should be prevented means addition of tubulins and GTPs. This is achieved if the density of tubulin-GTP pairs in axonal water is reduced. The generation of GTP from GDP requires a formation of gravitational HBs from ordinary HBs. The density of ordinary HBs should be reduced.

2. Could the presence of the anesthetic reduce the density of ordinary HBs in the axonal water? HBs are associated with water clusters. How could the presence of anesthetic reduce the rate for the generation of water clusters and therefore HBs in the axonal water?

   In the TGD inspired theory consciousness, the MBs of water clusters can be seen as correlates for mental images of water as a conscious entity [K50] [L160]. The level of consciousness for

water would be reduced. It would be water, which is anesthetized! This would freeze the MTs so that also the axonal membrane freezes electrically.

3. Meyer and Overton observed that the potency of anaesthetic agents correlates with their lipid solubility. Anesthetics also seem to affect specific ion channels and receptors. One can argue that if the anesthetic is solvable to lipids, it can also enter inside the axon and somehow reduce the density of HBs assignable to the water molecule clusters accompanied by gravitational MBs. The effective charge of the axonal interior would become more negative and induce a hyperpolarization if the exterior is not affected.

4. How happens when water is anesthetized? A hint comes from the Pollack effect [L27]. The exclusion zones discovered by Pollack are negatively charged regions at the interfaces of hydrophilic surfaces. The TGD based interpretation could be that part of protons become dark protons at gravitational HBs. It is known that anesthetics diminish the amount of EZ water (`https://pubmed.ncbi.nlm.nih.gov/27054588/`).

5. How could anesthetics prevent the formation of EZs and thus of gravitational HBs? A metabolic energy feed is needed in the Pollack effect and is by photons as also the delayed luminescence for MTs demonstrates. How could the feed of photons needed to produce EZs be prevented by anesthetics? Energy is feeded in resonance. Could the presence of anesthetic change the energy needed to transform HB to dark gravitational HB so that the resonance condition would not be satisfied.

2.4 How multicellular without a nervous system can behave as if it had a nervous system?

In the TGD framework, the quantum models of cell membrane and nerve pulse rely on the notions of magnetic body and dark matter [K40, K85, K86, L120]. The generalization of this view leads to a notion, which could be christened as pre-neural system (PNS). Also the multi-cellulars without CNS would possess PNS.

2.4.1 Animals without the brain behave as if they had the brain

The motivations for this article came from the Quantum Magazine article (`https://cutt.ly/IDnfovQ`) telling about the findings of Manu Prakash and Mathew Storm Bull. The work of Prakash and Bull is published as 3 articles [**?**]hat can be found in arXiv.org. In the following I summarize the findings as they are described in the popular article.

Findings of Prakash et al

Trichoplax adhaerens is a marine creature, classified as a placozoan, which has the smallest known genome in the animal kingdom. Trichoplax has thousands to few millions of cells and is between prokaryotes and eukaryotes as far complexity is considered.

Trichoplax (`https://cutt.ly/SD6GGW5`) is a very flat organism formed with diameter about 1 mm and thickness about 25 μm. For cell number N in the range $[10^3, 10^6]$ cells and for a cell approximated as a ball with radius r, this gives r in the range $[2.1, 21]$ μm. Despite the lack of neuronal system and muscles, the motion of trichoplax is extremely well-orchestrated and efficient.

The goal of the project of Manu Prakash and his graduate student Matthew Storm Bull was to understand how the neuromuscular system might have evolved and how the early multicellular creatures without a nervous system managed to move, find food and reproduce. Epithelial sheets formed by Trichoplax cells are studied. Trichoplax cells are monociliated that is they have only a single cilium. This simplifies the experimental study and modelling of Trichoplax.

First some basic facts.

1. Motile cilia and flagella are the analogs of muscles and primary (non-motile) ciliar serve the role of sensory organs at the cellular level. Cilia and flagella have similar structures and only their functions differ. Cilia force liquid to move with respect to the cell. Flagella make it possible for the cell to move with respect to liquid (`https://cutt.ly/TDngqhO`).

2. The force needed for the bending of the cilium is produced by the outer and inner dynein arms of the axonemal MT doublets connected to the central pair of microtubules by radial spokes. Airway cilia have components typical for motile cilia.

3. Beating waves as contraction waves of the axoneme induce bending of the cilium. The frequency of the beating wave is the key parameter in the dynamics of the cilium.

   That the beating frequencies are in the EEG range suggests that in some respects neurons and ordinary cells have much more in common than thought. Beating frequency would take care of synchrony and one can ask whether cilia have an analog of EEG.

Popular summary of the experimental findings

I add to the summary my own comments in order to give a hint about TGD based interpretation of the findings.

1. The claim is that behavior of Trichoplax can be described entirely using the language of physics and dynamical systems.

   Comment: To my understanding, a description in this sense means mathematical modelling using formalism of physics and identifying simple basic mechanical functions serving a role analogous to program modules of the software.

   The nature of the living systems is very difficult to understand using only recent day physics and it is very difficult to believe that purely mechanistic description could be possible. However, the possibility to construct such a simple model is in itself a strong guideline in attempts to really understand how the motor actions of Trichoplax are possible.

2. Cilia are typically seen in the context of fluids: propelling bacteria or other organisms through water, or moving mucus or cerebrospinal fluids in a body. Therefore the expectation was that the cilia to glide over surfaces, with a thin layer of fluid separating animal and substrate. But when the researchers looked through their microscopes, they saw that the cilia seemed to walk, not swim.

   The claim is that instead of hydrodynamic description, it is possible to have much simpler description in terms mechanics involving notions like friction and adhesion.

   Comment: I understand that these conclusions hold true for the motion along the surface and one can wonder whether the conclusions hold true for swimming.

3. The characterization of the cilia's walking gait was taken as a goal. Only three types of basic motions: slipping, during which the cilia barely grazed the surface; walking, when the cilia adhered to the surface briefly before popping off; and stalling, when the cilia got stuck against the surface.

   Comment: What is really surprising is that the motion consists of such simple basic modules somewhat like a computer program. For instance, in a general Hamiltonian system one expects Hamiltonian chaos. Bohr orbits are what comes into the quantum mind.

   Mechanical models for the walking activity were developed by the authors [I94, I92, I93].

1. In the models the walking activity emerged naturally from the interplay between the internal driving forces of the cilia and the effective energy of their adhesion to the surface. The right balance between those two parameters (calculated from experimental measurements of the cilia's orientation, height from the surface and beat frequency in the EEG ranfe in the situation considered) resulted in regular locomotion, with each cilium sticking and then lifting away, like a leg. The wrong balance produced the slipping or stalled phases.

   Comment: My understanding is that the driving force of the cilium serves as an input analogous to external force and chosen so that a model for a particular motion is obtained. The model is therefore not fully deterministic and autonomous. On the other hand, the reduction of hydrodynamical description to mechanical description is highly non-trivial and suggests that some new physics is involved.

2. The walking cilium can be modeled as an excitable system. In an excitable system, the signals spread and get amplified rather than progressively damping out and coming to a stop. A neuron is a classic example of an excitable system. Small voltage perturbations can cause it to fire suddenly, and above some threshold, the new stimulated state propagates to the rest of the system.

   The same phenomenon seems to occur in the cilia. In the experiments and simulations, small perturbations in the height of cilium from the surface, rather than voltage, led to relatively large changes in the activity of nearby cilia. They could suddenly change their orientation, and even switch from a stalled state to a walking one.

   Comment: Excitability, and self-organization in general, is in conflict with the expectations based on second law of thermodynamics. The metabolic energy feed is the way to understand the situation in non-equilibrium thermodynamics.

   This behavior requires an highly non-linear mechanical system at criticality. This does not however explain why so few modes, in fact analogous to Bohr orbits, are possible. A quantum biologist could ask whether quantum criticality is involved. At classical level catastrophic theoretic description in terms of phase transitions is suggestive.

   The similarities with neuronal behaviors inspire the question whether the ciliary system defines some kind of pre-neuronal system preceding the nervous system in evolution and shared by it as the fact that sensory receptors are cells with cilia.

3. It was measured how the mechanical gait of each cilium led to small, local fluctuations in the height h of the tissue. Equations for how this would 'tug' at nearby cells to affect their behavior were deduced, even as the cilia on those cells cycled through movements of their own. A convenient analogy is a network of springs tied together by tiny oscillating motors.

   When the researchers modeled this dance between elasticity and activity, as they called it, they found that the mechanical interactions of cilia pushing against a substrate and cells tugging at each other transmitted information rapidly across the organism.

   Stimulating one region led to waves of synchronized cilia orientation that moved through the tissue. This elasticity and strain in the physics of a walking cilium, now multiplied by millions of them in a sheet, gives rise to coherent motile behavior.

   Comment: Here it is difficult to avoid the question whether the 'tug' as touching of cells (or cilia of different cells) is analogous to synaptic transmission in the neural system.

4. The synchronized orientation patterns could be complex. Sometimes the activity of the system produced vortices, with the cilia oriented around a single point. In other cases, the cilia reoriented in fractions of a second, first pointing one way and then another flocking as a group of starlings or a school of fish might, and resulting in an agility that made it possible for the animal to sometimes change direction on a dime.

   Comment: Courageous quantum biologists might associate with the agility a quantum jump in multi-cellular scale.

5. It was found that the information transmission was selective. After certain stimuli, the energy injected into the system by the cilia just dissipated instead of spreading and changing the organism's behavior. As if the organism would direct its attention to particular parts of the perceptive field and react only to the changes in these parts.

   Comment: Brain is able to direct its attention to particular objects of the perceptive field. Is the ciliary system able to direct its attention?

The model for the cilium and ciliary motor actions

The model starts from the model of nerve pulse and generalizes it to the case of cilium.

Concerning the understanding of the findings about the motor actions of multi-cellulars without a nervous system, this vision raises obvious questions.

1. MB should serve as the "boss" also for the multi-cellulars without a nervous system. The general quantal sensory communication and control mechanism should be the same as for organisms with a nervous system. Frequency modulated dark Josephson radiation should mediate sensory data to MB and dark cyclotron radiation would mediate the control commands from MB as pulse patterns as a response to sensory input.

2. Could the beating wave, which has frequency in EEG range, be analogous to EEG wave, membrane oscillation, and possibly perturbed oscillon/soliton sequence, which defines the ground state of ciliary membrane?

3. Cilia are analogous to axons. Could ciliary membrane act as a Josephson junction communicating sensory data to MB? The MTs of the motile cilia play a role analogous to that of axonal MTs as motor organs of MB. Could one consider analogs of nerve pulses for cilia inducing ciliary motor actions rather than nerve pulse patterns? No nerve pulse is involved. Could the analogs of nerve pulses be pre-nerve pulses analogous to miniature potentials of .4 meV generated in synaptic contacts for instance by acetylcholine containing vesicles (`hhttps://cutt.ly/JD1ONEu`) and induce beating waves inducing ciliary bending? 100-200 hundred miniature potentials are needed to generate a nerve pulse.

4. Here the poorly understood origin of the ATP needed by ciliary motor activities [I120] serves as a guideline. Cilia and flagella cannot have mitochondria as ATP sources inside them and the diffusion of ATP from nearby mitochondria is strongly limited. The proposal discussed in [I120] is that a local generation of ATP using mechanisms, which depend on nutrients could solve the problem. It is difficult to avoid the feeling that something strange is involved with the ciliary metabolism.

   TGD leads to the proposal that the standard metabolic energy quantum of about .5 eV corresponds to the change of gravitational binding energy as a proton of HB is transferred to a dark proton at at the gravitational flux tube around its Bohr orbit in the gravitational field of Earth with gravitational Planck constant $h_{eff} = h_{gr} = GMm/v_0$. Dark electrons would correspond to gravitational binding energy for a valence electron or a pair of valence electrons (Cooper pair) transferred to a gravitational flux tube.

   The energy of the single electron metabolic energy quantum would be by a factor $m_e/m_p \sim 2^{-11}$ smaller than the standard metabolic quantum about .25 meV and relate to the standard metabolic energy quantum like cent to dollar. For an electron Cooper pair it would be 2 times larger and about .5 meV. Intriguingly, this energy is rather near to the Coulomb energy change assignable to the miniature potentials .4 meV (`https://cutt.ly/vDRysfU`)! Could the analog of nerve pulse be a propagating miniature potential induced by the dropping of an electron Cooper pair of say Ca^{++} ion from the gravitational Bohr orbit back to Rydberg state with very small binding energy.

5. Cilium is modelled as a 2-D quantum gravitational pendulum with gravitational Planck constant controlled by MB using electronic metabolic energy quanta and the resulting model for the motion is in many respects similar to the model of nerve pulse. In the resting state ciliary penduli oscillate or rotate with constant phase difference so that a wave-like motion results.

6. The analog of nerve pulse transmission can be identified. Temporary fusion of pre- and postsynaptic cells takes place in nerve pulse transmission. The tugs would correspond to the adhesion of their cilia and make possible the transfer of quantum coherence and synchrony between the neighboring cells and in this way generate quantum coherence in multi-cell scale? The adhesion of cilium to the plane in which it moves is also possible.

   Both kinds of adhesions spoil the synchronous oscillation of neighboring penduli. The adhesion followed by de-adhesion changes the relative phase and a further 'tug' is plausible. This leads a domino effect to an analog of nerve pulse conduction. In this process, the U-shaped flux tubes assignable to the cilia of the neighboring cells fuse to form a larger quantum coherent unit. Same would happen in the case of ordinary nerve pulse transmission [L120]. The system is quantum critical in the sense that when the cilia oscillate/rotate with a phase

difference below some critical value, no touchings occur and no nerve pulses are generated. Perturbations change the situation.

2.4.2 Ciliary flocking and emergent instabilities enable collective agility in a non-neuromuscular animal

It is useful to start with a more technical summary of the work of Prakash *et al* provided by the abstract of the article "*Ciliary flocking and emergent instabilities enable collective agility in a non-neuromuscular animal*" [I94] by Mathew Bull, Vivek Prakash, and Manu Prakas as such.

> *Effective organismal behavior responds appropriately to changes in the surrounding environment. Attaining this delicate balance of sensitivity and stability is a hallmark of the animal kingdom. By studying the locomotory behavior of a simple animal (Trichoplax adhaerens) without muscles or neurons, here, we demonstrate how monociliated epithelial cells work collectively to give rise to an agile non-neuromuscular organism.*
>
> *Via direct visualization of large ciliary arrays, we report the discovery of subsecond ciliary reorientations under a rotational torque that is mediated by connective tissue mechanics and the adhesion of cilia to the underlying substrate. In a toy model, we show a mapping of this system onto an "active-elastic resonator". This framework explains how perturbations propagate information in this array as linear speed traveling waves in response to mechanical stimulus.*
>
> *Next, we explore the implications of parametric driving in this active-elastic resonator and show that such driving can excite mechanical 'spikes'. These 'spikes' in collective mode amplitudes are consistent with a system driven by parametric amplification and a saturating nonlinearity.*
>
> *We conduct extensive numerical experiments to corroborate these findings within a polarized active-elastic sheet. These results indicate that periodic and stochastic forcing are valuable for increasing the sensitivity of collective ciliary flocking. We support these theoretical predictions via direct experimental observation of linear speed traveling waves which arise from the hybridization of spin and overdamped density waves. We map how these ciliary flocking dynamics result in agile motility via coupling between an amplified resonator and a tuning (Goldstone-like) mode of the system. This sets the stage for how activity and elasticity can self-organize into behavior which benefits the organism as a whole.*

2.4.3 The analog of the nervous system at the level of multi-ciliary system

The TGD based model for nerve pulse and EEG generalizes in a rather straightforward manner to cilia.

1. Ciliary membranes define pre-neural system. The membranes act as generalized Josephson junctions. The modulations of the oscillation frequency of dark Josephson radiation code for the sensory input to MB. Beating waves have frequencies in EEG range and define the analogs of EEG waves as propagating oscillation patterns of the membrane potential.

2. The first guess is that non-motile cilia serve as sensory receptors mediating sensory input to MB as dark Josephson radiation and motile cilia as motor instruments of MB and analogs of muscle. Trichoplax has only a single cilium, which acts as a motor organ. Does it also act as a sensory receptor, or does the remaining cell membrane serve in this role?

3. Pre-nerve pulses at the level of animal would correspond to perturbations of the soliton sequences or their oscillatory variants: either one rotating/oscillating pendulum starts to oscillate/rotate. This transition would be induced by the response of MB and cyclotron resonance pulse. Nerve pulse/action potential would be replaced by propagating miniature potential.

4. The ciliary counterparts of action potentials would be analogs of miniature potentials and induced by the electronic metabolic energy quantum. They would represent the response of

MB at cilia, propagate to the basal body and proceed as chemical communications to the cell nucleus using second messangers and induce gene expression as a response.

5. The ciliary MBs of cells organize to a larger MB controlling the motion of cell and the MBs of cells in turn organize to even larger MB controlling the collective motion.

6. Synaptic transmission would be replaced with 'tug, that is the touch of neighboring cells, making possible the transfer of the beating waves between the cells. If the touch reduces to the touch of the cilia, the connection with the model of nerve pulse transmission would be even closer. Note however that there is only one flagellum per Trichoplax cell. The orbits of straight ciliar define cones, which correspond to 2-D space-times in 4-D space-time.

   The intersection of these surfaces consist of discrete points in the generic case. If the neighboring cilia rotate with the same frequency and are in the same phase so that the minimal distance between ciliar remains constant, they cannot touch. Above some critical phase difference touching can take place and the touching can occur and the neighboring cilia drop from the phase synchrony.

7. The quantum coherence extended in the fusion of the ciliary MBs generated in the touching of cells or individual cilia. Does also the transfer of local bioharmony take place in the touch. Are the analogs of transmitters involved and affect the bioharmony of the MB of the receiving cell just like nerve transmitters are proposed to do?

2.4.4 TGD based intepretation of the findings of Prakash *et al*

The findings described in the articles [I94, I92, I93] have made it possible to develop a TGD based picture about the situation.

Homeostasis in the TGD Universe

In biology the balance between sensitivity and stability modelled by Prakash *et al* is known as homeostasis. In biological view, homeostasis is based on a complex many-layered control hierarchies analogous to those used in computation as if a master programmer had written these programs. But can these kinds of control hierarchies really emerge in standard physics?

The proposal of the model of Prakash *et al* is that the 'active-elastic' resonator as a relatively simple mechanical system can at least mimic homeostasis. The model for the epithelial sheet of the animal as a set of oscillators representing cilia coupled by strings. The direction of the cilium defines an effective spin. A resonant coupling of this spin to an external torque represents the control of the motion and parametric resonance allows energy cascades creating collective responses.

In the TGD framework, homeostasis emerges spontaneously via the second law of thermodynamics in reverse time direction.

1. In zero energy ontology (ZEO), biological self-organization and homeostasis involve in an essential manner the possibility of time reversal occurring in "big" (ordinary) state function reduction (BSFR) occuring in long length scales. Time reversal changes repellers to attractors so that homeostasis as an ability of the system to stay near the critical point becomes possible by performing BSFRs.

2. Dissipation of energy is a process in which the coherence scales of excitation decreases. Time reversed periods mean dissipation with a reversed arrow of time and in the model of Prakash *et al* they would correspond to energy cascades proceeding from short to long length scales.

Parametric amplification and a saturating nonlinearity can be seen as the mathematical model for the BSFR inducing time reversal.

1. 'Spikes' mean amplification and in ZEO they could correspond to BSFR changing the arrow of time at the level of MB so that the amplification process would reduce to dissipation with a reversed arrow of time.

2. I have proposed that the interpretation of nerve pulse as a pair of BSFRs temporarily changing the sign of resting potential. An analogous interpretation could make sense now.

Cilium as a quantum gravitational pendulum

The findings of Prakash *et al* makes it possible to consider a concrete TGD inspired model for a single cilium and its dynamics.

1. The observed sub-second time scale for the ciliary reorientations conforms with the interpretation of beating waves are analogs of EEG waves transformed to mechanical waves as longitudinal contraction waves of cilium causing the bending. These waves would be induced by the membrane potential waves of ciliary membrane and in TGD corresponds to waves associated with the Josephson junction defined by the membrane communicating data to the MB of the system characterized by $h_{eff} = h_{gr} = GMm/v_0$.

2. In the first approximation, one can idealize the cilium/flagellum as a rigid linear object of radius $r = .2$ μm, length $l = 100$ μm, and with a density not far from the density of water of 10^3 kg/m^3. The presence of gravitational Planck constant suggests that one can model cilium as a gravitational pendulum with a mass independent oscillation period $T = 2\pi\sqrt{l/g}$, which corresponds to a sub-second time scale $T \simeq .2$ s for $l = 100$ μm.

   The values of l vary in a wide range. For $l = 20$ μm mentioned as an upper bound for the length of flagellum, one has $T \sim .1$ corresponding to 10 Hz EEG resonance frequency. The range $l = 2 - 4$ μm was mentioned in [I24] as a lower bound for the length of beating cilium, corresponds to 25-36 Hz frequency range. In the same source, 10-12 μm was reported as normal cilium length: it corresponds to pendulum frequency 15.8 Hz. Furthermore, the beating frequency was reported to depend only weakly on l so that the beating frequency and pendulum frequency cannot be identified.

   The estimates for the period of the cilium as gravitational pendulum correspond to EEG frequencies as also in the frequency range of beating waves. For $h_{eff} = \hbar_{gr} = GMm/v_0$ and m equal to proton mass, the corresponding transition energies are in the eV scale of biophotons for protons. What puts the bells ringing is that for electrons the energy scale is the same as that of the electronic metabolic energy quantum.

3. As a 2-D gravitational pendulum cilium can also rotate. Angular momentum is quantized as units $h_{eff} = h_{gr}$. Electronic metabolic energy quanta can induce transitions between the harmonic oscillator states of the cilium. The transitions between the states of the quantum gravitational pendulum changing angular momentum would serve as the quantum counterpart for the torque in the models of Prakash *et al*. They would represent the quantum control by MB by using the transformation of gravitationally dark electrons to ordinary electrons.

Correlation between the height of the tissue and membrane potential of cilium

The height h of the tissue is interpreted as a parameter analogous to membrane potential.

1. TGD suggests that the membrane potential of cilium is proportional to the h. The critical height h_{cr} would correspond to a critical value V_{cr} of the ciliary membrane potential for the generation of miniature potential reducing V_{cr}.

2. Cilium as a gravitational pendulum is free when its distance from the surface is larger than the pendulum length l so that $h_{cr} = l$ is a natural identification. When the adhesion occurs MB induces a burst of miniature potentials $\Delta V = .5$ meV feeding electronic metabolic energy quanta to the cilium to achieve de-adhesion.

What happens in the adhesion and de-adhesion?

The key step of the process is the adhesion of cilia to the substrate and its reversal. The probability for the adhesion depends on the tissue height h and obviously vanishes for $h > l$, l the length of cilium. For very small h the cilium sticks on the surface. Part of the cilium would stick to the

surface horizontally. Effective adhesion energy is assumed to be in a crucial role. The control action of the cell (animal) is modelled as an external torque on cilium.

Adhesion can also mean that two neighboring cilia moving in opposite direction stick together.

1. In the TGD framework, the de-adhesion could be induced by a transformation of a suitable number of electronic metabolic energy quanta about $E_c = .25$ meV associated with single electron (cilia do not have mitochondria) to the kinetic energy of the cilium as a gravitational pendulum.

   One can estimate the velocity v if the de-adhesion induced by a receival of single metabolic energy quantum E_c from $mv^2/2 = E_c$. This gives $v \simeq 60$ μ m/s. The estimate looks rather reasonable. For the standard metabolic energy quantum .5 eV, one would be $v \simeq 2.7$ mm/s.

2. If momentum is conserved, the change of the horizontal momentum component for the cilia as a pendulum is compensated by the recoil momentum of the entire cell. This gives an estimate for the change ΔV of the velocity of the cell as $\Delta V \sim (m_c/M) \times v$.

Adhesion energy and de-adhesion as precedessor of nerve pulse generation

What the notion of effective adhesion energy could mean in the TGD Universe (note that adhesion energy as a term is misleading since it actually corresponds to adhesion energy per surface area).

1. A very naive order of magnitude estimate used in the modelling of wetting of a surface by water approximates adhesion energy density with the surface tension σ_W for water: $\sigma_w \simeq 7210^{-3} kg/s^2$. This corresponds to an energy density per unit area $\epsilon = .5 \times 10^{-11}$ eV/(μ m)^2. For the cilium with radius $r = .2$ μ m attached vertically this would give $W = sigma_W \pi r^2 \simeq .7 \times 10^{-12}$ eV. This is extremely small energy and looks unrealistic.

2. For instance, if chemical or other kinds of bonds are formed with the surface, the adhesion energy can be even in the eV range. TGD suggests the formation of flux tube bonds between cilia and surface is what comes into mind and the adhesion energy would correspond to the reduction of energy when the bond is formed and shortens by the reduction of h_{eff} as in the basic step of bio-catalysis.

3. The thermal stability of adhesion would suggest that the adhesion energy is of the order of thermal energy, which is of the order .05 eV, which is about 10 percent of the standard metabolic energy quantum. If this is the case, the size of .5 meV for the metabolic energy quantum of electron Cooper pairs implies that at least 100 dark gravitational electrons must transform to ordinary ones to liberate the cilium, which has stuck vertically. Recall that cilia can also stick to each other and the same estimate holds also now as a lower bound coming from the thermal stability of adhesion.

4. Intriguingly, the number of miniature potentials generated by acetylcholine vesicles needed to generate action potential is 100-200 (`hhttps://cutt.ly/JD1ONEu`)! This suggests that the de-adhesion process is a precedessor for the generation of nerve pulse in the postsynaptic neuron. This conforms with the view that the ciliary membrane is a precedessor of axon.

5. Nerve pulse transmission connects the pre- and postsynaptic flux tubes to longer flux tubes and generates larger quantum coherent units. 100-200 miniature potentials generate an action potential after the connection has formed. What could be the counterpart of this at the level of cilia?

   Intriguingly, the de-adhesion from the surface requires at least 100 miniature potentials in the model of cilium as a gravitational pendulum. Also the cilia of the neighboring cells can stick together if they move in opposite directions. De-adhesion would require roughly the same energy. Both mechanisms would generate the analog of nerve pulse.

   Could the preneural system have transformed to a neural system by the evolution of single flagellum to axon? Could primary cilia have evolved to dendrites? Did flagella having even rather long lengths start to form permanent almost-contacts with the primary cilia of the

neighboring cell or even more distant cells, which then developed to synaptic contacts. This would have required the evolution of cilia with radius below .5 μ to axon with radius about 2.5 μm, and containing axonal MTs instead of axonemal MTs. ATP based metabolism in the interior would have emerged besides electron based metabolism, and besides miniature potentials also action potentials and critical membrane potential would have emerged.

Do 'spikes' correspond to real spikes?

Spikes induced by a driving of an 'active-elastic' resonator define a key notion in the models of Prakash *et al*. The intuitive picture of the resonator is as a collection of cilia as motors connected by strings. The 'spikes' would be analogs of nerve pulses. 'Spikes' correspond to tugs inducing flocking and in neuroscience induce formation of larger coherent units of neurons.

In the TGD based model for nerve pulse, spike corresponds to a perturbation coming from MB and transforming the motion of a single pendulum from rotation to oscillation or vice versa. Same should be true now if the cilium is the precedessor of the axon.

1. The active-elastic resonator could correspond to cilia as quantum gravitational penduli and the temporary formation of flux tube connections between the MBs of the penduli could be a counterpart for the formation of strings.

2. A direct touch of cells is not necessary for a 'tug'. The touching of neighboring cilia might be enough and could be regarded as one particular case of adhesion and would be analogous to touch of pre- and postsynaptic cells mediated by the neurotransmitter vesicle. Since the distances between cells are measured in micrometers and if the ciliar lengths are about 100 μ, this is possible.

   In the TGD framework, one can consider the option that cilia do not even touch. Since quantum coherence is at the level of MBs, and what is needed in the TGD framework, is a reconnection of the U-shaped flux tubes associated with the cells: this is assumed to take place also in the synaptic contact in which neurons fused temporarily.

3. The probability for the reconnection of flux tubes (for the touching of cilia) increases as the cells approach each other and could lead to a fusion of several cellular MBs to a larger MB inducing a flock behavior controlled by the larger MB. This would take place when two neighboring ciliary gravitational penduli are in opposite phase with large enough amplitude so that they approach each other.

4. The propagation of nerve pulse would be a domino effect in which the adhesion of neighboring cells or adhesion of cell to surface followed by de-adhesion, which spoils synchronous motion locally and inducies new adhesion. A multiple collision generating quantum coherent at the flux tube level would be in question.

5. In the collective mode the metabolic quanta E_c from cells would arrive in synchrony (but with time lapse to give rise to a wave) so that the cells would walk in synchrony. The rotation of the cilia as gravitational penduli with a constant phase difference gives rise to a wave. In this macroscopic gravitational quantum state Trichoplax would walk. Walking involves gravitation in an essential manner so that the appearance of quantum gravitation is not surprising.

The generation of propagating waves

The model for the generation of propagating waves is very much analogous to the model of axonal membrane as Josephson junction [K85, K40, K86] [L120, L125]. The oscillating waves for the phase differences of the Cooper pair wave function over Josephson junction define a dynamics analogous to that to a sequence of gravitational penduli. This model could apply as such at the level of ciliary membrane serving as a pre-axon.

The local motion could correspond to oscillation or rotation and the analog of nerve pulse would mean local transformation of oscillation to rotation or vice versa generating soliton or defect of soliton sequence locally.

Also waves that propagate at the level of the entire animal are involved and can be associated with a system of genuine gravitational penduli forming a planar structure. There would also be a propagating wave at the larger MB induced by the temporary fusion of MBs of cilia.

1. The local oscillation of the cilium takes place with the frequency $f = \sqrt{g/l}/2\pi$ of the gravitational pendulum. For the propagating wave $u = \omega t$ is replaced with $\omega(t - x/V)$. The rotation of the pendulum in a vertical rotation plane does not make sense but there are also modes in which the pendulum rotates in plane and have angular momentum which is large since one has $h_{eff} = h_{gr}$ serves as the unit of angular momentum. These modes would be crucial for the control of the motion.

   The speed V of the wave would be analogous to a conduction velocity of nerve pulse. The first guess for the velocity would be as the velocity $V \sim (m_c/M) \times v$, where v is the horizontal velocity gained by the cilium de-attachment already estimated, and m_c and M are the masses of cilium and cell.

2. If one or more metabolic energy quanta E_c feed energy to a single pendulum, the pendulum ceases to be in phase with its neighbors. If the same takes place for MBs, they might reconnect. Could a phase transition initiated by a seed at the level of MBs generate a larger quantum coherent unit analogous to a moving vortex? Energy cascade would correspond to BSFR with time reversal.

Flocking as a generation of quantum gravitational coherence

What could the formation of collective modes, flocking, mean in the TGD framework?

1. The modes of a single cilium correspond to a sticking to the plane without motion, rotation around a roughly elliptical orbit in plane, and rotation without motion. If a single cilium behaves as a solid body, one has a vortex- like structure rotating like a rigid body. Note however that Trichoplax can be very far from a rigid body: it can even split into two parts.

2. The quantal description of the cilia as a quantum gravitational pendulum combined with the conservation of angular momentum suggests that the angular momentum for the center of mass motion of the Trichoplax and the total angular momentum of the ciliary oscillators sum up to zero. This would explain the nearly circular motions. Linear motion of Trichoplax would correspond to a common vertical rotation plane without rotation.

   In fact, both momentum and angular momentum generation could rely on conservation laws and reduce to exchanges of these conserved quantities between MB and system. This seems to be the only option since metabolic energy quanta with $h_{eff} = h$ cannot create forces and torques in the scale of an organism.

   It deserves to be mentioned that the generation of angular momentum of astrophysical objects such as galaxies is poorly understood in the general relativistic framework and the TGD proposal is that the angular momentum of visible matter is accompanied by opposite angular momentum of dark matter and magnetic bodies of astrophysical objects [L84].

3. This model would realize the fractal aspect of holography: the ciliary motion would correspond to the motion of the entire animal. Second aspect of holography is that 3-D data fix the time evolution in the sense that the orbits are analogous to Bohr orbits. In TGD, this is forced by the realization of the general coordinate invariance, and means that the 3-D surface of $H = M^4 \times CP_2$ is almost uniquely determined by a 3-D surface without any data about its 4-D tangent space. Also this aspect of holography is realized and could explain why such an extremely simple model can describe the motion of Trichoplax.

4. Moving vortex-like defects could correspond to the formation of quantum coherent states in which cilia as gravitational penduli are in the same quantum state with non-vanishing angular momentum and non-trivial center-of-mass motion. There is also an analogy with the decomposition of the rotational motion to vortices in super-fluidity.

How could a living system direct its attention?

Prakash *et al* [I94, I92, I93] also found that Trichoplax can also react in a selective manner to perturbations as if it could direct its attention.

According to the TGD inspired theory of consciousness, a metabolic energy feed to the target of attention serves as a correlate for the directed attention. The target corresponds to a mental image of the MB of the system. Mental images have correlates at the level of the space-time surfaces. Space-time surfaces are minimal surfaces with singularities analogous to soap films with frames [L141]. At the frames the dynamics fail to be completely deterministic so that they naturally serve as space-time correlates of mental images. The non-determinism is also finite.

This mental image 'wakes up' in a BSFR separating it from the environment and the superposition of 4-D soap films is reduced so that a single alternative from a finite number of time evolutions is selected. This explains the mysterious looking discovery that during intensive discussion almost anything can happen in the background and remain unnoticed. Sensory input does not lead to a wake up of mental image. The behaviour of the Trichoplax is completely analogous to the behaviour of higher life forms.

2.4.5 Possible implications of the notion of pre-CNS

The notion of pre-CNS is very general and it is interesting to consider the most obvious implications.

Can organisms without CNS learn?

In [I75] the question whether learning without the nervous system is impossible is considered. Computers are left out of consideration and this restricts the discussion to organic matter. One can consider several definitions for learning. If the change in behaviour is taken as a signature of learning, one ends up to the conclusion that there are large classes of organisms without nervous systems, which are able to learn: paramecia, bacteria and plants are three large classes of this kind of organisms.

There is evidence that multi-cellulars have evolved from the colonies of mono-cellulars, and it is known that colonies of bacteria learn [I81] (`https://cutt.ly/zDOvhuN`). For instance, E. Choli colonies can anticipate changes in the environment by associating higher temperatures with a lack of oxygen. This is the basic type of learning in neural systems and interpreted in terms of changes of synaptic strengths.

Animals with ciliary systems have pre-CNS in the proposed sense, and could learn by essentially the same mechanisms as neuronal networks. Associative learning involves a strengthening of synaptic contacts increasing the probability for the formation of transmitter vesicles. Now this would mean the increase of the probability for the formation of a 'tug' contact and this would lead to the analogs of sub-neural networks.

The model of genetic code based on bioharmony [L24, L111, L128, L162] leads to the proposal that the basic mechanism of learning emerge already at the level of basic biomolecules DNA, RNA, tRNA, and amino acids (AA). Bioharmonies define different moods and the learning by conditioning involves in an essential manner moods affected by the stimulus already at the molecular level. The basic moods would be realized already at the level of basic biomolecules X=DNA, RNA, tRNA, AAs, or rather, the pairings DX-X where DX is the dark analog of X identified as dark nucleon sequence [L162]. Epigenetic mechanisms could stabilize the bioharmonies as correlates for the moods.

There is experimental evidence for this kind of learning (`https://cutt.ly/6SuLNqk`). When the RNA of an animal, which has learned a conditioned behavior, is scattered on the neurons of the animal that has not learned the behavior, the neurons so the signatures of learned behavior. Somehow the RNA transmits the conditioning based on negative or positive emotions generated by the stimulus. The explanation terms of DRNA-RNA pairing carrying the mood infecting the neurons with the conditioned behavior is discussed in the TGD framework in [L72, L87].

Also plants have senses and motor actions

Also plants have senses (https://cutt.ly/mDOA9Zo) and motor actions (for instance, sun flower orients itself towards Sun) and can learn (https://cutt.ly/sDOPUZo).

Can the proposed general model for pre-CNS explain these findings?

1. Microtubules are essential for cilia and axons. In general, plant cells do not have centriole or flagella: the motile, freely swimming sperm cells of some plants are an exception.

   Plants however have root hair (https://cutt.ly/JDOA7rc) consisting of epidermal cells having lateral tubular extensions resembling cilia. Their radius varies between 17-17 μm and the length varies between 80-1,500 μm so that their scale is roughly 100 times larger than that of cilia. The basic function of root-hair cells is to collect water and nutrients from the soil.

2. The MBs of root-hair cells controlling them must be able to receive sensory input from root-hair cells and control their activities. Essentially the same general model seems to work as in the case of axons and cilia.

   The membranes of root-hair cells could serve as sensory receptors using Josephson radiation to communicate the sensory input to MB. Root hair cells do not contain chloroplasts nor do they perform photosynthesis, which suggests that also now the electronic variant of metabolism is involved. The miniature potentials would appear as analogs of nerve pulses.

   Some parts in the stem of the plant can be surrounded by hairy extensions which consist of a single cell or are multicellular structures. Also these could serve as sensory receptors. Note that the hairy geometry would maximize the sensory area.

3. What about the counterpart of the neuron network? Although plant cells are covered by cell walls composed of cellulose, hemicelluloses and pectin, they are not completely isolated. Plasmodesma (https://cutt.ly/9DOSraf) are gap junction-like connections between neighboring plant cells, which allow the transfer of molecules. Plasmodesma could also act as analogs of permanent synaptic contacts, something which brings in mind a meridian system. Note that plasmodesma also have MTs as components.

4. Plants communicate with each other [I39] (https://cutt.ly/PDOSies), for instance via their roots send signals to each other under the soil by using chemical secretions.

   In the TGD Universe, the communications mediated by dark photon signalling via the layers of MB could make indirect communications possible. Plants form communities (https://cutt.ly/eDOSf0F). One can even ask whether for instance a crop field or wood resembling a ciliary community covering a cell membrane could give rise to a higher level nervous system of some kind.

Talking fungi

After having written this article I learned of a fascinating discovery of Andrew Adamatsky [I21], 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 fun- gal 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 [L128, L162]. 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 [K118]. 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.

2.5 Are space-time boundaries possible in the TGD framework?

One of the key ideas of TGD from the very beginning was that the space-time surface has boundaries and we see them directly as boundaries of physical objects.

It however turned out that it is not at all clear whether the boundary conditions stating that no isometry currents flow out of the boundary, can be satisfied. Therefore the cautious conclusion was that perhaps the boundaries are only apparent. For instance, the space-time regions correspond to maps $M^4 \to CP_2$, which are many-valued and have as turning points, which have 3-D projections to M^4. The boundary surfaces between regions with Minkowskian and Euclidean signatures of the induced metric seem to be unavoidable, at least those assignable to deformations of CP_2 type extremals assignable to wormhole contacts.

There are good reasons to expect that the possible boundaries are light-like and possibly also satisfy the $det(g_4) = 0$ condition and I have considered the boundary conditions but have not been able to make definite conclusions about how they could be realized.

1. The action principle defining space-times as 4-surfaces in $H = M^4 \times CP_2$ as preferred extremals contains a 4-D volume term and the Kähler action plus possible boundary term if boundaries are possible at all. This action would give rise to a boundary term representing a normal flow of isometry currents through the boundary. These currents should vanish.

2. There could also be a 3-D boundary part in the action but if the boundary is light-like, it cannot depend on the induced metric. The Chern-Simons term for the Kähler action is the natural choice. Twistor lift suggests that it is present also in M^4 degrees of freedom. Topological field theories utilizing Chern-Simons type actions are standard in condensed matter physics, in particular in the description of anyonic systems, so that the proposal is not so radical as one might think. One might even argue that in anyonic systems, the fundamental dynamics of the space-time surface is not masked by the information loss caused by the approximations leading to the field theory limit of TGD.

   Boundary conditions would state that the normal components of the isometry currents are equal to the divergences of Chern-Simons currents and in this way guarantee conservation laws. In CP_2 degrees of freedom the conditions would be for color currents and in M^4 degrees of freedom for 4-momentum currents.

3. This picture would conform with the general view of TGD. In zero energy ontology (ZEO) [L96, L132] phase transitions would be induced by macroscopic quantum jumps at the level of the magnetic body (MB) of the system. In ZEO, they would have as geometric correlates classical deterministic time evolutions of space-time surface leading from the initial to the final state [L83]. The findings of Minev et al provide [L83] lend support for this picture.

2.5.1 Light-like 3-surfaces from $det(g_4) = 0$ condition

How the light-like 3- surfaces could be realized?

1. A very general condition considered already earlier is the condition $det(g_4) = 0$ at the light-like 4-surface. This condition means that the tangent space of X^4 becomes metrically 3-D and the tangent space of X^3 becomes metrically 2-D. In the local light-like coordinates, $(u, v, W, \overline{W})$ $guv = g_{vu}$) would vanish (g_{uu} and g_{vv} vanish by definition.

   Could $det(g_4) = 0$ and $det(g_3) = 0$ condition implied by it allow a universal solution of the boundary conditions? Could the vanishing of these dimensional quantities be enough for the extended conformal invariance?

2. 3-surfaces with $det(g_4) = 0$ could represent boundaries between space-time regions with Minkowskian and Euclidean signatures or genuine boundaries of Minkowskian regions.

   A highly attractive option is that what we identify the boundaries of physical objects are indeed genuine space-time boundaries so that we would directly see the space-time topology. This was the original vision. Later I became cautious with this interpretation since it seemed difficult to realize, or rather to understand, the boundary conditions.

   The proposal that the outer boundaries of different phases and even molecules make sense and correspond to 3-D membrane like entities [L141], served as a partial inspiration for this article but this proposal is not equivalent with the proposal that light-like boundaries defining genuine space-time boundaries can carry isometry charges and fermions.

3. How does this relate to $M^8 - H$ duality [L104, L105]? At the level of rational polynomials P determined 4-surfaces at the level of M^8 as their "roots" and the roots are mass shells. The points of M^4 have interpretation as momenta and would have values, which are algebraic integers in the extension of rationals defined by P.

   Nothing prevents from posing the additional condition that the region of $H^3 \subset M^4 \subset M^8$ is finite and has a boundary. For instance, fundamental regions of tessellations defining hyperbolic manifolds (one of them appears in the model of the genetic code [L128]) could be considered. $M^8 - H$ duality would give rise to holography associating to these 3-surfaces space-time surfaces in H as minimal surfaces with singularities as 4-D analogies to soap films with frames.

   The generalization of the Fermi torus and its boundary (usually called Fermi sphere) as the counterpart of unit cell for a condensed matter cubic lattice to a fundamental region of a tessellation of hyperbolic space H^3 acting is discussed is discussed in [L143]. The number of tessellations is infinite and the properties of the hyperbolic manifolds of the "unit cells" are

fascinating. For instance, their volumes define topological invariants and hyperbolic volumes for knot complements serve as knot invariants.

This picture resonates with an old guiding vision about TGD as an almost topological quantum field theory (QFT) [K52, K14, K115], which I have even regarded as a third strand in the 3-braid formed by the basic ideas of TGD based on geometry-number theory-topology trinity.

1. Kähler Chern-Simons form, also identifiable as a boundary term to which the instanton density of Kähler form reduces, defines an analog of topological QFT.

2. In the recent case the metric is however present via boundary conditions and in the dynamics in the interior of the space-time surface. However, the preferred extremal property essential for geometry-number theory duality transforms geometric invariants to topological invariants. Minimal surface property means that the dynamics of volume and Kähler action decouple outside the singularities, where minimal surface property fails. Coupling constants are present in the dynamics only at these lower-D singularities defining the analogs of frames of a 4-D soap film.

   Singularities also include string worlds sheets and partonic 2-surfaces. Partonic two-surfaces play the role of topological vertices and string world sheets couple partonic 2-orbits to a network. It is indeed known that the volume of a minimal surface can be regarded as a homological invariant.

3. If the 3-surfaces assignable to the mass shells H^3 define unit cells of hyperbolic tessellations and therefore hyperbolic manifolds, they also define topological invariants. Whether also string world sheets could define topological invariants is an interesting question.

2.5.2 Can one allow macroscopic Euclidean space-time regions

Euclidean space-time regions are not allowed in General Relativity. Can one allow them in TGD?

1. CP_2 extremals with a Euclidean induced metric and serving as correlates of elementary particles are basic pieces of TGD vision. The quantum numbers of fundamental fermions would reside at the light-like orbit of 2-D wormhole throat forming a boundary between Minkowskian space-time sheet and Euclidean wormhole contact- parton as I have called it. More precisely, fermionic quantum numbers would flow at the 1-D ends of 2-D string world sheets connecting the orbits of partonic 2-surfaces. The signature of the 4-metric would change at it.

2. It is difficult to invent any mathematical reason for excluding even macroscopic surfaces with Euclidean signature or even deformations of CP_2 type extremals with a macroscopic size. The simplest deformation of Minkowski space is to a flat Euclidean space as a warping of the canonical embedding $M^4 \subset M^4 \times S^1$ changing its signature.

3. I have wondered whether space-time sheets with an Euclidean signature could give rise to black-hole like entities. One possibility is that the TGD variants of blackhole-like objects have a space-time sheet which has, besides the counterpart of the ordinary horizon, an additional inner horizon at which the signature changes to the Euclidean one. This could take place already at Schwarzschild radius if g_{rr} component of the metric does not change its sign.

2.5.3 But are the normal components of isometry currents finite?

Whether this scenario works depends on whether the normal components for the isometry currents are finite.

1. $det(g_4) = 0$ condition gives boundaries of Euclidean and Minkowskian regions as 3-D light-like minimal surfaces. There would be no scales in accordance with generalized conformal invariance. g_{uv} in light-cone coordinates for M^2 vanishes and implies the vanishing of $det(g_4)$ and light-likeness of the 3-surface.

What is important is that the formation of these regions would be unavoidable and they would be stable against perturbations.

2. $g^{uv}\sqrt{|g_4|}$ is finite if $det(g_4) = 0$ condition is satisfied, otherwise it diverges. The terms $g^{ui}\partial_i h^k\sqrt{|g_4|}$ must be finite. $g^{ui} = cof(g_{iu})/det(g_4)$ is finite since $g_{uv}g_{vu}$ in the cofactor cancels it from the determinant in the expression of g^{ui}. The presence of $\sqrt{|g_4|}$ implies that the these contributions to the boundary conditions vanish. Therefore only the condition boundary condition for g^{uv} remains.

3. If also Kähler action is present, the conditions are modified by replacing $T^{uk} = g^{u\alpha}\partial_\alpha h^k\sqrt{|g_4|}$ with a more general expression containing also the contribution of Kähler action. I have discussed the details of the variational problem in [K20, K14].

   The Kähler contribution involves the analogy of Maxwell's energy momentum tensor, which comes from the variation of the induced metric and involves sum of terms proportional to $J_{\alpha\mu}J_\mu^{beta}$ and $g^{\alpha\beta}J^{\mu\nu}J_{\mu\nu}$.

   In the first term, the dangerous index raisings by g^{uv} appear 3 times. The most dangerous term is given by $J^{uv}J^v_v\sqrt{|g|} = g^{u\mu}g^{v\nu}J_{\alpha\beta}g^{vu}J_{vu}\sqrt{|g|}$. The divergent part is $g^{uv}g^{vu}J_{uv}g^{vu}J_{vu}\sqrt{|g|}$. The diverging g^{uv} appears 3 times and $J_{uv} = 0$ condition eliminates two of these. $g^{vu}\sqrt{|g|}$ is finite by $\sqrt{|g|} = 0$ condition. $J_{uv} = 0$ guarantees also the finiteness of the most dangerous part in $g^{\alpha\beta}J^{\mu\nu}J_{\mu\nu}\sqrt{|g|}$.

   There is also an additional term coming from the variation of the induced Kähler form. This to the normal component of the isometry current is proportional to the quantity $J^{n\alpha}J^k_l\partial_\beta h^l\sqrt{|g|}$. Also now, the most singular term in $J^{u\beta} = g^{u\mu}g^{\beta\nu}J_{\mu\nu}$ corresponds to J^{uv} giving $g^{uv}g^{vu}J^{uv}\sqrt{|g|}$. This term is finite by $J_{uv} = 0$ condition.

   Therefore the boundary conditions are well-defined but only because $det(g_4) = 0$ condition is assumed.

4. Twistor lift strongly suggests that the assignment of the analogy of Kähler action also to M^4 and also this would contribute. All terms are finite if $det(g_4) = 0$ condition is satisfied.

5. The isometry currents in the normal direction must be equal to the divergences of the corresponding currents assignable to the Chern-Simons action at the boundary so that the flow of isometry charges to the boundary would go to the Chern-Simons isometry charges at the boundary.

   If the Chern-Simons term is absent, one expects that the boundary condition reduces to $\partial_v h^k = 0$. This would make X^3 2-dimensional so that Chern-Simons term is necessary. Note that light-likeness does not force the M^4 projection to be light-like so that the expansion of X^2 need not take with light-velocity. If CP_2 complex coordinates are holomorphic functions of W depending also on $U = v$ as a parameter, extended conformal invariance is obtained.

2.5.4 $det(g_4) = 0$ condition as a realization of quantum criticality

Quantum criticality is the basic dynamical principle of quantum TGD. What led to its discovery was the question "How to make TGD unique?". TGD has a single coupling constant, Kähler couplings strength, which is analogous to a critical temperature. The idea was obvious: require quantum criticality. This predicts a spectrum of critical values for the Kähler coupling strength. Quantum criticality would make the TGD Universe maximally complex. Concerning living matter, quantum critical dynamics is ideal since it makes the system maximally sensitive and maximallt reactive.

Concerning the realization of quantum criticality, it became gradually clear that the conformal invariance accompanying 2-D criticality, must be generalized. This led to the proposal that super symplectic symmetries, extended isometries and conformal symmetries of the metrically 2-D boundary of lightcone of M^4, and the extension of the Kac-Moody symmetries associated with the light-like boundaries of deformed CP_2 type extremals should act as symmetries of TGD extending the conformal symmetries of 2-D conformal symmetries. These huge infinite-D symmetries are also required by the existence of the Kähler geometry of WCW [K52, K32, K89] [L136, L163].

However, the question whether light-like boundaries of 3-surfaces with scale larger than CP_2 are possible, remained an open question. On the basis of preceding arguments, the answer seems to be affirmative and one can ask for the implications.

1. At M^8 level, the concrete realization of holography would involve two ingredients. The intersections of the space-time surface with the mass shells H^3 with mass squared value determined as the roots of polynomials P and the tlight-like 3-surfaces as $det(g_4) = 0$ surfaces as boundaries (genuine or between Minkowskian and Euclidean regions) associated by $M^8 - H$ duality to 4-surface of M^8 having associative normal space, which contains commutative 2-D subspace at each point. This would make possible both holography and $M^8 - H$ duality.

   Note that the identification of the algebraic geometric characteristics of the counterpart of $det(g_4) = 0$ surface at the level of H remains still open.

   Since holography determines the dynamics in the interior of the space-time surface from the boundary conditions, the classical dynamics can be said to be critical also in the interior.

2. Quantum criticality means ability to self-organize. Number theoretical evolution allows us to identify evolution as an increase of the algebraic complexity. The increase of the degree n of polynomial P serves as a measure for this. $n = h_{eff}/h_0$ also serves as a measure for the scale of quantum coherence, and dark matter as phases of matter would be characterized by the value of n.

3. The 3-D boundaries would be places where quantum criticality prevails. Therefore they would be ideal seats for the development of life. The proposal that the phase boundaries between water and ice serve as seats for the evolution of prebiotic life, is discussed from the point of TGD based view of quantum gravitation involving huge value of gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ making possible quantum coherence in astrophysical scales [L145]. Density fluctuations would play an essential role, and this would mean that the volume enclosed by the 2-D M^4 projection of the space-time boundary would fluctuate. Note that these fluctuations are possible also at the level of the field body and magnetic body.

4. It has been said that boundaries, where the nervous system is located, distinguishes living systems from inanimate ones. One might even say that holography based on $det(g_4) = 0$ condition realizes nervous systems in a universal manner.

5. I have considered several variants for the holography in the TGD framework, in particular strong form of holography (SH). SH would mean that either the light-like 3-surfaces or the 3-surfaces at the ends of the causal diamond (CD) determine the space-time surface so that the 2-D intersections of the 3-D ends of the space-time surface with its light-like boundaries would determine the physics.

   This condition is perhaps too strong but a fascinating, weaker, possibility is that the internal consistency requires that the intersections of the 3-surface with the mass shells H^3 are identifiable as fundamental domains for the coset spaces $SO(1,3)/\Gamma$ defining tessellations of H^3 and hyperbolic manifolds. This would conform nicely with the TGD inspired model of genetic code [L128].

2.6 Krebs cycle from TGD point of view

This section was inspired by the YouTube video (`https://cutt.ly/7XTY1Cc`) in which biologist Nick Lane talked of Krebs cycle, also known as citric acid cycle, (`https://cutt.ly/kXTY9B5`). The title of the video was "How the Krebs cycle powers life and death?". I am grateful for Marko Manninen for the link.

2.6.1 Lane's view of the role of Krebs cycle in the emergence of life

Lane's talk starts with a picture about the network of metabolic reaction pathways of an animal cell. Its complexity is absolutely stunning. In the network nodes correspond to various biochemical compounds and edges between them to reactions catalyzed by biocatalyst.

This huge complexity shows how magnificent work biochemists have done but also forces, at least me, to ask whether there should exist a description relying on deeper principles and involving something beyond chemistry.

Before continuing, I can of course reveal the cards already now and tell that I have been working for roughly two decades with what I could call TGD (Topological Geometrodynamics) [L136] inspired quantum biology. Quantum gravitation in the TGD sense and phases of ordinary matter, which can be quantum coherent in arbitrarily long length scales and behave in many respects like dark matter, play a crucial role in this model. The model challenges the vision of life as nothing but biochemistry.

Krebs cycle

In the middle of the illustration of the metabolic network stands the Krebs cycle. There is in fact also another cycle found by Krebs: readers can try to identify it from the picture of the video.

1. The input of the cycle is glucose C_6H_{12} produced in previous reactions splitting carbohydrates, proteins and lipids. Glucose is first split into pyruvate involving 2 carbon atoms. This produces carbon dioxide CO_2, which can be said to be a waste product. Second output of the cycle is water H_2O.

2. The Krebs cycle has two basic functions. The first function is to build precursors of various biomolecules like amino acids, nucleotides, and lipids for further processing in the other parts of the reaction pathway network.

   Second function is to liberate the metabolic energy of the pyruvate. Mitochondria, where Krebs cycle takes place are both power stations and molecular factories of the cell building the basic building blocks constructed in other parts of the cell.

3. Although CO_2 and H_2O can be said to be the outputs of the aerobic Krebs cycle, Lane prefers to talk about $2H$ as the output. The pairs $2H$ react with NAD^+ to give $NADH + H^+$. The reaction liberates energy kicking the proton H^+ over the potential wall defined by the membrane voltage.

   Eventually the proton falls back and gains energy by acceleration in the electric field: the energy of the proton makes possible the energization of ADP by phosphorylation: $ADP \to ATP$ adding one phosphate P_i to ADP. $ATP \to ADP$ in turn takes care of the further distribution of the metabolic energy. One can say that ATP serves as a basic metabolic currency and all biological processes use this standard coin. Note that Krebs cycle has both aerobic and anaerobic variants and only the last step involves oxidative phosphorylation.

   NADH , which has taken hydrogen and one electron e^- of 2H carries the electron to electron chain in which electrons are transferred in a stepwise manner along the mitochondrial membrane and gradually gives up its energy and end up to oxygen and ADP.

4. Krebs cycle is indeed a cycle. At the first step it transforms pyruvate involving two C atoms to a compound with 6 C atoms and and at the first half of the cycle it is transformed to a compound with 4 C atoms going through 4 steps being eventually transformed to the compound with 6 C atoms.

Reverse Krebs cycle

In the reverse Krebs cycle (`https://cutt.ly/HXTY5RR`, CO_2 and $2H$ and energy are the inputs and pyruvate is the output. Also reactions like $NAD^+2H \to NaDH + H^+$ are reverted so that a time reversal at some level is suggestive. Instead of production of ATP, ATP is used to get energy in absence of some other energy source such as solar radiation. The symmetry between the two halves of the Krebs cycle allows the production of the precursors of various biomolecules also in the reverse Krebs cycle.

1. Reverse Krebs cycle is obviously a natural predecessor of the Krebs cycle, which appears when animals use the energy stored chemically by photosynthesizing organisms. Instead of photons, the reverse Krebs cycle can also use biochemical energy. Even electron energy can be used.

2. Photosynthesis relies on the reverse Krebs cycle used by plants and some other photosynthesizing organisms (algae living in oceans). Energy comes from photons of solar radiation and is stored in various biomolecules and ATP produced in the reverse Krebs cycle. The biomolecules storing energy are then used by animals using the Krebs cycle.

3. In the archaea and bacteria H_2O as input of reverse Krebs cycle can be replaced with H_2S. This can occur even in mammalian mitochondria under stress conditions, when oxygen supply is reduced (`https://cutt.ly/qXTUe4j`)

4. The Krebs cycle can be reversed under some conditions such as cancer. Lane argues that the reverted Krebs cycle is favourable for cancer cells since it produces basic precursors of the basic biomolecules. But also the Krebs cycle does this: maybe the reverse Krebs cycle does this more effectively. In any case, the reverse Krebs cycle does not liberate metabolic energy so that it has disastrous effects.

5. Some primitive life forms can use both Krebs cycle and reverse Krebs cycle, be animal- or plant-like, one might say.

The importance of charge separation

Lane emphasized the importance of charge separation. The interior of the cell is negatively charged and the outside positively charged. This charge separation is very common in living matter. For instance, DNA is negatively charged: one unit of negative charge per nucleotide associated with phosphate. Earth's interior is negatively charged and exterior positively charged.

Pollack effect [I63, I64, L27, I99, I128] generates negatively charge regions of water, exclusion zones with effective stoichiometry H_2O and layer like hexagonal structure consisting of hexagons. Clearly, the Pollack effect produces OH^- from H_2O molecules.

Pollack effect is induced by the irradiation of water in a presence of gel at visible or IR wavelengths and induces charge separation. This effect is poorly understood in the standard chemistry framework and its explanation involving new physics is a central element in the TGD based view of living matter [L27].

Krebs cycle takes care of the charge separation requiring energy feed metabolic energy storage in the pyruvate.

The proposal for the evolution of life

Lane also discusses evolution of life starting from the idea that the primitive form of reverse Krebs cycle preceded the recent forms of life. It was discovered in 1966 that photosynthetic bacteria living in anaerobic environments use the reverse Krebs cycle to produce basic biomolecules and to store energy.

1. Margaret Dayhoff was the mother of bioinformatics. On the basis of the evolution of the present day form of enzyme ferredoxin, which has simple inorganic active site and has a key role in photon energy utilization, Dayhoff suggested that its prototype was incorporated into metabolism very early in biological evolution, even before genetic code existed(!). Ferredoxin was evolved by a doubling of a shorter protein, which would have evolved only 8 the simplest amino acids. This shorter ancestor in turn involves only amino acids alanine, proline, serine, and glycine.

   For instance, methanogens (archaea) and acetogens (bacteria) use a simple analog of Krebs cycle to grow from H_2 and CO_2 by using a so-called COA pathway.

   Reverse Krebs cycle is associated with anaerobic photosynthetic bacteria and since photosynthesis makes chemical energy storage possible, reverse Krebs cycle must have appeared first. Its analog can also use chemical energy of inorganic molecules.

2. Bill Martin proposed that so-called LUCA living in hydrothermal vents is the ancestor of bacteria and archaea (`https://cutt.ly/hXTUoZ6`). LUCA would have lived 4 billion years ago. LUCA was autotrophic and made all its biomolecules from the inorganic molecules of the environment containing hydrogen, CO_2 and nitrogen turning them to organic compounds like ammonia. It lived in the dark and there was no oxygen so that it would have obtained its metabolic energy from some other source than recent plants and animals.

   It would have used the primitive version of the reverse Krebs cycle with H_2S and CO_2 as inputs to build basic biomolecules. This process is an analog of photosynthesis storing energy as chemical energy. Inorganic molecules would have replaced photons as the source of metabolic energy.

   The genes of LUCA would have been very simple. The first naive guess is that the genes of LUCA are shared by archaea, prokaryotes, and eukaryotes and this gives constraints on the speculations concerning their genome. This gives however quite too high a number of candidates. The lateral transfer of genes must be taken into account. It implies that the common genes need not be possessed by LUCA. The outcome was a proposal involving 355 genes for LUCA. For instance, the genes responsible for the synthesis of nucleic acids and amino acids were missing. Also the genes needed to code complete ribosomes were missing.

3. Deborah Kelley discovered alkaline hydrothermal vents with charge separation between interior containing. They are rich in hydrogen gas. Hydrothermal vents were predicted by geologist Mike Russel based on the study of what looked like fossilized mineral sponges. The pores of this inorganic structure would have had OH^- ions in the interior and protons in the exterior. The walls would have contained FeS.

Lane suggests that inorganic pores inside the hydrothermal vents represent a candidate for a proto cell.

1. Lane emphasized the importance of the charge separation. The interior of both proto cell and its modern version must have been negatively charged (alkaline) whereas the exterior was positively charged. Lane notices that a similar charge separation also characterizes Earth interior and exterior: the electric field of Earth is made possible by this charge separation. What is amusing and thought provoking is that the strength of the electric field in lightning is the same as through the cell membrane! Could one see Earth itself as a giant cell? Did life proceed from long scales to short scales or vice versa?

2. A primitive predecessor of reverse Krebs cycle using perhaps H_2S and CO_2 instead of water would have generated the building bricks of chemical life. Oxidation of inorganic compounds such as iron ions could have served as the source of the metabolic energy.

3. Lane discusses a proposal for the steps leading to pyruvate from which the Krebs cycle starts from. Bound methanol from CO_2. From this to pyruvate containing two carbons. This is realized in the lab. Also lipids would have been generated leading to the emergence of cell membranes.

   It should be noticed in passing that in the experiments producing the basic biomolecules UV light is often needed: this is understandable since the scale of molecular energies is in visible and UV. The problem is that the recent life forms do not however utilize UV light.

4. These life forms would have lived in hydrothermal vents and would have disappeared as life based on photosynthesis generating oxygen emerged. All plant-like life forms not using photosynthesis would have disappeared in CE if they existed at all.

   Oxygen based life would have been the winner since reverse Krebs cycle for photosynthesis is much more effective than for the variant of Krebs cycle using chemical energy. Also aerobic Krebs cycle is much more effective than that based on fermentation. The monocellular life forms, possibly using H_2S based metabolism, would have disappeared in CE when the oxygen levels in oceans would have increased dramatically.

5. Note that the same proposal for the proto cell could work if H_2O replaces H_2S if it is available. One can also make "What if?" question. Can on imagine that photons and oxygen were in some mysterious way available from the beginning.

6. The next revolution according to Lane would have been the emergence of photosynthesis as analog of reverse Krebs. H_2O would have replaced H_2S from water. $CO_2 + H_2 \rightarrow CH_2O + O_2$ became the basic reaction making possible the storage of metabolic energy to carbon compounds and producing the basic building blocks of biomolecules.

   The Great oxidation event (GOE) , estimated to have occurred for 2.4-2.2 billion years before the Cambrian explosion (CE), would have initiated a very slow oxidation of oceans and amplified in CE dramatically. This would explain why the fossils of life forms utilizing oxygen based photosynthesis are absent before CE.

The scenario however has problems.

1. The proposal is that metabolism came first. However, metabolism requires biocatalysts and their generation requires genes. If metabolism was miraculously possible without genes, how genes emerged from metabolism? All nothing-but-chemistry based views of the origin of life have hen-egg problems. Did the cell membrane emerge first? Did proteins or genes emerge first? Did proteins, DNA or RNA emerge first?

   All these need each other in recent life, which leads to asking whether something much deeper emerged first or was present from the beginning at the level of fundamental physics. Could this something relate to the difference between in-organic and organic matter and to the incredible efficiency and precision of bio-catalysis? Does biophysics involve something totally new, not yet identified?

2. Did the GOE really happen? What is known of fossils suggests that it occurred in CE but how is this possible? Did oxygen rich oceans appear out of nowhere just like the complex multicellulars. Could one think that this somehow occurred and multicellular cells replaced the possibly existing life forms in hydrothermal vents at the surface of Earth using chemical energy as metabolic energy?

3. As Lane emphasizes, charge separation is crucial. Pollack effect induces it. We do not understand the Pollack effect in the standard biochemistry framework.

These objections give a good motivation for developing a TGD based view about Krebs cycle. This view is based on some basic ideas of TGD inspired quantum biology, quantum gravitational views of metabolism [L150] and evolution of life [L145], the TGD inspired view about how Pollack effect induces charge separations leading also to a view of genetic code realized in terms of both dark proton and dark photon triplets, the TGD proposal for what happened in Cambrian explosion in which oxygenated oceans and highly developed multicellulars emerged apparently out of nowhere [L71, L140, L126].

2.6.2 TGD view of Krebs cycle and early life

The TGD based view of life could have emerged from the problems of the view of Lane.

1. Brief overview of quantum TGD

TGD and TGD inspired theories of consciousness and quantum biology rely on a new view of space-time and quantum theory [L136].

1. In the original form TGD was proposed to be a geometrization of classical physics: the gauge fields of standard model and gravitational fields are geometrized in terms of the geometry of 8-D space $H = M^4 \times CP_2$ in which space-times are 4-D surfaces.

   The new view of space-time leads to notions like topological field quantization. Maxwellian fields are replaced by topological field quanta such as magnetic flux quanta (tubes and sheets) and electric flux quanta which correspond to space-time surfaces of finite spatial size in H.

2. Later the geometrization program was extended to include entire quantum physics and was based on the notion of the "world of classical worlds" (WCW) consisting of 4-D surfaces identified as space-time surfaces in H, which are preferred extremals of action principle analogous to Bohr orbits.

Preferred extremal/Bohr orbit property leads naturally to holography which is not quite exact, which has important implications for quantum biology and understanding of cognition. This in turn leads to zero energy ontology (ZEO). Quantum states are not superpositions of 3-D surfaces but of 4-surfaces.

They are therefore quantum variants for analogs of deterministic time evolutions: functions, behaviors of computer programs. The notion of function is central in biology and neuroscience and would be also a central notion in fundamental quantum physics.

ZEO leads to a TGD inspired theory of consciousness as a generalization of quantum measurement theory solving its basic problem due to the conflict of the determinism of unitary time evolution with non-determinism of state function reduction. Quantum jump replaces the entire superposition of space-time surfaces with a new one rather than violating the deterministic time evolution of a given space-time surface. There are two causalities: this solves the basic problem of quantum measurement theory. There are also two times: the geometric time of a physicist and the subjective time as a sequence of quantum jumps.

This in turn leads to a new view about state function reductions (SFR): in ordinary "big" SFR the arrow of time changes whereas in "small" SFR as an analog of weak measurement it is not changed. The findings of Minev et al [L83] provide direct support for ZEO [L83]. Also the views about thermodynamics must be modified since the arrow of time can change. The implications are especially profound in biology.

3. Later came a generalization of the physics based on real numbers to what I call adelic physics [L59, L60]. Adeles are fusion of reals and p-adic number fields identified as correlates of cognition and intention. p-Adic number fields are completions of rationals just like real numbers. They allow an infinite number of extensions induced by algebraic extensions of rationals.

   It is natural to interpret the hierarchies of extensions of rationals as evolutionary hierarchies and one can assign to extensions the value of effective Planck constant $h_{eff} = nh_0$ determined by their dimension. Also biological evolution reduces to the increase of algebraic complexity in a sequence of quantum jumps replacing zero energy state with a new one.

   This framework led to $M^8 - H$ duality, which generalizes the momentum-position duality of wave mechanics. This duality provides two views of physics. The complexification M^8_c of M^8, as analog of complexified8-D momentum space, has an interpretation as complexified octonions. At the level of M^8 the counterparts of 4-surfaces are determined by the roots of monomial polynomials P of a real argument and having integer coefficients. The roots of P correspond to, in general complex, mass squared values defining mass shells H^3 (hyperbolic spaces) in momentum space $M^4_c \subset M^8_c$. The roots are algebraic numbers in an extension of rationals defined by P and the Galois group of P acts as symmetries of the theory.

   These 3-D objects are continued by holography to 4-surfaces. The holographic dynamics is dictated by the condition that the normal space of the 4-surface is associative, that is quaternionic. The second condition is that the normal space contains commutative space (analogous to complex numbers). This guarantees that the normal space corresponds to a point of CP_2 and makes it possible to map these associative 4-surfaces to space-time surfaces in H.

Some basic ideas of TGD inspired quantum biology

Consider now some aspect of TGD inspired quantum biology relevant for what follows.

1. Dark matter and quantum biology

Basic prediction of the number theoretic vision of TGD is a hierarchy of dark matter phases labelled by $h_{eff} = nh_0$, where n is the dimension associated with the extension of rationals.

1. Dark matter in the TGD sense residing at monopole flux tubes is central for the TGD view of life. Also the electric flux quanta, which correspond to deformations of minimal surfaces of H with 2-D membrane-like projection to E^3 are expected to be important and accompany for instance, the lipid layers of cell membrane and boundaries between two phases. For instance,

molecules could be accompanied by these kinds of membranes involving $h_{eff} > h$ phases. Dark variants of protons and electrons and perhaps also ions reside at the field equanta.

2. Large value of h_{eff}/h would mean high algebraic complexity and high "IQ" so that the magnetic body (MB) would naturally use the biological body as a motor instrument and sensory receptor.

3. There are reasons to believe that the value of h_{eff} correlates with the interactions mediated by the flux tubes. Gravitational Planck constant $\hbar_{hr}/ = GMm/\beta_0$, where $\beta_0 = v_0/c \leq 1$ defines a quantize velocity parameter, M corresponds to either Earth's or solar mass and m is mass of a particle, is determined by Equivalence Principle and would characterize gravitational flux tubes. $\hbar_{gr}$ must be used in the condition $\hbar_{gr}/\hbar \geq 1$ is satisfied. This notion was originally introduced by Nottale [E1] and discussed from the TGD point in [K94, K75, K77].

   This proposal generalizes to other interactions. The gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = GM/v_0 = r_S/2\beta_0$, where r_S is Scwartshild radius. For Earth this gives $\Lambda_{gr} =$ .45 cm. This should be a fundamental biological and also hydrodynamical length scale [L145, L135] besides the corresponding length scale associated with the Sun.

4. Large values of h_{eff}, in particular $\hbar_{gr}$, mean the presence of long range quantum fluctuations serving as correlations for quantum criticality, which in the TGD Universe would accompany ordinary criticality. In living matter these fluctuations would be associated with the criticality with respect to melting/freezing and boiling/condensing.

   There would also be criticality around physiological temperature especially relevant to biological life [L145]. In these transitions, large density fluctuations take place and this leads to the TGD view about the role of quantum gravitation in biology and theory of conscious experience. Quantum gravitation would not be relevant in Planck scale but for Planck mass scale and appear in macroscopic scales longer than Λ_{gr} and even in the scale of Earth and even Sun.

5. One ends up with a quantum gravitational view of metabolism [L150] based on the proposal that both hydrogen bonds and valence bonds are accompanied by magnetic flux tubes and be characterized by even $\hbar_{gr}$ and therefore can have very long lengths giving rise to quantum coherence in long scales. The delocalization of dark protons at gravitational flux tubes by the absorption of dark solar photons would be a central element and one can say that the gravitational flux tubes serve as gravitational batteries with the metabolic energy stored in the reduction of the gravitational binding energy. One also ends up with a vision of how the neural system evolved [L150].

6. Pollack effect [I63, I64, L27, I99, I128] is a central element in the TGD view of living matter [L27, L46, L106, L41]. What would happen is that in the presence of a gel phase, the irradiation by visible or IR light would generate the negatively charged exclusion zone (EZ) by kicking protons of H_2O to the flux tubes of the MB of water where they could form sequences of dark protons.

   Pollack effect would thus explain charge separation occurring for cell and DNA and even for Earth and would be absolutely central for TGD. A feed of metabolic energy would be necessary to preserve the charge separation requiring dark protons. An alternative interpretation is that preservation of high level of cognitive consciousness, measured by the value distribution of h_{eff} as analog of IQ, requires metabolic energy feed

7. Dark proton triplets or dark nucleon triplets [L162] at monopole flux tubes would provide a realization of the genetic code, and give rise to dark variants of DNA, RNA, tRNA and amino acids already at the level of water. Since also metabolism is involved.

8. The realization of the genetic code in terms of dark photon triplets would be essential for communications. The biochemical realization would be a secondary realization of the genetic code and would emerge later.

9. Number theoretic vision leads to a proposal that genetic code is universal [L128, L162]. Even the cell membrane could realize the genetic code. The key notion would be so-called icosatetrahedral tessellation at the hyperbolic space H^3 (mass shell and its counterpart in H) allowing realization of genetic code which would induce realizations at the space-time level. Also higher than 1-D realizations, such as realization at the level of cell membrane.

This picture would solve the hen-egg problems of the nothing-but-chemistry approach [L148]. All the basic building blocks necessitating each other emerge simultaneously. The TGD based view of space-time also strongly suggests that membrane-like structures are universal at the space-time level [L141] and are associated with cell membranes and various boundary layers.

2. Zero energy ontology

Zero energy ontology (ZEO) [L96, L132, L144] [K117] is also important for the TGD view of life.

1. "Big" or ordinary SFRs (BSFRs), would reverse the arrow of time and the interpretation of BSFR could be interpreted as a universal counterpart of death. BSFR would however mean reincarnation with an opposite arrow of time.

2. Sleep-awake cycle could be due to BSFRs at some level of MB. At the level of bio-molecules analogous cycles are also present. During the sleep period, dissipation occurs with a reverse arrow of time and this looks like healing when looked from the opposite time direction.

   Since MB controls biological matter with f $h_{eff} = h$, the change of the arrow of time in BSFRs at the level of the magnetic/field body would induce effective time reversal at the level of the ordinary biomatter. The arrow of time for ordinary matter would change in a very short time scale since BSFRs would occur with a high rate.

An attractive conjecture is that Krebs cycle and its reversal are time reversals of each other at some level of MB. If so, the appropriate levels of MBs of animals and plants tend to live in opposite time directions. As noticed, the Krebs cycle can change to its reversal, say in cancer, and the interpretation would be that the analog of cell death followed by a reincarnation with an opposite arrow of time occurs.

Expanding Earth hypothesis, Cambrian explosion, and emergence of oxygen rich oceans

The TGD proposal is that life and photosynthesis and higher chemical life emerged in underground oceans. Oxygen is needed and oxidation of the underground oceans would have taken place by photosynthesis by reverse Krebs cycle and been based on water instead of H_2S.

1. Evolution of life in underground oceans

Consider now the TGD picture.

1. Life would have evolved in underground oceans shielded from meteoritic bombardment and cosmic rays. The radius of Earth increased rapidly by a factor of about 2 during the Cambrian explosion (CE). The multicellular life utilizing photosynthesis bursted to the surface of Earth and formed recent oceans.

   There would have been no oceans before the CE. Hydrothermal vents could have existed. The possible lifeforms were very simple bacteria, which photosynthesized using H_2S since there was now water and oxygen.

   Earth was like Mars now: Mars has no oceans and no oxygen. There are indications of underground reservoirs of water and signs of simple life forms.

2. Cosmic expansion in GRT predicts astrophysical objects to expand smoothly. This does not happen. In the TGD Universe, the expansion would be a quantum phenomenon and take place in rapid jerks and such a jerk would have induced CE.

   I got interested in the Expanding Earth hypothesis after watching a video [F6] by Neal Adams. The video is very impressive artwork but in the lack of references skeptics probably

cannot avoid the feeling that Neal Adams might use his highly developed animation skills to cheat the reader. I found also a polemic article [F1] of Adams but the references were lacking. The basic argument was that the Wegener hypothesis generalizes. If the radius of the Earth were 1/2 of the recent radius, the whole Earth would be covered by continents fitting together along their boundaries.

2. Expanding Earth hypothesis

This leads to Expanding Earth Hypothesis (EEH) [L71, L140, L126].

1. EEH stating that the radius of Earth increased rather rapidly by a factor of about two in Cambrian Explosion and underground oceans serving as seats for highly evolved photosynthesizing life bursted to the surface and forming oceans.

2. Highly developed multicellular animals and photosynthesizing algae bursted to the surface. Note that algae are responsible for the production of most oxygen also in the recent oceans. If hydrothermal vents contained sulphur based life it disappeared because the generation of the basic building blocks of biomolecules was too slow.

   Interestingly, the radius of Mars is roughly 1/2 of that for Earth. Could Mars have underground oceans teeming with life? When does the radius increase by factor two?

3. There is however a problem. How is photosynthesis possible underground? It is dark there! The basic proposal is that solar photons with energies in the visible and possibly infrared range arrive as dark photons along monopole flux tubes, which extend above the Earth and carry dark matter. The strength of the magnetic field would be about .2 Gauss and fraction 2/5 of the nominal value of the Earth's total magnetic field involving also a non-monopole part.

4. Also dark photons from the interior of Earth propagating along the flux tubes or associated with them could have served as an energy source. The temperature in the Earth's inner core (with radius about 20 percent of the Earth's radius) corresponds to about 5,500 K, which corresponds to a thermal energy scale of about .55 eV, which corresponds to the nominal value of the metabolic energy quantum.

   The energy at the maximum of the energy distribution is roughly 3 times larger than this energy and would be around 1.65 eV. The energy at the maximum wavelength of thermal energy distribution is 5 times higher and about 2.75 eV, which is the upper bound for the energy range 2-2.75 eV of visible photons.

   If the temperature of the inner core before CE has not differed appreciably from that now, which could hold true if the inner core was already before CE in the expanded state as also water containing regions, the idea about dark photons from the inner core as a metabolic energy source, which would make possible the evolution of photosynthesis in underground oceans, makes sense.

3. A model for the growth of the Earth radius by factor 2

The idea about relatively fast growth of the Earth radius by factor 2 raises the eyebrows of standard physicists. How can such a large change of density make sense? It seems safe to exclude the possibility that the mass of Earth has increased roughly by a factor of 8 (mass should have arrived from dark magnetic flux tube structure to which the core of Earth is associated as a tangle).

Monopole flux tube spaghetti should determine the structure of the ordinary condensed matter making Earth. One can consider several possibilities by allowing a fractal behaviour of the matter density induced by the structure of the flux tube spaghetti if it does not fill the entire volume [L140, L126].

The increase of the radius of Earth by factor about 2 means that the average density decreases by a factor 1/8. I have considered several options for what this could mean.

1. Quantum gravitation plays a key role in the TGD view of the emergence of life [L145] and brings in a completely new element. Density fluctuations at quantum criticality associated

with the density changing phase transitions, such as freezing and evaporation, affect gravitational binding energy dramatically in long scales. This leads to a view how life could have evolved from this kind of quantum criticality. If the density fluctuations correspond to local scalings, they affecte all gravitational binding energies in the same manner by reducing them.

Quantum gravitational Compton length $\Lambda_{gr}GM/\beta_0$ using the definition $\hbar_{gr} = GMm/\beta_0$ defines the key parameter. This suggests a considerable flexibility since the transition could be induced from the level of quantum gravitational flux tubes and leave the details for what happens in scales below Λ_{gr} open.

2. Both the necessity of local scalings and energy conservation in the transition give further constraints. In the scaling of the radius of Earth by factor 2 induced by local scalings, the gravitational binding energy is reduced dramatically. There must be a way to compensate for the increase of the energy. Energy must be liberated in some degrees of freedom and condensed matter degrees of freedom in atomic scales are a natural candidate here.

   For protons the gravitational binding energy is below .5 eV and for nucleus with mass number A it is below $.5A$ eV. The reduction of the gravitational binding energy per particle in the phase transition would be of this order of magnitude. Encouragingly, this energy corresponds to a typical energy scale for the interactions energies between atoms.

3. The electronic size of an atom is inversely proportional to $n^2h_{eff}^2/Z^2$, where n is the principal quantum number for valence electrons and Z is the charge of the atomic nucleus. The electronic binding energies are proportional to Z^2n^2/h_{eff}^2 so that the transition would require energy feed if scaling occurs in electronic degrees of freedom. Energy is not liberated. Furthermore, the electronic size of the atom cannot be affected in the transition.

   Note however that the experiments of Randell Mills [D9] provide support for the possibility of h_{eff} smaller than h for valence electrons [L43]. The TGD inspired model for chemical bonds [L56] suggests that the value of h_{eff} characterizes valence bonds.

4. Second possibility is that the energy is liberated in atomic size scales defined in terms of the size lattice constant a defining the unit cell of the atomic lattice, which is rather constant. The atomic p-adic length scale defining a would increases by factor 2 or the value of h_{eff} assignable to the atomic p-adic length scale (the p-adic length scale $L(137)$ is a good guess) increases by a factor 2 from $h/2$ to h. Note that before the transition the value of h_{eff} assignable to a cannot be the same as the value assignable to the atomic electrons, since the latter cannot change in the transition.

   The reduction of the gravitational binding energy should correspond to the liberated interatomic interaction energy depending on a which would increase by a factor 2. If this interaction energy can be regarded as positive interaction energy of positively charged atoms without conduction electrons, it is positive, and would decrease in the transition and could compensate for the reduction of the gravitational binding energy.

5. The phase transition would have been local and occurred gradually. The regions of water containing the photosynthesizing life forms and multicellular animals would have been in the recent phase already before CD. Water atoms behaved like dark matter since h_{eff} was twice its value for other atoms (as unit cells).

   The same could apply also to the inner core serving as a source of dark photons providing the metabolic energy. Indeed, the radius of the inner core is roughly 1/5 of the radius of Earth, so that the possibility that also the inner core was in the ordinary phase looks realistic: the doubling of the Earth radius would be replaced with a scaling by factor 10/6.

   Only the mantle would have been in the exotic phase. Of course, also the uppermost layers could have been also in the ordinary phase as the recent situation on Mars would suggest. The phase transition would have gradually proceeded in the mantle during the period when the radius of Earth was doubled.

6. The arguments of [L126] based on the idea that CP_2 length scale corresponds actually to Planck length scaled by factor $\sqrt{h/h_0}$ led to a speculation that $h_{eff} = h$ could be proportional to integer $n_0 = (7!)^2$ defining the order of Galois group for the number theoretic ground

state in the length scales of atomic physics [L131]. 7! would correspond to the order of the permutation group S_7 and $S_7 \times S_7$ would define the Galois group of the ground state corresponding to $h_{eff} = h$.

This suggests that the order of the Galois group was given by $n = n_0/2 = 7!^2/2$ before CE and was replaced with $n_0 = (7!)^2$) in CE. The Galois group would have been $S_7 \times A_7$, where A_7 is an alternating group, which is simple. Z_2 is the only normal subgroup of S_7.

Can one imagine any evidence for an analog of the exotic phase in the framework of known physics? In the case of water, superionic ice [D10] (`https://cutt.ly/uXUIkUQ` and `https://cutt.ly/3XUIWhX`) existing at extreme pressures is a possible candidate for the exotic phase of water. Superionic ice is proposed to appear in the mantles of giant planets such as Uranus and Neptune and in [L140, L126] the possibility that it could occuring the Earth's mantle was considered. The density of superionic ice is slightly less than 4 times the density of ordinary ice. The reduction of h_{eff} with factor 2 ($n = n_0/2 = (7!)^2/2$) would given a density, which is 8 times the density of ordinary ice. The increase of the density by factor 2 would require effective 2-dimensionality but superionic ice is 3-D.

4. Quantum gravitational metabolism

Consider first the quantum gravitational metabolism at Earth in the recent situation. In [L150], I discussed the following vision.

1. The long gravitational monopole flux tubes with $\hbar_{eff} = \hbar_{gr} = GM_Em/\beta_0$, $\beta_0 = v_0/c \leq 1$, have lengths much longer than gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = GM/\beta_0$ does not depend on the mass m of charged particle, now proton at the dark hydrogen bond. Λ_{gr} is about .45 cm for $\beta \simeq 1$ using $\hbar_{gr} = GMm/\beta_0$. There are several pieces of evidence suggesting that Λ_{gr} is a fundamental scale of hydrodynamics [L135, L145].

   The length of long dark hydrogen bond flux tubes should be of order Earth size scale. For the recent life forms they would extend from the surface of Earth to the atmosphere.

   The dark photons of sunlight are absorbed by these flux tubes and this would increase the length if the energy reduces the gravitational binding energy. These flux tubes would serve as quantum gravitational batteries just like cell membranes as electromagnetic batteries.

2. Skeptics can of course wonder how it is possible that extremely weak gravitational interaction of gravitation and photons allows the transfer of dark photon energy to gravitational degrees of freedom. As a matter fact, quantum coherence means that gravitational interaction is actually extremely strong!

   In ordinary quantum theory one should use $\alpha_{gr} = GMm/\hbar$ as a coupling strength. It is larger than unity for Mm larger than Planck mass squared and the perturbation series fails! The introduction of $\hbar_{gr}$ saves the perturbation theory! As a matter of fact, the original motivation for h_{eff} was that the Universe is theoretician friendly and the increase of $\hbar$ means a phase transition making perturbation theory possible.

   One can characterize dark gravitational interaction by a dimensionless coupling parameter $\alpha_{gr} = GMm/4\pi\hbar_{gr} = \beta_0/4\pi$, which depends on β_0 only and is $1/4\pi$ for $\beta_0 = 1$ and therefore by a factor $1/e^2$ larger than fine structure constant and still of the same size as strong coupling strength α_s!

3. The upper bound for the gravitational binding energy of a proton in the Earth's gravitational field is of the order of . 5 eV metabolic energy quantum. If the dark proton at the long flux tube is localized at the surface of Earth, its gravitational binding energy increases and energy is liberated as metabolic energy. The flux tube can be given the original length by the absorption of a dark photon of solar radiation. The order of magnitude of energy is around metabolic energy quantum if 3 protons are localized simultaneously [L150]. ATP machinery indeed involves 3 protons which could have formed dark 3-proton.

4. The model also predicts a new metabolic energy currency associated with electrons. It is by the ratio $m_e/m_p \simeq 2^{-11}$ smaller than the standard metabolic energy quantum with the nominal value .5 eV.

5. The situation before CE

Consider now the situation before CE, when oceans were underground. One can imagine several options depending on whether dark solar radiation, dark photons from the Earth's core, or both provide the metabolic energy in the primordial photosynthesis.

1. For the simplest option involving only dark photons from the Earth's core, the dark flux gravitational flux tubes extending downwards to the interior of Earth would be spontaneously formed and their formation would have liberated metabolic energy given by the increase of the gravitational potential. If the flux tube extends down to the surface of the inner core with radius of $2R_E/5$, the metabolic energy released for the hydrogen bond would be about 1.5 eV to be compared with metabolic energy quantum of .5 eV. The absorption of a dark photon with energy of 2 eV would leave .5 eV of metabolic energy.

   One can ask whether the ADP molecule could have contained this kind of long dark hydrogen bond and whether it could have shortened in ADP $\rightarrow$ ATP transition by absorption of a dark photon before CE.

   One can also imagine that the dark cyclotron state of the dark proton was excited by the dark solar photon and was liberated as the metabolic energy in the interior as the dark proton was localized.

2. Could the dark photons from the Earth's core be involved with the metabolism of recent life forms? Say those living underground? Could the increase of the radius of Earth by a factor of 2 have reduced the rate for the increase of the length of dark hydrogen bonds so that this mechanism became insignificant? Could one imagine that the Earth's mantle still contains life forms utilizing the core of Earth as a metabolic energy source? I have suggested this half-jokingly for more than 2 decades ago [K38, K39].

The next question concerns the identification of the primordial photosynthesizers.

1. They would have been the underground counterparts of the recent plants. Dark magnetic flux tubes emanating from them would have formed a kind of magnetic forest.

2. They did not have roots, leaves, nor flowers and lived in underground oceans and did photosynthesis. Algae `https://cutt.ly/9XTBTEO`) living in oceans satisfy these conditions. They include cyanobacteria (red and green algae) and glaucofytes. They or their predecessors (at least cyanobacteria) should have lived in the underground oceans and have evolved to the recent algae and plants after CE. Interestingly, algae produce most of the oxygen of Earth also in the recent biosphere. Cyanobacteria living in endosymbiosis with algae are the first known organisms that have produced oxygen.

3. This picture also solves the problem of how the oceans were oxygenated. They were oxygenated from the beginning and only bursted to the surface of Earth in CE.

4. This picture also conforms with the proposal of Lane that Earth and cell are very much analogous and makes this idea very concrete. The TGD variant of this proposal suggests that lightnings are actually analogs of action potentials possible even for unicellular organisms.

2.6.3 Appendix: A Corrected physical interpretation of the parameter β_0

Writing of this article led to an observation an apparent paradox, which resulted from a wrong interpretation of the parameter β_0 in Nottale's formula.

1. As already discussed, the quantum gravitational phase transition reducing the value of β_0 by factor 2 was involved with CE and led to the increase of the radius of Earth by factor 2.

   There are indications that the recent value β_0 is $\beta_0 \simeq 1$ and thus near to the maximal value [L135, L145]. This however leads to the conclusion that $\beta_0 = 2$ was true before CE. This leads to a contradiction if one assumes that $\beta_0 = v_0/c$ is consistent with special relativity.

2. The resolution of the apparent contradiction is based on the fact that the definition of the parameter β_0 in the Nottale's formula is actually not unique and determined only by scaling without further inputs such as the condition $\beta_0 \leq 1$. Therefore one can replace the formula $\hbar_{gr} = GMm/\beta$ with the formula $\hbar_{gr} = GMm/2\beta_{0,ph}$ if one defines $\beta_{0,ph} = \beta_0/2$. For this option, the value of $\beta_{0,ph}$ would have decreased from $\beta_{0,ph} = 1$ to $\beta_{0,ph} = 1/2$ in CE. The value of Λ_{gr} after CE would be $\Lambda_{gr} = GM/2\beta_{0,ph} = r_s/2$ just as proposed earlier [L135, L145].

2.7 About the mechanism of the energy transfer in photosynthesis

I learned about very interesting results related to photosynthesis. A popular article on the BigThink page (`https://rb.gy/phb4c`) tells about an article published in the journal PNAS [I122] (`rb.gy/9zppa`).

The basic mystery of photosynthesis is extreme energy efficiency. Up to 95% of the photon's energy is transmitted in a medium that would seem to be as inhospitable as possible for energy transmission with almost no dissipation. The use of very low temperatures, the shooting of monochromatic photons into a lattice, and superconductivity are out of the question. The incoming photons also have a wavelength distribution, which does not facilitate the energy transfer either.

2.7.1 Some facts

Consider first a summary of the basic findings and conclusions.

1. Chlorophyll is the basic structure involved with photosynthesis. Its basic function is to gather solar energy and transfer it to the reaction center where the energy is stored to various biomolecules. There are 2 wavelength bands, corresponding to 430 nm in blue and 662 nm in red, where the absorption is especially strong. The so-called LH2 proteins act as antennas absorbing photons. In the reaction center LH1 proteins perform photosynthesis by building biomolecules to which the solar energy is stored.

2. It has been observed that the lower limit of the size of the so-called light-absorbing LH2 antenna proteins is 2.5 nm. It is also the minimum distance between LH2 proteins. The proposal is that the LH2 antenna network could somehow make the transfer of energy almost without dissipation.

   It is believed that the disorganization of the proteins might explain this. However, in the popular article there was no intuitive argument as to why this is so. The claim is made on the basis of computational models and empirical facts gained by studying the transfer process. I find it difficult to imagine how the irregular positions of proteins could promote the process.

3. The proposed interpretation of the findings is as follows. A photon enters and excites the electron of the LH2 protein. When the electron is de-excited, one or more photons are generated which in turn excite the electrons of the next LH2 proteins. Finally, the generated photons excite the electrons of the reaction center and these electrons are used in the photosynthetic process to produce sugar molecules.

2.7.2 The TGD based model

The findings seem to resonate with two key views of the TGD inspired quantum biology.

1. Photosynthesis involves at least a temporary storage of solar energy to quantum gravitational energy batteries [L150, L145].

2. There is dark variant of the genetic code and realization of dark DNA double strand base on the icosahedral tessellation [L165] of the hyperbolic 3-space H^3, which is realized both as a mass shell in $M^4 \subset M^8$ and light-cone proper time=constant 3-surface in $M^4 \subset M^4 \times CP_2$.

Icosa-tetrahedral and possible other hyperbolic tessellations would be associated, not with the biological body, but with the magnetic body (MB) of the biosystem carrying dark matter identified as phases of the ordinary matter with effective Planck constant $h_{eff} = nh_0$. The location of dark matter at the field body would explain why dark matter has not been found in various searches.

Basic questions

What are the questions waiting for an answer?

1. Why would the dissipation be so low? Quantum coherence in a scale of at least the order of tens of nanometers could guarantee this. Dark matter as phases with a large value of h_{eff} indeed implies a long quantum coherence scale. Also a regular crystal structure is a natural prerequisite for a low dissipation. The dissipation is minimized if the energy, or possibly the electrons, are transferred through the hyperbolic tessellation of the MB carrying dark matter.

2. The minimum distance between LH2 proteins is about 2.5-4 nanometers, which corresponds to the DNA codon size scale. In the TGD based model for genetic code, the dark realization of the genetic code and the DNA double helix are connected to an icosa-tetrahedral honeycomb in hyperbolic 3-space H^3 assigned with the MB [L165]. Could the crystalline structure be realized by using the same icosa-tetrahedral tessellation as associated with the dark DNA and dark genome controlling the ordinary genome.

   If the transfer of energy to the reaction center occur at the MB as a transfer of dark electrons, the dissipation could be very small since there would be no direct interaction of the dark electrons with the ordinary matter if the interaction vertices can involve only particles with the same value of h_{eff}, as seems natural.

Quantitative data

Consider next the quantitative data.

1. The distance between LH2 proteins is in the range 2.5-3.1 nm. This scale corresponds to the DNA codon size scale and to the cell size of the fundamental region of the icosa-tetrahedral tessellation, which has Platonic solids as cells [L165]. There are 12 icosahedrons, 20 tetrahedrons and 30 octahedrons forming a region of size 10 nm, which corresponds to the p-adic length scale $L(151)$ (associated with a p-adic prime $p \simeq 2^k$, $k = 151$) appearing as a characteristic length scale in bomatter. This region corresponds to 10 DNA codons for which the total twist along the DNA strand is 6π that is 3 full turns.

2. The size of the structure involved with the photosynthesis would be naturally cell size scale? The wavelength of the red light gives a length scale of order .5 μm and serves a natural lower bound. Note that cell nucleus size is about 1 μm.

3. The time τ required for the energy transfer between adjacent antenna proteins varies from 5.7 to 14 ps. In time τ, the distance traveled by the light is $L = 1.71 - 4.2$ mm. Interestingly, for Earth the gravitational Compton wavelength $\Lambda_{gr}(E) = GM_E/\beta_0(E)$ is for $\beta_0(E) = v_0/c = 1$ equal to $\Lambda_{gr}(E) = 4.5$ mm. Gravitational Compton frequency is $f_{gr}(E) = 67$ GHz and corresponds to a time of about $T_{gr}(E) = 15$ ps, the upper limit for the estimated time.

   f_{gr} corresponds to a photon energy of $E_{gr} = .27$ meV. The electronic metabolic energy quantum in the case of the Earth would be related by a factor m_e/m_p the protonic metabolic energy quantum identifiable as standard metabolic energy currency. The model for the findings of Andrew Adamatsky [I21] suggests that sponges have a language based on membrane potential oscillations with membrane potential variations of order mV. The TGD based model suggests the existence of metabolic energy quantum of this order of magnitude [L150]! meV is also the energy associated with the miniature membrane potentials. Could τ be identifiable as the gravitational Compton time T_{gr} at which the dark matter at the MB would oscillate?

How could the electrons be transferred to the reaction center as dark electrons?

Could the process at the level of LH2 antenna proteins correspond to the propagation of the dark electron and the hole associated with it? The dark electron would hop between the sites of the tessellation perhaps by quantum tunneling, which in TGD Universe corresponds to a pair of "big" (ordinary) state function reductions (BSFRs) changing the arrow of time temporarily. The dark electron current would be analogous to super current and the system "hole + dark electron" would be analogous to a Cooper pair.

1. The duration τ of a single step should correspond to the oscillation period $\tau \sim T_{gr}$. If so, the oscillation would play the role of EEG resonance oscillation coordinating the transfer by induces the pairs of BSFRs.

2. The first guess is that electrons are converted to dark electrons with a large value of the gravitational Planck's constant $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0(M)$ [E1] located at the gravitational MB of the Earth or Sun. They would be transferred to the U-shaped monopole flux tubes and the reduction of the binding energy of the electron would be equal to the energy of the incoming photon absorbed by it.

   The reduction of the binding energy cannot be however purely gravitational. For electrons, the maximal gravitational binding energy in the case of the Earth is about $E_{gr}(Earth, e) =$ .25 meV whereas the incoming photon has energy $E \simeq x \times .5$ eV, where x is in the range 4 to 6 in the wavelength range considered. For the Sun the maximal binding energy E_{gr} is reduced by the ratio $[M(Earth)/M(Sun)] \times [R(Sun)/R(Earth) = .071$. In the case of protons with $E_{gr}(Earth, p) = .5$ eV this gives to $E_{gr}(Sun, p) = .14$ eV, which happens to be roughly twice the energy assignable to membrane potential. For electrons this gives $E_{gr}(Sun, e) = 1.8$ μeV.

   For the energy transfer in photosynthesis, the energy of the solar photon cannot therefore correspond to the change of gravitational binding energy in the case of electrons. Rather, the energy must be identified as the change of electromagnetic binding energy as an atom is effectively ionized when an electron becomes a dark electron at the MB. This MB need not be gravitational and could also correspond to a relatively small $h_{eff} > h$.

3. What comes to mind are dark unpaired valence electron states of atoms in which the h_{eff} of an unpaired electron increases so that binding energy is scaled down by $1/h_{eff}^2$. The binding energy spectrum of the dark electron states is obtained by scaling the ordinary binding energy spectrum and these states are analogous Rydgerg states in that the radius of Bohr orbits is scaled up by h_{eff}^2. If the valence electron becomes gravitationally dark ($h_{eff} = h_{gr}$), the atom effectively suffers ionization to a state with vanishing energy and positive charge. Dark ions could correspond to this kind of states.

4. How could the energy transfer to the reaction center take place? The simplest mechanism could be the following. One can charge the solar energy batteries by transforming ordinary electrons to dark electrons at the MB of the Sun. At the reaction center the dark electrons drop back and transform to ordinary electrons and are available for the photosynthesis proper, storing the energy to biomolecules.

   The experimental findings could be consistent with the assumption that the pairs formed by a dark electron and hole move to the reaction center, and the movement of the dark electron is analogous to a conduction in a lattice by hopping. The lattice could correspond to the tetra-icosahedral tessellation assignable also with DNA and genetic code. The time for one transition would correspond to $T_{gr}(Earth) \sim 15ns$. This supports the view that the MB of the Earth is present.

5. Why would the dropping down to Earth take place in the reaction center? The holes have an effective positive charge because the dark electrons have a large distance to the surface of Earth. If the reaction center has a negative charge, it attracts the positively charged holes. The holes move towards the reaction center and the dark electrons and gravitational monopole flux tubes and dark electrons follow. The electrons transform to normal ones and holes disappear. The predicted negative charge of the reaction center serves as a test for the proposal.

6. How this negatively charged region in the reaction center could be generated? Pollack effect [I63, L27, I128, I99], discussed from the TGD point of view in [L27], is caused by (say) IR radiation in the presence of gel phase, and indeed generates negatively charged exclusion zones. The exclusion zones could be due the transfer of protons of water molecules to dark protons at the flux tubes of the MB,which is however not gravitational. Both cells and DNA represent examples of negatively charged objects. Pollack effect is indeed a key element of the TGD inspired view of living matter. There it is natural to assume that the exclusion zone is present also in the reaction center.

If the energies of dark electrons and holes are separately conserved, they can annihilate to the ordinary electron in the reaction center. Can this be true?

1. Why would the energy of the dark electron be conserved in the hopping along the tessellation? Single step would correspond to a motion under the magnetic Lorentz force, which conserves energy since force is orthogonal to the velocity.

2. What about the dark electron-hole interaction? This interaction is present if the flux tube follows the motion of the hole-dark electron pair. This pair would form a bound state analogous to the Cooper pair and its energy would be conserved if its scattering would reduce to the magnetic scattering of the dark electron. The situation would be very much like in the case of superconductivity.

3. If the hole corresponds to a transition of an unpaired valence electron to a large h_{eff} analog of a Rydberg state with a very large size, the binding energy and energy of the state is very near to zero. The ionization energy scale for valence electrons is measured in electron volts just like for the photons from the Sun.

   The energy scale for icosa-tetrahedral honeycomb scaling like $\hbar_{eff}^2/(2m_eL^2)$, L the size of the fundamental region, gives an estimate for the unit of energy quantization, which does not depend on $\hbar_{eff}$. The energy scale is 10^2 eV for $L = L(151) = 10$ nm. This scale is expected to be very large as compared to the energy gap so that transitions are not possible. The situation would be like in superconductivity and superfluidity.

4. What about energy conservation in the motion of the localized valence hole? Valence electron hole can be replaced with the valence electron of a neighboring atom and this makes possible its movement towards the negatively charged reaction center. The energy of the valence hole in the center of mass system of the atom is not changed but the ionized atom or the molecule containing it would experience the Coulomb force assumed to be associated with the reaction center and its center of mass energy can change.

   How is it possible that the attractive Coulomb field between the hole and the reaction center does not affect the energy of the valence hole? The question is well-motivated The Coulomb energy between the hole and the reaction center is expected to be much larger than the energy gap. For instance, for distance of 1 μm the Coulomb energy between unit charges is of order 10^{-2} eV.

   What prevents the valence hole from accelerating and getting more energetic? The U-shaped gravitational magnetic flux tube has a string tension and the lengthening of the flux tube could compensate for the Coulomb force. The Coulomb energy would be transformed to elastic energy of the flux tube. In the reaction center the flux tube would contract and the dark electron could fuse with the hole having the same energy.

Is this picture consistent with the quantum gravitational storage of metabolic energy?

Is this picture consistent with the earlier proposal for the metabolic energy storage, which is based on the notion of gravitationally dark protons [L150] and also predicts electronic metabolic energy currency of about .25 meV for which there is some evidence [I21]?

1. The motivation for the proposal is that the gravitational potential energy of a proton at the surface of Earth is .5 eV: this happens to be the nominal value of metabolic energy quantum. Of course, since the electromagnetic binding energies in molecular scale are measured using

eV as units, this might be a pure accident. The weaker optimistic interpretation is that this co-incidence makes possible interaction between quantum gravitational and quantum electromagnetic degrees of freedom.

When the distance from the surface of Earth in the direction of the Sun, the gravitational forces of Sun and Earth are identical. This condition gives an upper bound for the distance $r(Earth)$ of the particle from the Earth in the direction of Sun as $r(Earth)/AU - r(Earth) = \sqrt{M(Earth)/M(Sun)}$ giving $r(Earth) \simeq 100R(Earth)$ to be compared to the distance of Moon about $r(Moon) \simeq 60R(Earth)$. The value of the gravitational potential difference as is 99% of the maximal one.

The proposal [L150] is that the transformation of protons of water molecules to gravitationally dark protons could serve as a mechanism for the storage of metabolic energy.

If the metabolic energy quantum is determined *solely* by the gravitation of Earth, this mechanism does not work at large distances from the surface of Earth. The fact that Moon travellers have survived does not favor a purely gravitational mechanism but the fact that molecular binding energies are of the same order, might save the mechanism. A more imaginative option is that the gravitational MB of the Moon traveller is still associated with Earth and makes it possible to store metabolic energy to the gravitational MB of Earth.

2. Dark protons triplets could serve as a storage of metabolic energy in the case of ATP (high energy phosphate bond) and maybe even in the case of biomolecules. This is supported by the appearance of 3 protons as a kind of basic unit in ATP→ ADP metabolic machinery.

3. In the Pollack effect, IR radiation effectively ionizes water molecules and produces effective stoichiometry $H_{1.5}O$ inside a negatively charged exclusion zone. The decrease of the electronic binding energy per water molecule in the Pollack effect could be naturally given by the energy of the IR photon and would be rather small. If the Coulomb binding energy of the dark proton triplets with the exclusion zone is equal the metabolic energy quantum $E = .5$ eV, the reduction of the gravitational binding energy in the transfer of dark proton triplet to the gravitational MB would be given by E and would lead to a zero energy state. Could one the build-up the energy carrying bio-molecules by transferring dark proton triplet to the gravitational magnetic bodies of the biomolecules by using the energy liberated by dark electrons as they drop down and transform to ordinary electrons in the reaction center?

2.8 Appendix: Basic facts about cilia and flagella

Intermediate filaments, actins and microtubules (MTs) are basic structures of cytoskeleton. MTs are associated with centrosome, cell membrane protrusions known as cilia, flagella, and axons (`https://cutt.ly/FDnfEVP`). Axonal MTs and part of MTs in the cell interior are dynamical and have a varying length. Actins are protrusions of the plasma membrane protrusions known as microvilli (`https://cutt.ly/HDRaxxf`) are analogous to cilia.

Cilia, flagella, axons, and microvilli are involved with motor activities of some kind. In the case of MTs and actins, contractions and lengthenings define the basic element of dynamics. Actin dynamics relates to the gross motion of the cell. The dynamics of axonal MTs might also relate to the nerve pulse conduction. Axonal MTs are not organized into regular structures like the other MTs.

Motile cilia and flagella are precedessors of muscles and motor system. Primary cilia function as antennas and act as mechanical, chemical, and thermal sensory organs.

2.8.1 Structure and function of cilia

Cilia start from the basal body. One can distinguish between primary and motile cilia (`https://cutt.ly/IDnfKAB`). Unlike motile cilia, primary cilia do not beat and dynein arms and other structures needed for motion are missing. These cilia act as antennas and sensory receptors. All sensory cells have cilia playing the same role so that cilia could be seen as cellular sensory and motor organs.

1. Cilium is a cylindrical protuberance of the plasma membrane. Its radius is about .1 μ m to be compared with axonal radius radius about .25 mum. The length of cilium varies in the range 1-30 μm.

2. Inside cilium is its cytoskeleton known as axoneme. For motile cilia the MTs of the axoneme have 9+2 structure and for primary cilia they have 9+0 structure. For the basal bodies the structure consists of a ring of 9 MT triplets without central MTs. Vertebrates can also have other types of cilia.

3. The 9 pairs of the ring are partially overlapping, which makes it possible for them to glide with respect to each other: this induces the bending of the motile cilium. The tubulins of these pairs are horizontally connected by nexin bonds to form a ring-like structure. Radial spokes and outer and inner dynein arms force the gliding motion.

   The pairs or rings consist of two kinds of MTs. The MT of type A has 13 tubulin protofilaments and MT of type B has 10 protofilaments. In motile cilia and flagella, structures essential for motility, such as axonemal dyneins, radial spokes, and the nexin dynein regulatory complex (N-DRC), are arranged on DMTs with a 96-nm repeating unit.

4. The members of the central pair are non-overlapping MTs connected by a bridge. The center MTs are involved with the control of the ciliary motion induced by the gliding.

   Stabilization of cilia MTs is by inner lumen proteins. The structure and protein composition of motile cilia and flagella are well conserved among eukaryotes.

2.8.2 Beating waves

Cilia and flagella have similar structures and only their functions differ. Cilia force liquid to move with respect to the cell. Flagella make it possible for the cell to move with respect to liquid (`https://cutt.ly/TDngqhO`). The force needed for cilia beating is produced by the outer and inner dynein arms of the axonemal microtubule doublets connected to the central pair of microtubules by radial spokes. Airway cilia have components typical for motile cilia.

1. Motile cilia and flagella beat in a synchronized pattern. This coordination is achieved by metachronal rhythm, in which a wave of simultaneously beating groups of cilia moves from the anterior to the posterior end of the organism. The motions of cilia along the cell surface have different phases so that the motion looks like a wave: mexican wave (`https://cutt.ly/iDRUehV`) is a good example of this. The waves in the crop field induced by wind serve as a good example.

2. The cilia on the same line perpendicular to the direction of the effective stroke are synchronized and thus have the same phase, and adjacent rows of cilia parallel to the direction of the effective stroke beat with a phase difference.

   Beating corresponds to a contraction wave and here the dynein arms are in an essential role. Orientation, beating frequency, wavelength, amplitude parametrize the motion of cilium.

3. Waves begin from cilia rather than the basal body so that the obvious idea that the cell would initiate the motion, need not be correct. Various wave forms such as plane waves and non-symmetric waves cause the bending.

4. The beating frequency varies in EEG range, which need not be an accident. Some sources report beating frequencies in the range 4-10 Hz. Some sources report 20-60 Hz frequency (`https://cutt.ly/uDngfyO`).

Chapter 3

Comparison of Orch-OR hypothesis with the TGD point of view

3.1 Introduction

Diosi-Penrose variant of the Orch-Or [J13] model constrains the range of the separation parameter R, also called the resolution scale of matter density, and predicts that weak em radiation accompanies Orc-OR, which are not predicted by the original Penrose model [J32]. Two years ago experiments by Donadi et al carried out in Gran Sasso underground laboratory failed to detect the predicted radiation [D5] (see `https://cutt.ly/JJ569SI` or arXiv version `https://cutt.ly/ZJ56482`).

These conclusions have been strengthened in a theoretical article by Diosi et al [J10] (`https://cutt.ly/8J6qdD8`) inspired by these experimental findings. The authors represented theoretical arguments leading to the conclusion that D-P theory theory is highly implausible with reasonable values of the scale parameter R.

According to the abstract of [J10], partial separation, applying at the microtubular (MT) level, requires the brain to maintain coherent superpositions of tubulin of such mass, duration, and size that vastly exceed any of the coherent superposition states that have been achieved with state-of-the-art optomechanics and macromolecular interference experiments. The conclusion is that none of the scenarios discussed in the article (with a possible exception to the case of partial separation of tubulins) are plausible. There is also a popular article (`https://cutt.ly/KJ6qrPp`) briefly summarizing these conclusions.

In the sequel Penrose view about gravitational state function collapse, Penrose-Hameroff (P-H) model (P-H model) and Diosi-Penrose (D-P) model are discussed from the TGD point of view.

3.1.1 Penrose theory

It is appropriate to briefly summarize the assumptions of the original Penrose theory [J32] for quantum gravitationally induced state function collapse.

1. Quantum superpositions for masses in different configurations have different gravitational energies. Also gravitational fields must appear in quantum superposition. However, since a theory of quantum gravitation is lacking, it is not clear how to mathematically formulate this intuition.

   The description of the two states with different self-interaction energies relies on a classical non-relativistic description of gravitation. When two configurations in the superposition are known, it is in principle straightforward to calculate the difference E_g of self-interaction energies.

The basic hypothesis is that the superpositions of gravitational fields of different configurations are unstable against collapse. For simplicity a superposition of two configurations is assumed.

2. An intuitive estimate for the duration of the state ending with collapse is based on Uncertainty Principle:

$$\tau \sim \frac{\hbar}{E_g} \quad .$$

τ inversely proportional to E_g. τ is suggested to correspond to a typical time scale of human consciousness via the formula $\tau = \hbar/E_g$. The value of E_g is extremely small, which makes gravitational quantum coherence extremely vulnerable.

3. One must somehow characterize the states appearing in the superposition. The notion of separation distance R characterizes ΔE_g. The value of R must be guessed. This is not easy since the very definition of R remains unclear, at least to me. One could take R only as a phenomenological parameter characterizing the resolution scale.

   Alternative identification would be as a separation distance. Separation would mean creation of a superposition of two classical configurations for which internal gravitational energies differ. As if the distance between nucleons of nuclei or between nuclei of atoms had changed by length R. For nuclei (atoms) R would correspond to the nucleon (nuclear) size scale.

   Coherence is required in the sense that the change of gravitational energies tends to be of the same sign for all particles. Otherwise the change E_g of the gravitational self-interaction energy is expected to be vanishingly small to give short enough $\tau \simeq \hbar/E_g$.

4. Since the change of gravitational interaction energy for all particle pairs must be of the same sign, the replacement of R as a scaling parameter comes into mind: different configurations would differ by a scaling.

3.1.2 Penrose-Hameroff theory of consciousness

Penrose's view about gravitational state function reduction [J32] is part of the Orch-OR proposal of Penrose and Hameroff [J26, J22, J25]. The duration of the quantum gravitational coherence must last long enough, of the order of the typical time scale of conscious experience or possibly time between two conscious experiences. Perturbations should not induce a too fast decorence: in standard quantum theory this looks unavoidable.

1. Microtubule (MT) hypothesis states that MTs are systems able to appear in quantum gravitational superpositions. Why this should be the case, remains unclear to me.

2. Superpositions of MT configurations must last long enough. τ could correspond either to the duration of conscious experience or time between two moments of consciousness. τ should be long enough and is estimated to be in the range 5 sec- 10^{-2} seconds. $\tau = \hbar/E_g$ gives an estimate for E_g, which is extremely small, of order 10^{-13} eV for $\tau = .1$ seconds corresponding to 10 Hz frequency in alpha band. Extremely small energies (in comparison to metabolic energy quantum of about .5 eV) are involved and one can argue that electromagnetic interactions unavoidably spoil the gravitational quantum coherence in standard quantum physics framework.

3. The separation scale R appearing as a basic parameter must be estimated or rather, guessed. The problem is that the definition of R does not have clear geometric meaning. Atomic separation of order nuclear or nucleon size scale for Carbon atoms is assumed as a working hypothesis. The rate for a collapse in the case of a single Carbon atom can be estimated from the dimensional estimate for the change of the gravitational energy as $E_g \simeq Gm^2/R$. The change is assumed to have the same sign for all Carbon atoms so that this estimate is multiplied by the number of Carbon atoms. $\tau = 25$ ms is assumed from a 40 Hz synchrony time scale. The gravitational quantum coherence of $N \sim 10^{11}$ tubulins is required with this assumption.

Tubulin has a mass of 50 kDa, and Da corresponds to proton mass. This makes a mass of $5 \times 10^{16} m_p = 3.9 \times 10^{-4}$ Planck masses. The length of a structure containing 10^{11} tubulins forming a cylinder of parallel 13 MTs, each consisting of 13 tubulin units of length about 10 nm, would be of order 15 m so that a single axon cannot satisfy the constraints. Empirical inputs restrict the value of R. Shifts of the nuclei would be measured in femtometers:$R = 2.5fm$. 1 nm scale separations for electrons would be required.

The following items summarize what I found difficult to understand.

1. The changes of gravitational interaction energies should have the same sign in order to guarantee that τ is not too large. Scalings would satisfy this constraint. The notion of separation scale does not code for this intuition.

2. What about the changes of electromagnetic energies induced by the separation? Can they be the same for the states of superposition so that only gravitational energy would be liberated in Orch-OR?

3. Why would microtubules be so special? Why not for instance axonal membranes or DNA?

4. The idea that consciousness consists of moments identifiable as quantum jumps is attractive but in conflict with the idea that conscious experience has a duration. This has been a decades-long headache also in the TGD framework. Could the quantum jump be the beginning of a conscious experience and the next quantum jump the end of it? Could one have a kind of holography of consciousness with quantum jump as analog of the 3-D boundary of space-time coding the information determining the contents of conscious experience: this is the most recent TGD view [L158]. Also self hierarchy as analog of various geometric hierarchies of TGD would conform with the idea that the structures for the physical world and conscious experience reflect each other. A category theorist might speak of a functor between physics and consciousness.

3.1.3 Diosi-Penrose theory

Diosi-Penrose (D-P) theory involves the additional prediction that Orch-OR involves also weak emission of electromagnetic radiation. This emission is argued to take care of energy conservation, which both Penrose and Diosi, regard as an unphysical feature.

It must be emphasized, the loss of classical conservation laws defines the basic problem of general relativity since the isometries of Minkowski space-time are lost and Noether's theorem cannot be used to derive the existence of energy, momentum and angular momentum. It was just this problem, which led to TGD.

I must confess that I really do not understand the mechanism of energy liberation proposed by Diosi. The following is only my humble attempt to understand.

1. One would have a superposition of two states with different gravitational self-interaction energies. In a non-relativistic Newtonian mechanics, one can in principle assign well-defined energies to them. Also changes of electromagnetic interaction energies and kinetic energies of particles must be taken into account. The changes of both gravitational and electromagnetic interaction energies and changes of particle energies can be computed classically if the two configurations are specified precisely.

   This is because the separation scale R, whatever it might mean, does not induce only a change of gravitational energy but also of electromagnetic interaction energies and kinetic energies. Stationarity assumption simplifies the situation.

   In short scales, the changes of electromagnetic interaction energies have a completely different order of magnitude than gravitational interactional energies and this does not add to the plausibility of quantum gravitational coherence. In longer scales electromagnetic interaction energies are expected to compensate each other. Since gravitation is not screened, the situation can be and, in the case of MTs, should be different for gravitation.

   A solution of the objections might be based on a precisely defined notion of scale hierarchy allowing to separate gravitational and electromagnetic interactions.

2. The predictions depend on the resolution scale R of mass density identified also as a separation distance R. R can correspond a) to tubulin protein scale (partial separation), b) atomic nuclei ($R \sim 2.5$ Fermi for Carbon atoms), or c) its nucleons. By estimates, R should be of order nuclear size scale or even of nucleon size (b) and c)).

   The interpretation of the R has remained unclear for me. The illustrations of popular talks suggest an interpretation as a distance between copies of the system at different positions self-interaction energies for two configurations differing by a shift are the same.

   If the shift occurs in the relative radial coordinates for the parts of the system and if one stays in the framework of general relativity, it is difficult to avoid the interpretation as scaling. Both local and global scalings could be considered. It however turns out that TGD allows a more elegant view [L150].

3. What about the total energies of the superposed configurations? If the state with a higher energy is less probable, the collapse tends to lead to a less energetic state and the collapse liberates energy.

   The amount E_g of liberated gravitational binding energy liberated would be extremely small for $\tau = \hbar/E_g \sim .5 - 10^2$ sec, which corresponds to energy $E_g \simeq 10^{-12}$ eV. Here $E_g = N \times e$ refers to the total liberated energy. The total liberated energy would be proportional to the number of basic units in quantum coherence. For $R = \hbar/m_p$ and proton as a basic unit, this would give $e = Gm_p^3 \sim 10^{-38} m_p$. Roughly $N = 10^9$ protons would be required.

   It would seem that in the Diosi-Penrose model the liberated energy must be be essentially electromagnetic and kinetic energy. It is difficult to make any estimates without a detailed model. In any case, the electromagnetic energy would dominate at least in short enough scales.

4. The collapse is assumed to be a Poisson process: this reduces its description to a single particle level corresponding in scale R. Momentum changes should be random so that only dissipation visible as an increase of temperature should result. Temperature change is the measured observable.

5. Despite the incoherence for em interactions, the changes of gravitational self-interaction energies at single particle level should add up coherently. It is not easy to understand how gravitational coherence in long scales is possible if everything reduces to a single particle level and electromagnetic energy dominates. The existence of length scale hierarchy suggests a possible solution to this problem. The separation of electromagnetic and gravitational degrees of freedom however requires new physics.

To sum up, if the superposed states differ by scaling instead of R, the changes of both gravitational and em interaction energies could be estimated in the general relativistic framework from their scaling behavior and one obtains simple expressions. The estimate for the changes of kinetic energies requires some assumptions.

In the TGD framework scaling hypothesis is not necessary and for the already proposed mechanism of metabolism [L150] the space-time surfaces in the superposition do not differ by a scaling. However, it turns out that scaling induced density fluctuations could play an important role also in the TGD based view about quantum gravitation.

3.1.4 Empirical test of Diosi-Penrose theory

D-P model has been empirically tested by Donade et al [D5] (`https://cutt.ly/qKszmNC`). Authors estimate the rate for the emission of radiation predicted by the D-P model, which is faint but detectable. Also a dedicated experiment at the Gran Sasso underground laboratory to measure the emission rate is reported. The null result sets a lower bound on the effective size of the mass density of nuclei, which is about three orders of magnitude larger than previous bounds. This rules out the natural parameter-free version of the Diosi-Penrose model.

1. The weak radiation would relate to the change of electromagnetic energy induced by the change of gravitational self-interaction energy of charged particles. The radiation is assumed

to be a single particle phenomenon occurring spontaneously as a Poisson process in short scales even without the quantum coherent superposition of gravitational fields. Therefore it is argued that a gravitational long length scale quantum coherence need not be present and non-biological systems can be used in the test. As explained, this hypothesis remains rather unclear to me since no detailed mechanism is proposed: only the existence of the radiation is proposed.

One must consider a system exhibiting quantum coherence in a long enough scale. This quantum coherence is assigned with conduction electrons. A shielded germanium detector is used.

2. The mathematical treatment, discussed in the Appendix of [D5], is based on the evolution equation for the density matrix containing operator terms representing matter Hamiltonian and gravitational self-interactions. The collapses at single particle level give rise to diffusion as charged particles liberate energy in gravitational collapse.

3. No emission was detected within the wavelength range corresponding to nuclear-atomic length scale range and therefore photon energies in the range $10-10^5$ eV. Note that the large energy scales suggested by Uncertainty Principle suggest that something is badly wrong with the model. If quantum gravitational coherence in biological scale is involved , this is not expected.

   The separation scale R should be longer than atomic scale but this is excluded theoretically because the rate of spontaneous collapse would be quite too slow so that decoherence caused by other interactions would prevent long enough coherence time τ for Orch-OR.

In the sequel TGD based view of how quantum gravitation is present in quantum biology [L150, L155] is briefly summarized and compared with the ideas and models of Penrose, Hameroff and Diosi.

3.2 Comparison with TGD based approach

Quite recently, the role of quantum gravitation in the biology of the TGD Universe has been considerably clarified [L150, L155]. This includes quantum gravitational models of metabolism, biocatalysis, and the analog of topological quantum computation.

The TGD view about quantum gravitation differs in many aspects dramatically from that of Penrose. What is common is the vision about quantum coherent superpositions of space-times, now space-time surfaces, as also the proposal that MTs might have a special role as also water. The reason would be quantum criticality making possible long length scale quantum fluctuations, which can be described in terms of the effective Planck constant h_{eff} labelling phase of ordinary matter behaving like dark matter [K34, K35, K36, **?**, K35, K36, K37]. By its huge value, $h_{eff} = h_g r = GMm/v_0$, introduced originally by Nottale [E1], would be most important for biology and consciousness at brain level [K77, K18] [L138, L135].

For these reasons, it is interesting to find how the TGD view relates to P-H and D-P models.

3.2.1 TGD inspired quantum gravitational view about metabolism and nerve pulse conduction

A considerable progress in the understanding of quantum gravitational aspects of quantum biology in the TGD framework has taken place recently [L150, L155].

1. The TGD based view about cell and neuronal membrane, nerve pulse and EEG assumes pre-neural level, which is quantal. In this view, cell membranes act as Josephson junctions and communicate sensory input to the magnetic body (MB) of the system as dark Josephson radiation. MB in turn controls the cell by dark cyclotron radiation produced as pulses as MB receives frequency modulated Josephson radiation resonantly.

   Number theoretic vision implies the notion of Galois confinement [L127], which inspires the notion of a dark N-particle, which consists of N dark particles as an analog of the color confined state of quarks. Dark 3N-protons and dark 3N-protons as fundamental representations

of genetic code are central for the TGD inspired quantum biology [L111, L128]. Cyclotron 3N-resonance for dark 3N-photons makes possible targeted communications and control with gene defining the address of the receiver like in LISP and frequency scale modulation defining the signal transformed to N-cyclotron resonance peaks.

2. Gravitational MB of Earth, which consists of very long U-shaped tentacle like flux tube loops with a scale of the Earth radius with gravitational Planck constant $\hbar_{gr}$ introduced by Nottale [E1] explains the findings of Blackman [J8] and others about physiological and behavioral effects of ELF radiation in EEG rane, is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs) so that hydrogen is effectively negatively ionized.

   Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide H_2O_2). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

3. The estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton HB becomes ordinary is of a correct order of magnitude. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP.

   For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential of few meV. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it [L150].

4. Electronic metabolism would solve the problem due the lack of ATP machinery inside cilium and near it. This picture leads to a rather detailed model of the role of phosphate in metabolism and also to a detailed model for the pairing of DNA and dark DNA (DDNA) and forces to modify the earlier model somewhat.

5. Also the gravitational MB of Sun could be involved, and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies so that photosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as metabolic energy storage.

The quantum gravitational view about metabolism leads also to a modification of the views about nerve pulse conduction [L150].

1. In the quantum model, the cell membrane acts as a *generalized* Josephson junction for biologically important dark metal ions. These ions are identified as gravitationally dark effective ions with gravitationally delocalized electron Cooper pairs.

2. The delocalization of protons and possibly also electrons to gravitational bonds provides a concrete realization of the Josephson junction model in which the ground state of the axon corresponds to a soliton sequence, which has a sequence of rotating gravitational penduli as a mechanical analog [K85]. Action potential would correspond to a soliton (or several solitons) with an opposite direction of rotation. One cannot exclude the option that the ground state corresponds to a propagating wave of small oscillation and the nerve pulse to a soliton or several solitons.

3. The conduction of neural signals through the myelinated portions of the axons, where nerve pulse is impossible, remains a still unsolved problem of neuroscience. The formation of dark hydrogen- and valence bonds leads to an effective ionization, which takes membrane potential below critical value for the generation of nerve pulse, which is generated in the unmyelinated sections.

   The critical dynamics of microtubules (MTs) involves variation of MT length relying on GDP $\rightarrow$ GTP transition, which involves the change of MB to gravitational MB and vice

versa changing the local membrane potential. Therefore MT dynamics makes possible the propagation of the action potential. The effect of anesthetics can be understood in terms of reduced density of HBs preventing the formation of gravitational HBs so that MTs and the axonal potential freeze.

4. A model of the pre-neural system [L150], based on the gravitational MB and the predicted electronic metabolic energy quantum, is developed in order to explain how animals without a nervous system behave as if they had the brain. These animals move using cilia/flagella, which have no mitochondria inside them or in their vicinity. This suggests that the electronic metabolism could replace the usual metabolism.

Quantum gravitation in the TGD sense also provides insights about bio-catalysis and topological quantum computation-like processes [L155, L161].

Dark-electron hole pairs as a signature of gravitational metabolism

An intriguing resemblance between the physics of electron-hole pair Bose-Einstein condensates at very low temperatures and photosynthesis have been discovered. The findings are described in a popular article at (`https://rb.gy/fnv3j`). The original article of Schouten et al [I113] can be found at `https://rb.gy/b982c`. It has been observed that electron-hole pairs as quasiparticles form Bose-Einstein condensates at very low temperatures. They behave very similarly as in living matter where temperature is much higher and these Bose-Einstein condensates should not exist.

1. TGD predicts dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$ (n integer, $h_0 < h$) residing at field body (in particular, at the monopole flux tubes of the magnetic body (MB)) defining the TGD counterpart for classical em fields in TGD as collection of space-time sheets carrying classical fields.

   The large value of h_{eff} makes these phases macroscopically quantum coherent and analogous to Bose-Einstein condensates. This leads to a variety of predictions. In particular, the magnetic body (MB) would be in a key role in living matter controlling the ordinary biomatter and forcing it to behave coherently. The very large value of gravitational Planck constant $h_{eff} = h_{gr} = GMm/\beta_0$, $\beta_0 = v_0/c \leq 1$, makes possible gravitational quantum coherence at the gravitational MB and the classical gravitational fields of Sun and Earth play a key role in quantum biology: this is reflected by many magic numerical co-incidences [L145].

2. The strange effects in the brain (the quantal effects of ELF em fields in the brain) originally led to the TGD view of dark matter, which is also predicted by the number theoretical vision of TGD. For instance, superconductivity and analogous phenomena are possible at room temperatures at MB of the system. The TGD based model of high Tc superconductivity relies on them [K82, K83, L123].

3. One interesting structure is a pair of a dark electron and the hole created as the electron becomes a dark electron at MB. The quantum numbers of holes and dark electrons are in 1-1 correspondence, and this could make possible a kind of quantum holography mapping the state of holes to that of dark electrons. This would provide representations of biological body (BB) at MB as kinds of sensory perceptions about the state of BB [L168].

4. The transfer of electrons to dark electrons can cause electronic charge fluctuations in ordinary matter due to the transfer of electrons to dark electrons at MB. For strange metals, these fluctuations have been observed: it is difficult to understand them as being caused by the attachment of electrons to atoms of strange metal since the time scale is too long (`https://rb.gy/ws51f`).

The reported experimental findings about a connection between electron-hole pair BE-condensates at low temperatures and photosynthesis can be seen as a support for the TGD view of dark matter and living systems. In particular, the TGD view would be important for understanding photosynthesis and other proposals for how quantum physics could be relevant for biology. For instance, the model for the ability of birds to navigate by utilizing the magnetic field of Earth suffers from a problem that the ordinary Planck constant is too small by a factor of order 1/100.

1. The TGD explanation of the new findings is in terms of the hierarchy of Planck constants labelling dark matter as phases of ordinary matter. Gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$, $\beta_0 \leq 1$, labels a levels of hierarchy, which are of special importance in the TGD based model of living matter.

2. In TGD, one could have Bose-Einstein condensates of hole-dark electron pairs. Dark electrons would reside in a very long gravitational flux tube and would be kicked to height of order Earth radius by solar photons during photosynthesis. They would serve as a metabolic energy resource: gravitational batteries would be loaded in photosynthesis. When dark electrons drop down and transform to ordinary ones, they liberate energy which can be stored or used. ATP-ADP process could involve this dropping down.

   Also dark protons could be transferred to magnetic fux tubes. This would take place in Pollack effect in which irradation of water in the presence of gel phase leads to the formation negatively charged regions with effective stoichiometry $H_{1.5}O$. Part of protons goes somewhere and one possible place could be gravitational MB but also much shorter flux tubes for which dark proton corresponds to the size scale of DNA nucleotide are possible and would be important for the reaization of dark genetic codon. Perhaps the most plausible option is that triplets of dark protons and electrons are involved in the case of metabolic energy storage.

3.2.2 The P-H theory and TGD

One could end up with the analog of Orch-OR in the TGD framework via the following arguments.

1. Gravitation is an unscreened long range interaction. Therefore it is plausible that it should allow quantum coherence in arbitrarily long scales. The first guess for the coherence scale in the presence of a large mass is as Schwartschild radius $r_s = 2GM$: the analog of the quantum gravitational Compton length is indeed proportional to it. This however requires large values of Planck constants and leads to the TGD view of dark matter as $h_{eff} = nh_0$ phases of ordinary matter.

   Note that in the P-H model the gravitational self-interaction energy was in a crucial role. In the proposed TGD based model for metabolism, for genetic code, and for the role MTs in the propagation of action potential, the interaction of dark electrons and protons with gravitational fields of Earth and Sun is in a key role. This suggests a strong dependence of life on the planetary environment [L150], which is not a good news for space travellers. The metabolic mechanisms relying on self-interactions would avoid this dependence.

2. One can indeed generalize the notion of gravitational metabolism to gravitational self-interactions for quantum critical systems of which MTs and water at physiological temperature range provide basic candidates. At quantum gravitational criticality these systems would define quantum superpositions of gravitational MBs with different values of $\hbar_{gr} = GMm/v_0$ and gravitational Compton length $\Lambda_{gr} = GM/\beta_0$, $\beta_0 = v_0/c$. β_0 is expected to have a discrete spectrum by number theoretic constraints and $\beta_0 = 1/n$ is the simplest option.

   Also now the presence of a large mass M (planet, star or both) is needed in order to have large enough value of gravitational Compton length Λ_{gr}, which defines a lower bound for the quantum gravitational coherence scale.

3. The crucial finding is that binding energy of protons in the Earth's gravitational field is of order of the metabolic energy quantum .5 eV. A more precise model [L150] leads to the conclusion that metabolic energy quantum corresponds to 3 protons: the transfer of 3 protons through the cell membrane indeed takes place in ATP-ADP process. Also electrons give rise to metabolic energy quantum. Also the solar gravitational field gives rise to metabolic energy currency and this currency would be important in photosynthesis.

4. Intriguingly, the mass of a water blob of radius 17 μm, the size of a neuron, equals the Planck mass. This suggests that Planck mass, rather than Planck length, is important in biology. The estimate for the gravitational energy of this water blob gives energy which is of the same order of magnitude as Coulomb energy $ZeV = 0.05Z$ eV associated with the membrane potential. Could a cell define a gravitationally quantum coherent structure and could the

changes of the gravitational self-interaction energy serve as metabolic energy quanta? The changes seem to be too small if they correspond to scalings.

Furthermore, in the case Earth, the Schwartschild radius is .9 cm, which is a biological length scale and one has $\Lambda_{gr} = r_s/cv_0 = GM/v_0 = .45cm(c/v_0)$. One has $\beta_0 = v_0/c \simeq 1$ in a good approximation.

5. There are indications that β_0 is quantized to rational values. The space-time surfaces in the superposition would correspond to different values of β_0 and Λ_{gr}

   Could different space-time surfaces assignable to MBs in the superposition correspond to different values of β_0? $\beta_0 = 1/n$? For $n = 2$, Λ_{gr} would be scaled up by factor 2. This need not imply scaling at the level of ordinary matter but could imply it at the level of MB. $\beta_0 = 1 - 1/n$ would allow arbitrarily small scalings of Λ_{gr}.

   In the TGD framework, the space-time surfaces in the superposition need not be scaled variants of the ground state space-time surface. The gravitational binding energy of long gravitational flux tubes accompanying the gravitational HBs and VBs is reduced and would serve as a local metabolic energy resource. Could the number of potential metabolic energy quanta as the number of these bonds to the integer n appearing in v_0?

P-H hypothesis involves the assumption that MTs are quantum systems.

1. There is indeed evidence for MTs as quantum coherent systems [J4, J22] discussed from the TGD point of view in [L26]. In TGD the quantum coherence would be due to metabolic energy feed taking care that dark particles decaying back to ordinary ones can be re-created [L123]. Quantal flow equilibrium would be in question.

   In TGD, a related crucial element is the hierarchy of dark matters labelled by $h_{eff} = nh_0$. The gravitational Planck constant GMm/v_0 would correspond to the top of this hierarchy and make possible gravitational quantum coherence in long scales.

2. In the TGD framework, one expects that MTs define an important level in the hierarchy of consciousness. The criticality of axonal MTs in the sense that their lengths are continually changing could be actually quantum criticality at the level of the MB of MT. This could make MTs special since quantum criticality makes a system an ideal sensory receptor and controller. The increase of h_{eff} in turn increases the cognitive resources of the system since algebraic complexity increases.

3. The transfer of protons from MTs to dark protons at its MB can indeed explain why the conduction of action potentials through the myelinated sections of the axon is possible. The charge of the MT region changes and this changes membrane potential and gives rise to action potential.

4. The inclusion of self-gravitation could add the ability of water to serve as a metabolic energy source gravitational self-interaction energy as a metabolic energy. One might hope that this allows us to overcome the dependence of metabolism on planetary gravitational fields. In fact, only water is able to do this.

Could the following picture make sense?

1. Superpositions of geometries are replaced in TGD with superpositions of space-time surfaces with quantum gravitationally important modifications assignable to the gravitational magnetic body. There would be no problems with energy conservation and the new view about space-time allows us to identify also MTs as and their MBs as space-time surfaces, which are minimal surfaces with singularities analogous to soap films with frames.

2. A lot of new physics emerges: number theoretical physics and geometric physics related by $M^8 - H$ duality, number theoretical h_{eff} hierarchy labelling dark matter as phases of ordinary matter; gravitational Planck constant $\hbar_{gr} = GMm/v_0$ characterizing particle of mass touching gravitational flux tube; and zero energy ontology (ZEO).

3. The crucial point is that the huge value of $\hbar_{gr}$ would allow to avoid the loss of quantum gravitational coherence otherwise caused by the other interactions.

   For $\hbar_{gr} = GMm/v0 > \hbar$ one must replace $\hbar$ with $\hbar_{gr}$ meaning that $GMm > v_0\hbar$. The TGD based quantum gravitation becomes visible for particles of mass m in the gravitational field of large mass M at flux tubes with $GMm/v_0 > \hbar$. The gravitational Compton length $\Lambda_{gr} = GM/v_0 = r_s/2v_0$ does not depend on m and for Earth one has $\Lambda_{gr} = .45\ cm/(v_0/c)$, which is a biological scale. Cyclotron frequencies for a charged particle with mass m are also independent of m. Josephson frequency $f_J = ZeV/\hbar_{gr}$ is dramatically smaller than for ordinary $\hbar$ and corresponds to ELF frequency in the case of cell membrane.

4. Gravitational variants of hydrogen bonds (HBs) and valence bonds (VBs) as long U-shaped flux tubes are part of picture. Liberation of metabolic energy as an increase of gravitational binding energy as very long dark gravitational HB or VB becomes short. Metabolic energy quanta come as protonic and electronic varaints differing by factor m_p/m_e. The masses of Earth and Sun have a central role. Also other masses involved but the proportionality of $\hbar_{gr}$ to M means that these are the most important ones.

5. Gravitational energy difference would be roughly $\Delta GMm/R$ for a long gravitational flux tube associated with dark HB (VB) and short tube and corresponds to metabolic energy associated with the long HB (VB). A rough guess for the metabolic energy would be about .5 eV for proton. This would give time of order 10^{-14} sec corresponding to an energy of IR photon. For electron the metabolic energy in the meV range. A more careful estimates increase the number of protons and electrons to 3.

   This would suggest that the space-time surfaces in the superposition correspond to space-time surfaces with various numbers of potential metabolic energy quanta. These space-time surfaces are *not* scaled versions of the ground state space-time surface as in the GRT picture but analogous to the deformation of the surface of Earth by the presence of biosphere such as plants and trees. By fractaility. this kind of magnetic forests of U-shaped flux tubes would appear in all scales and first emerged in the model of atomic nucleus carring quarks.

In order to get some grasp on the new idea, one can play with numbers.

1. One can consider the analog of the P-H hypothesis $\tau = \hbar/E_g$ as $\tau = \hbar_{gr}/E_g = \hbar/R$ in the case of the gravitational flux tubes of Earth with size scale R determined by Earth radius R_E.

   The time scale corresponding to dark proton flux tube of length of order Earth radius $R_E \sim 6.37 \times 10^6$ m would be $R_E/(v_0/c)$ and would give $\tau = 21$ ms for $\beta_0 = v_0/c = 1$. The time scale of nerve pulses is a few ms.

2. Also gravitational Compton time should have relevance. For $\beta_0 = 1$ one has $\tau = GM/c = r_s/2c$. For Earth this would give $\tau = 1.7 \times 10^{-11}$ s. For ordinary Planck constant this corresponds to an meV energy scale. So called miniature end plate potentials .4 mV (`https://cutt.ly/HSJIn76`) have this scale.

3.2.3 Could the space-time surfaces in the superposition correspond to different scalings?

The change of gravitational interaction energy should not be random and should be such that the changes of gravitational energy are of the same sign for all particles. The interpretation of the parameter R as a shift does not look plausible.

This does not leave many options in the GRT framework. The change of the gravitational interaction energy could be induced by a scaling also in TGD framework, but most naturally at the level of gravitational MB as scaling of magnetic flux tube thickness, whose thickness is naturally proportional to $\hbar_{gr}/\hbar$. This would conform with the underlying scaling invariance of TGD so that R should be replaced by a dimensionless scaling parameter $\Lambda - 1$.

1. Scalings are indeed natural in the TGD framework, where the analog of time evolution is assigned with scaling rather than time translation and p-adic thermodynamics with conformal

weight rather than energy so that a discrete superposition of scaled variants of space-time surface would make sense. One option is that scalings correspond to different p-adic primes , perhaps near to each other. Scalings by say powers of 2 suggested by p-adic length scale hypothesis could make sense at the level of visible matter in critical situation involving large density fluctuations (as in the evaporation). In this case the quantum criticality of MB could induced criticality of the ordinary matter.

The scaling of flux tube thickness could correspond to that for the universal particle independent gravitational Compton length $\Lambda_{gr} = GM/v_0$ induced by the change of the velocity parameter as $\Delta v_0/v_0\Delta\Lambda$. Small scalings would be possible and they would be realized for dark particles at gravitational flux tubes. Note that this requires the presence of a heavy astrophysical object such as a star serving also as a metabolic energy source.

2. The scale change would be proportional to the change of the scaling parameter $\Lambda - 1 = \Delta\Lambda$. In the P-H model, the estimates for the separation scale R, whose interpretation seems to be as a shift, vary between nucleon size scale and size scale of tubulin protein (10 nm).

3. A simple estimate shows that for 10^{11} tubulins assignable 10 m long axon containing 13×13 tubulins per length of about 10 nm, the scale of gravitational self-interaction energy is of order 10^{-16} eV so that the interpretation of a reduction of gravitational binding energy for an analog of Orch-OR as a potential metabolic energy is excluded. The mechanism proposed in [L150] is the only possible mechanism involving only MTs (plus the gravitational field of Earth to make Λ_{gr} large enough).

4. For the TGD based quantum gravitational model of metabolism E_g has a scale of metabolic energy quantum and is many orders of magnitude larger than allowed by the constraint if it defines a time scale in a range 5 sec- 10^{-2} sec. For ordinary Planck constant, one would have $\tau \sim 10^{-13}$ sec. In the TGD framework $h_{eff} = \hbar_{gr}$ implies $\tau = h_{gr}/E_g$. For the Earth's mass, the time scale would be the desired one. This supports the hypothesis that cell interiors consisting of ordered water define gravitationally quantum coherent regions and the surfaces in the superposition differ by the number of gravitational HBs and VBs.

The metabolic mechanism based on gravitational HBs and VBs imply the dependence of life on planetary gravitational fields. However, metabolic autonomy could be of high relevance for the life on other planets and also for space travel (this is discussed from the TGD point of view in [L150]). Also the possible proto cells in interplanetary space could use a metabolism based on gravitational self-energy. The presence of a nearby star seems however necessary to guarantee that the quantum gravitational coherence scale $\Lambda_{gr} = GM/v_0$ is long enough. For biological systems, such as cells, it is extremely small.

Could the gravitational self-interaction energy of water serve as a source of metabolic energy and allow to circumvent this dependence?

1. Consider first the cell scale. Water blob of Planck mass $M_{Pl} = 2.2 \times 10^{-8}$ kg has size $R \simeq 1.74 \times 10^{-4}$ m, which corresponds to the size of a large neuron. In this case, one has $E_g = \Delta E = [\lambda - 1)/lambda]E_g$, $E_g \simeq GM^2/R \sim 7$ meV. Maximum energy gain is 3.5 meV, which is roughly 10 times the energy scale of miniature potentials and is by a factor of 10 smaller than the Coulomb energy scale $\sim .05$ eV assignable to the membrane potential. The energy scale corresponds however to the difference of Coulomb energies of cell membrane for opposite values of membrane potential.

   If the system is critical so that large density fluctuations inducing the scaling of R and preserving M are possible, the scaling parameter $\Delta\Lambda$ characterizing the possible changes of water volume can be large. In this case, one could consider the possibility that some kind of metabolic energy needs could be satisfied.

2. Could larger water blobs, say those assignable to muscles, which indeed experience scale changes, help? For the entire body of mass of 50 kg and size scale of $R = 1$ m, the estimate for gravitational self-interaction energy is of order 6.4×10^{12} eV, which is about 10^{-6} J: lifting a weight of 1 kg to a height of 1 m requires 10 J. This option does not look realistic. Note also that the liberated metabolic energy feed cannot be targeted in a precise way.

3. Just for fun, one could also consider the entire biological body with (say) size $R = 1$ m and mass $M = 50$ kg and regard cells with mass of order Planck mass m_{Pl} as the dark particles at the flux tubes of its MB. The flux tubes connecting cells to each other would be stretched to gravitational flux tubes of length of roughly body size R. This option would allow a targeting of the metabolic energy by transforming the dark cell back localized to the biological body.

   The estimate for the order of magnitude of a metabolic energy quantum $E = GMM_{Pl}/R$ for MB flux tubes of size R would be $E \sim .25$ eV, one half of the value of the metabolic energy quantum. As will be found, the change of the sign of the membrane potential involved with an action potential requires energy of 3.5 meV and this energy could be generated already by a mass $M \sim .5$ kg.

3.2.4 Could the TGD analog of Orch-OR make possible an action potential for protocells?

The idea about gravitational superpositions of space-time surfaces related by scalings looks interesting since the scalings could relate to the scaling of the parameter β_0 in $\hbar_{gr} = GMm/v_0$ and in Λ_{gr} in the case that the flux tubes correspond to the mass of Earth or Sun.

For the masses M of say living organisms Λ_{gr} is extremely small. The presence of a stellar object, having a gravitational field characterized by $\hbar_{gr} = GMm/v_0$ and $\Lambda_{gr} = GM/v_0$, is needed in order to have quantum gravitational coherence in biologically interesting scales.

Quantum gravitational phase transitions of water blobs as the TGD counterpart of Orch-OR?

Instead of Orch-OR, quantum gravitational phase transitions are suggestive in the TGD framework. The quantum gravitational superpositions would be associated with quantum phase transitions changing Λ_{gr} and perhaps also inducing a scaling of the system consisting of ordinary matter. This scaling would mean large density fluctuations affecting the gravitational self-interaction energy.

1. Ordered water forming a gel-like phase in the presence of biomolecules is a natural guess for what gravitationally quantum coherent phase could be. A membrane-like object separating proto-cell from environment is needed to create a volume of water with quantum gravitational coherence.

   2-D membrane-like objects with 1+2-D M^4 projection, possibly pairs of them forming double membranes, appearing in these scales could serve as templates for membrane-like objects, which could have preceded cell membrane and also for the recent cell membrane. Their presence could have led to the emergence of lipid layers, which involve only hydrocarbons. These membrane-like objects form a fractal hierarchy and could accompany both galactic and planetary planes as walls and also the biosphere at the surface of Earth serving as analog of the cell membrane.

2. p-Adic length scale hypothesis and the number-theoretically miraculous appearance of 4 Gaussian Mersenne primes $L(k) \simeq 2^k$, $k = 151, 157, 163, 167$, between the cell membrane length scale and cell nucleus scale suggests that gravitational quantum coherence in these scales is involved.

3. Protocell as a pair of 2 membrane-like objects and as a template of cell membrane could define electric flux quantum as a counterpart of magnetic flux quantum. It would have carried an electric field as an analog of capacitor plates.

   If the electric voltage is absent, only mechanical work is possible. The energy scale in mechanical thermodynamic degrees of freedom is however huge as compared to the energy scale in gravitational self-interaction energy degrees of freedom so that the change of gravitational self-interaction energy to mechanical work in the cellular scale is not possible.

   Pollack effect [L27] caused by the stellar radiation could have generated the negative charge to the interior of the inner membrane. In principle, this requires the presence of only water.

4. One can imagine that the value of $\hbar_{gr}$ characterized by the value of β_0 and associated with the stellar gravitational flux tubes, fluctuates locally and generates scaled variants of gravitational flux tubes in turn inducing density fluctuations and the thermodynamical criticality of water. Fluctuations would produce water regions with a reduced density analogous to a vapour phase.

5. The liberated self-interaction energy would be $E_{gr} \simeq (\lambda - 1)GM^2/R$, where R is the size of the water blob, and scales like R^5. λ is the scaling inducing also the scaling of $\Lambda_{gr} = GM/v_0 \to \lambda\Lambda_{gr}$.

   At quantum criticality, assumed to induce thermodynamic criticality, the change of the free energy would be very small for the values of scalings in the superposition. The first guess is that by the quantization of $\beta_0 = 1/n$, one has $\lambda = n$. $n = 2$ gives 2-adic scaling and p-adic length scale hypothesis favoring $p \simeq 2^k$ could relate to these phase transitions. This picture makes sense if the criticality is analogous to that of boiling water.

   For a water blob of Planck mass with $\beta_0 = 1/n$, the gravitational metabolic energy gain is below 3.5 meV, which corresponds to the miniature potential.

6. As already found, the gravitational self-interaction energy cannot be used to perform mechanical work in practice. Since the energy gains are in the meV range, a more promising option is that the energy goes to a creation of a pre-neuronal action potential. By the arguments of [L150], the metabolic energy quantum for electron based metabolism is of order .25 meV and miniature potentials about .4 meV. Action potentials are possible already for mono-cellulars and one can ask whether even a proto-cell could generate the analog of an action potential without the ATP-ADP machinery.

   The scaling of the volume as a phase transition at quantum criticality could be present also in recent biology and one can wonder if the swelling of cells during infection could relate to this process.

Could the generation of gravitational self-interaction energy give rise to action potential?

The generation of gravitational self-interaction energy of a water blob with Planck mass liberates energy. Could it have given rise to an analog of action potential?

1. The gravitational self-interaction energy is of order $E_{gr} = GM^2/R$ and as a function of R scales like R^5 so that it is rather sensitive to the value of R. Already the scaling of R from 10^{-4} m by factor 3.1 transforms metabolic energy quantum of 3.5 meV to .5 eV.

   For a fixed M, E_{gr} scales as $1/R$. The analog of Orch-OR would be following. A superposition of different scalings of a water blob would be created much like in evaporation. After that a phase transition leading to a less dense state with definite scaling would take place. This requires metabolic energy provided by a near enough star. The phase transition back to the original situation takes place and liberates the metabolic energy.

2. When an action potential is generated, the membrane potential changes sign. In ZEO this could correspond to two BSFRs, each of which changes the arrow of time. The change for the arrow of time corresponds naturally to the sign change of V.

   The change of energy in this process is $2QV = 2e^2V^2S/d$, eV corresponds to the Coulomb energy of membrane potential, $Q = ES = VS/d$ is the charged assumed to be conserved in the transition, $S = 4\pi R^2$ corresponds to the area of cell membrane. Charge conservation gives $V = d/S$. The natural scaling is $d \to \lambda d$ and $S \to \lambda^2 d$, which gives $V \to V/\lambda$.

   For $R = 10^{-4}$ m corresponding to Planck mass (large neuron size), $d = 10$ nm, and $V = .05$ V, the change of Coulomb energy of the membrane would be $\Delta E \simeq 6.3$ meV. The upper bound for the change of the gravitation binding energy was 3.5 meV corresponding to a scaling of 2. It would seem that the gravitational phase transition as a 2-fold scaling and its reverse could induce a proto version of the action potential.

3.2.5 How water blobs could have evolved into living organisms?

Quantum gravitational criticality could be assigned to water blobs. In interstellar space the possible metabolism would not depend on the planetary gravitational flux tubes but would depend on the mass M of the nearest stellar object. Stellar gravitational fields are indeed necessary for large enough gravitational Compton length GM/v_0.

Important facts about water

Consider a water blob of radius R. The phase diagram of water (`https://cutt.ly/EKx9nGX`) allows to understand how thermodynamic criticality under normal conditions and during the prebiotic period could differ. There are two different situations to consider. When the pressure is above tricritical pressure P_{cr}, water allows liquid phase. Below P_{cr}, only solid and vapour phases are possible.

1. The normal physiological situation with normal pressure $P_{phys} = 1$ atm (101.325 kPa) in the vicinity of physiological temperature around $T_{phys} = 37$ C, which is between the freezing point and evaporation point. This kind of criticality could have been present for pressures above the tricritical pressure along a critical line.

   The numerous thermodynamic anomalies of water suggest that it is quantum critical at the physiological temperature range between solid-liquid phase transition and liquid-gas phase transition. The temperature for this range is above $T = 0$ C. Quantum criticality would give rise to superposition of phases with different density and differing by scaling above the tricritical point.

   Solid-liquid critical curve would naturally correspond to quantum criticality. Could some kind of life forms be associated with this criticality?

2. Below the tricritical point, the liquid water phase is absent so that the counterpart of the physiological quantum criticality is not possible. If the pressure is below $P_{cr} = 611.657$ Pa $\simeq .006P_{phys}$ and temperature below $T_{cr} = 0.01$ C, only solid and vapour phase are possible and criticality would be associated with the curve at which sublimation of ice takes place.

   In particular, the situation with $T \simeq 30$ K would correspond to a very early prebiotic phase, when the age of the Universe was about 1 Gy and the cosmic temperature was about 30 K. In this situation, quantum criticality could relate to the sublimation and the density fluctuations associated with it and would involve a superposition of scaled variants of H_0^2 blob.

Snow flakes, Emoto effect, and Pollack effect: life at quantum criticality?

Suppose that solid-liquid solid-vapour critical curves correspond to quantum criticality. Could some kind of life forms be associated with these quantum criticalities?

1. Snowflakes (`https://cutt.ly/sKJclSy`) are amazingly ordered structures and appear in freezing and direct solidification of water vapour. Snow flakes do not have metabolism. Could snowflakes be "corpses" of life forms emerging at quantum criticality?

   The experiments of Masaru Emoto [L79], discussed from the TGD point of view in [L79], demonstrate that if water at freezing point is subject to sound signals, it generates freezing patterns, which can be extremely beautiful or ugly depending on the emotional content than human would associate to the signal. Emoto suggests an interpretation in terms of expression of emotions generated by the sounds.

2. In the TGD framework, a model of harmony leads to a model of genetic code [L24] [L111]. Genetic codons would consist of 6-bit codons realized also as 3-chords represented by 3 dark photons and by dark 3-proton states. The harmony is defined by 3 icosahedral Hamiltonian cycles, each representing a 12-note scale, plus the unique tetrahedral Hamiltonian cycle. The 3-chords define a bioharmony with 64-chords realized as dark photon triplets. Since ordinary harmony of music induces and expresses emotions, the proposal is that a given bioharmony defines an analog of mood already at the level of basic information molecules.

3. Could a dark realization of the genetic code be involved with the criticality of water and explain the high information content of snowflakes and the findings of Emoto? Snowflake has a locally violated 6-fold rotational symmetry and looks like a planar tree with branches emanating from the center. That one cannot find two identical snowflakes, can be understood in terms of criticality during their formation.

   Icosahedron and tetrahedron correspond to an icosahedral symmetry group with 60 elements and hexagon to Z_6. All these groups belong to an infinite hierarchy of discrete and finite subgroups of $SU(2)$ associated with the inclusions of von Neumann algebras known as hyperfinite factors of type II_1 [K113, K45]. $M^8 - H$ duality allows us to interpret $SU(2)$ as a covering group of the automorphism group of quaternions.

4. The dark proton realization genetic code would be in terms of icosa-tetrahedral tessellation of hyperbolic 3-space H^3 (light-cone proper time constant surface) [L128]. Ordinary ice I_h consists of hexagonal layers (`https://cutt.ly/sKJcveh`): could a hexagonal tessellation at the level of H^3 could be involved. This suggests that if the genetic code is realized at the level of MB, a symmetry breaking leading from an icosa-tetrahedral tessellation to a hexagonal tessellation at the level of ordinary matter takes place in the freezing of water.

5. Intriguingly, the size scale of the snowflake hexagon is of order .45 cm, which happens to be the gravitational Compton length $\Lambda_{gr} = GM_E/v_0$ in the gravitational field of Earth for $v_0 = c$ determined from other arguments [L135]! This scale is huge as compared with the size of order 1 Angström of the ice crystal hexagon. Quantum fluctuations at quantum criticality involve however large values of h_{eff} meaning scaled up sizes for the basic structures. For $h_{eff} = h_{gr}$ the minimum size would naturally be Λ_{gr}! Note that the thickness of human cortex varies in the range .1-.45 cm.

6. The fourth phase of water, as Pollack calls it, is formed in the Pollack effect [I63, L27, I128, I99] and consists of hexagonal layers connected by hydrogen bonds. The effective stoichiometry is $H_{1.5}O$ so that every fourth proton goes somewhere and a negatively charged exclusion zone (EZ) is formed. In the TGD based model, every fourth proton becomes a dark proton at flux tube so that the stoichiometry becomes $H_{1.5}O$.

   Dark protons with $h_{eff} = h_{gr}$ would not be present for snowflakes nor for the crystal-like structures studied by Emoto. However, at the quantum criticality for freezing they could emerge and be associated with quantum gravitational hydrogen bonds (flux tubes) containing dark protons delocalized in the Earth size scale [L150, L155].

   The basic claim of Emoto is that water at criticality has emotions and expresses them. If bioharmony determines emotions and is realized in terms of dark proton and dark photon sequences at quantum criticality, the question arises whether a dark realization of the genetic code for snow flakes and whether the MB controls and communicates with water using dark 3-photons. Conditioned learning is based on emotions: could water at criticality be able to learn in this way?

   If quantum criticality is the prerequisite of life, one can ask whether snowflakes of the crystal structures of Emoto could be "revived" by bringing the water to criticality.

7. At least for water, silicon, gallium, germanium, bismuth, and plutonium, the density is higher for liquid phase than solid phase above criticality. Could all substances with this property show analogs of Pollack and Emoto effects? Or could these effects appear universally at melting and sublimation curves. What about the analogs of snowflakes with size $\Lambda_{gr} \sim .45$ cm?

Strange coincidences related to gravitational Planck constant, basic biorhythms, membrane potential and metabolic energy currency

It is becoming clear that the gravitational quantum coherence is central for life on Earth. The hierarchy of Planck constants $h_{eff} = nh_0$ involves special values, in particular gravitational Planck constants $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0$, where M is a large mass (say mass of Sun or Earth) and m

is small mass (say mass of electron or proton) and $\beta_0 = v_0/c \leq 1$ is velocity parameter, are of key importance for living matter. Particles with a different value of $\hbar_{gr}$ correspond to different gravitational flux tubes and the value of β_0 can depend on the particle.

There are several amazing numerical co-incidences supporting this view.

1. For Sun one has $\beta_0 \simeq 2^{-11}$ which happens to be rather near to the electron proton mass ratio m_e/m_p. The condition $\hbar_{gr}(M_S, m_p, \beta_0(Sun) \simeq m_e/m_p) = \hbar_{gr}(M_S, m_e, \beta_0 = 1)$ would guarantee resonance between dark photons generated by the solar gravitational flux tubes assignable to protons and electrons.

2. In accordance with Equivalence Principle, the gravitational Compton length $\hbar_{gr}(M_S, \beta_0)/m = GM/\beta_0 = r_S/2\beta_0$ is independent of m for Sun $GM_S/\beta_0(Sun)$ is rather near to Earth radius. For Earth one has $GM_S/\beta_0(Earth) \simeq .45$ cm which corresponds to the size scale of the somewhat mysterious snowflake analogous to a zoom-up of a basic hexagonal unit cell of ice crystal. There is evidence for $\beta_0(Earth) = 1$ in hydrodynamics, in particular from the TGD based model [L135] for the observed hydrodynamical quantum analogs described in an article of Bush et al [D1] (see `https://cutt.ly/nEk5OLA` and `https://cutt.ly/xEk5Api`)

3. The gravitational Compton length of the galactic blackhole corresponds rather precisely to the $n = 1$ Bohr orbit associated with the Sun. This suggests gravitational quantum coherence in the scale of the galaxy.

In the following some additional strange coincidences are discussed. It would be very natural if the basic biorhythms defined by the duration $T_d = 24$ hours of day and the duration of year $T_y = 365$ days would correspond to energies of dark photons $E = \hbar_{gr} f$, which are biologically significant energies. The potential energy $eV_c \simeq .05$ eV associated with the cell membrane defines Josephson energy in the TGD inspired model of cell membrane. Metabolic energy currency with the nominal value of .5 eV is second important energy. Could the periods of fundamental biorhythms, fundamental biological energies, and the gravitational Planck constants for Sun and Earth correlate?

The above assumptions imply that one has $\beta_0(Sun)/\beta_0(Earth) \simeq m_e/m_p$ and $h_{gr}(Sun, me)/h_{gr}(Earth, m_p) \simeq M(Sun)/M(Earth)$. The value of Sun-Earth mass ratio is $M_S/M_E \simeq 6 \times 10^5$.

1. The corresponding frequency corresponding to the basic biorhythm $T_d = 24$ is $f_d = 1/G_d = 1/24 hours = [1/(2.4 * 3.6)]10^{-6} \simeq 1.1^{-6}$ s. The corresponding Josephson energy would be $E(\hbar_{gr}(Sun, m_e), f_d) \simeq .06eV = E_J$. This is very near to the Josephson energy E_J for cell membrane potential!

2. For $T_y = 1$ year $= 365$ days one has $E(\hbar_{gr}(Sun, m_p), f = 1/T_y) \simeq (m_p/m_e) * (24\, hours/year) \times E_J \simeq (2^{11}/365)E_J \simeq .33eV$. This is not far from the value of the metabolic energy currency near to .5 eV.

Metabolism of the protocell above tri-criticality

Consider first the situation above tricricality, when liquid water and perhaps also the counterpart of physiological quantum criticality was possible.

1. The temperature is above tricritical temperature $T = .01$ C (`https://cutt.ly/EKx9nGX`). The frequency distribution of thermal photons has a maximum at energy .131 eV at this temperature. This energy corresponds to a Josephson energy of a Cooper pair for membrane potential of .066 eV. The membrane potential varies in the range .04-0.08 eV.

   Note that the electronic variant of the gravitational metabolic energy quantum is about .25 meV, which might explain the metabolism of cilia [L150], is of the same order of magnitude as the thermal energy of CMB now.

2. According to the TGD view, biochemistry involves quantum gravitation at the level of dark hydrogen bonds and requires the presence of gravitational fields of both Earth and nearby Sun. In the interstellar space ATP-ADP machinery and its possible electronic counterpart

[L150] would have been absent and only gravitational self-interaction energy of the water blob could have served as a metabolic energy source receiving its energy.

Stellar radiation could feed energy to the quantum gravitational degrees of freedom of the proto cell, in particular in the range of visible energies. The gravitational energy could in turn be feeded to the degrees of freedom of the protocell. Hydrogen bonded structures involving dark HBs could receive this energy as a metabolic energy.

Could cosmic microwave background have served as metabolic energy source for prebiotic life-forms?

In the prebiotic phase at interstellar space the temperature was very low and the water blobs were below tri-criticality so that the liquid phase was absent. Therefore quantum criticality could relate to the sublimation of ice.

Stars are a possible source of metabolic energy but what about the cosmic microwave background as a heat bath providing metabolic energy for water blobs as prebiotic life forms?

1. Energy 3.5 meV assigned with the action potential corresponds to $T \simeq 35K$, which is roughly $T_{phys}/10$, and near to the temperature of the cosmic microwave background in the early Universe with age about 1 Gy. There is evidence that important biomolecules were present already at this time although chemistry should have been frozen. A TGD based explanation of this finding has been considered in [L148].

2. Could the heat bath defined by the cosmic microwave background (CMB) have served as a source of metabolic energy in the interstellar space during the prebiotic period providing the energy needed to induce action potential? The periodic generation of the action potential as a sequence of pairs of BSFRs would be analogous to breathing or sleep-awake cycle [L144].

   During the sleep period, the water blob would dissipate with a reversed arrow of time and effectively extract thermal energy from the environment. During the wake-up period after BSFR, the blob would dissipate this energy to both internal and external degrees of freedom. The blob would also receive energy from the CMB background serving as a heatbath. The energy dissipated in the internal degrees of freedom would have served as a metabolic energy driving self-organization and gradual chemical evolution in the presence of carbohydrates and atoms needed by the basic organic molecules.

3.2.6 Could quantum criticality make microtubules very special?

MTs are regarded as very special in P-H theory. Their role at the level of the brain indeed seems to be very special. Why should MTs be so special from the point of view of consciousness?

Quantum criticality is the key feature of the TGD Universe, in particular that of living matter. Quantum criticality makes possible quantum fluctuations and long range correlations at the level of MB realized as a superposition of phases with varying value of $h_{gr} = GMm/v_0$ and and therefore of scaled variants of MBs. Space-time surface in the superposition would correspond to slightly different values of v_0.

MTs are critical systems in the sense that their length fluctuates wildly and their decaying region expands also in transversal directions. This fluctuation could reflect a superposition of quantum critical dark matter at MB with varying values of $h_{eff} = h_{gr}$ and thus different size scales of flux tubes proportional to h_{eff}.

The variation of the flux tube scale would be proportional to $\Delta v_0/v_0$ and, as already proposed, presumably quantized by number theoretical reasons. $\beta_0 = 1/n$ is perhaps the realistic option. The changes of MT lengths could have an interpretation as being induced by the scalings of MB of MT with respect to origin near the passive end of MT so that the scaling would be largest at the active end.

3.3 Appendix: Quantum gravitational decoherence as a way to test the Diosi-Penrose model

The approach of Donati et al [D5] to test the Penrose-Diosi variant of the Orch-Or [J13] model yielded a null result. In the sequel, the Diosi-Penrose model is discussed from the point of view of standard quantum theory predicting the negative outcome and the experiment of Donati is summarized. Also the TGD view of the situation is briefly described.

3.3.1 Brief summary and criticism of Penrose-Diosi model

A natural starting point idea would be that ordinary quantum coherence induces quantum gravitational coherence.

1. Quantum superposition of 3-geometries dictated by mass distributions of particles defined by particle wave functions. The wave function of the many-particle system is a superposition over configurations with localized particles and each configuration corresponds to a superposition of gravitational potentials defining gravitational self-energy.

2. In general relativity, this superposition corresponds to a point in the space of 3-geometries, the superspace of Wheeler consisting of 3-geometries. Therefore quantum gravitation is unavoidable and quantum coherence for matter dictates that for the gravitation. Therefore ordinary quantum theory forces quantum gravitation in the counterpart of the superspace.

   In this view, the rate of quantum gravitational dehorence corresponds to the rate of ordinary quantum coherence: this conforms with Einstein's equations and Equivalence Principle.

3. It is essential that one has a many-particle system. For a single particle system the gravitational self-energy is the same for all positions of the particle and does not depend on the wave function at all. Even for many particle systems, the superposition of shifted systems have the same gravitational binding energy.

   In the Penrose-Diosi model, it is however proposed that the above argument works for single particle and gravitational interaction energy is estimated by assigning to wave function an effective 2-particle system.

   The underlying reason for this assumption is the idea that the notion of wave function and therefore also wave function collapse somehow reduces to classical gravitation.

This argument predicts a null result in any experiment trying to demonstrate gravitational quantum coherence in the sense of Penrose-Diosi.

3.3.2 Could one measure the rate of gravitational quantum decoherence in the Penrose-Diosi model?

In the Penrose-Diosi model [J13], the quantum gravitational coherence can in principle be detected by measuring the rate for gravitational quantum decoherence.

1. Quantum gravitational decoherence for a wave function representing a superposition of mass distribution and a shifted mass distribution is considered.

   The idea is gravitational quantum coherence could be detected if the corresponding quantum decoherence occurs faster than other forms of decoherence. The basic objection is that the Equivalence Principle states that the two decoherences are one and the same thing.

   If the gravitational coherence time is short enough but not too short, this might be possible. Limits for the decoherence time τ_{gr} are proposed and are between millisecond and second: these are biologically relevant time scales.

2. Gravitational quantum decoherence time τ_{gr} is estimated by applying Uncertainty Principle: $\tau_{gr} = \hbar/\Delta E_{gr}$. ΔE_{gr} is the difference between the gravitational self-energy for a system and a shifted system.

One has actually a superposition of different classical configurations each inducing a classical gravitational field. Wave functions for particles of *many-particle state* define the gravitational superposition. Gravitational superposition coded by a wave function for a large number of particles. In this case, gravitational binding energies E_{gr} ΔE_{gr} between 2 different quantum states are well-defined.

One could take atomic physics as a role model in the calculation of the change of the gravitational potential energy. Coulomb energy would be replaced with gravitational potential energy.

3. With a motivation coming from the notion of gravitational wave function collapse, one however considers *single particle* states obtained as a superposition of $\Psi(r)$ and its shift $\Psi(r+d)$. In this case, the gravitational interaction energy is not well-defined unless one defines it as a gravitational self-interaction energy, which however does not depend on the position of the particle at all and is same for local state and the bilocal state.

   Penrose suggests that the difference between gravitational interaction energies makes sense and can be estimated *classically* using effective mass densities $m|\Psi^2|(r)$ and $m|\Psi(r+d)|^2$ instead of $\Psi(r)$ and $\Psi(r+d)^*$. One seems to think that one has effectively a two-particle system and calculates the gravitational interaction energy for it. To me this looks like treating a delocalized single-particle state as a two-particle state.

4. The situation could be simplified for a superposition of a macroscopic quantum state, say B-E condensate, and its shift. One could try to detect decoherence time τ for this situation. Now however the fact that B-E condensate is effectively a single particle, suggests that the change of the gravitational self-interaction energy vanishes.

5. It turns out that it is not possible to find parameter values which would allow a test in the framework of recent technology.

   The intuitive idea is that the gravitational SFRs localizing the wave functions effectively induce instantaneous shifts of particles. For charged particles this induces accelerated motion and emission of radiation. This radiation might be detectable. The implicit assumption is however that a single particle state effectively behaves like a 2-particle state as far as gravitation is considered.

   No evidence for this radiation and therefore for gravitational SFRs is found.

One can represent several critical arguments against the Penrose-Diosi model besides the argument represented in the beginning.

1. The reduction to a single particle case does not make sense in standard quantum physics (Penrose suggests something different). The gravitational self-interaction energy is the same for both shifted single particle states for any single particle wave function. For many-particle states the situation would change.

2. The radiation should have wavelength λ of order of the shift parameter d. d is expected to correspond to atom size or nuclear or nucleon size in the case of atoms. The energies for photons would be above 10^4 eV. These energies are suspiciously large. Much larger shifts would be required but these are not plausible for the proposed mechanism.

3. Why shifted mass distributions are assumed? Even in the case of many-particle systems the gravitational self-interaction energy does not depend on wave function if the system is only shifted. The reason is that the relative positions of particles are not changed in the shift.

   If one uses many-particle states, a superposition of scaled mass distributions would be more natural in the standard quantum physics framework. A coherent, easy-to-calculate, change of the gravitational interaction energy. A possible connection with density changing phase transitions, such as melting and boiling, emerges. Water is a key substance in living systems!

3.3.3 The approach of Donadi et al

The model proposed by Donadi et al is as follows.

1. A many-particle state with delocalized single particle wave functions induces superposition of 3-geometries shifted with respect to each other. Now a superposition of a quantum coherent state and its spatial shift is considered.

2. The estimation for the gravitational decoherence time τ for Orch-OR from Uncertainty Principle: $\tau \sim \hbar/\Delta E_{gr}$. ΔE_{gr} is quantum uncertainty of the gravitational binding energy. Change in the gravitational self-interaction energy in the formation of superposition of shifted configurations.

3. One must calculate the average value of the binding energy for a single particle state effectively regarded as 2-particle state. The outcome is finite. ΔE_{gr} is assumed to be effectively the change of classical self-interaction energy for a mass density $\rho = m|\Psi|^2$, m the mass of the particle. Ψ can be solved from Schrödinger Newton equation. Point-like particle is replaced with the wave function of the particle defining a mass density.

   How could one test the model? There are two approaches.

Direct measurement of gravitational decoherence time τ_{gr} is not possible

Gravitational decoherence should be faster than ordinary so that ordinary causes of decoherence are not yet active. Could one find such a system and be able to measure τ_{gr}.

1. A direct test of the equation of τ requires creating a large superposition of a massive system, to guarantee that τ_{gr} is short enough for the collapse to become effective before any kind of external noise disrupts the measurement.

2. Penrose and collaborators suggested a setup for creating a spatial superposition of a mirror of mass 10^{-12} Kg that has a decay time of order $\tau_{gr} \sim 0.002 - 0.013$ s, which is competitive with standard decoherence times.

3. The major difficulty in implementing this and similar proposals consists in creating a superposition of a relatively large mass and keeping it stable for times comparable to τ_{gr}.

   (a) To give some examples, the largest spatial superposition so far achieved is of about 0.5 m, but the systems involved are Rb atoms (mass $m = 1.42 \times 10^{-25}$ Kg), which are quite too light.

   (b) In matter-wave interferometry with macromolecules states are delocalized over distances of hundreds nm, and masses beyond 25 kDa (10^{-23} Kg), still not enough. Mass too small!

   (c) By manipulating *phononic* states, collective superpositions of estimated 10^{16} carbon atoms (mass $\sim 10^{-10}$ Kg) are created over distances of 10^{11} m, coherence scale is about 10^{-5} meters, neuron size. The life-time of phonons is of order 10^{-12} s, which is too short. 2 ms is the lower bound for τ.

   What does this mean? A superposition of wave functions with mean positions differing by 10^{-11} m define mass densities? Coherence scale 10^{-5} m.

   These numbers show that keeping the measurement of τ is beyond the reach of recent technologies.

Could Brownian-like diffusion as a side effect allow the detection of gravitational wave function collapses?

The assumptions of the model of Donadi et al [D5]) are as follows.

1. Penrose-Diosi model is assumed and single particle states are considered. Gravitational wave function collapse is Poissonian: collapses occur independently.

2. Lindblad dynamics for the density matrix ρ of the system is assumed. Gravitational decoherence implies non-unitary dynamics. The form of the decoherence term is dictated by the difference between gravitational self-interaction energies. $Tr(\rho p^2)$ increases with time. Diffusion would heat the system. The size scale range $R_0 = 10^{-14} - 10^{-15}$ m for the system experiencing gravitational collapse is excluded experimentally.

3. This leaves however dissipative effects. One can argue that the collapse induces an emission of radiation by charged particles since effectively the charged particle is in instantaneous motion during the collapse. In collapses particles are randomly moved and radiate. The wavelength λ of the radiation is smaller than charged particle size: atom size or even nuclear or nucleon size.

   The first criticism is that one has a single particle state and according to the standard view gravitational self-energy does not depend on the wave function. The second criticism is that the scale of energies of photons is huge as compared to intuitive expectations for gravitational interaction energies.

4. The intensity of the radiation can be estimated. The predicted radiation intensity is weak but detectable. The wavelength of the radiation emitted in gravitational collapse should be of the order d. For d in the range of proton wavelength and atomic size scale, the energy would have a lower bound 10^4 eV. This looks unrealistic.

5. The radiation was not detected. No evidence for the proposed kind of collapse was observed in the expected range between atomic scale and proton Compton length.

3.3.4 Comparison with the TGD view

A brief comparison with the TGD view is useful.

Some suggestive observations

There are some suggestive observations which might be used to end up with a TGD based view of the role of quantum gravitation in living matter.

1. The gravitational binding energy of protons in the Earth's gravitational field is about .5 eV. For electrons one has .25 meV. These are biologically relevant energy scales!

2. Could quantum gravitation be quantum coherent in long, even astrophysical scales? For a macroscopic system GMm is the counterpart of coupling strength. If the entire system $M + m$ behaves like a quantum coherent system, the perturbation series is with respect to gravitational fine structure constant $\alpha_g r = GMm/\hbar \gg 1$ and does not converge.

3. Nottale hypothesis introduces gravitational Planck constant $\hbar_{gr} = GMm/beta_0$, $\beta_0 = v_0/ \leq 1$. Gravitational Compton length $\Lambda_{gr} = GM/beta_0 = r_s/2\beta_0$ ($r_s = 2GM$ is Schwartschild radius) of order Earth radius for M=M(Sun) and about .45 cm for $M = M(Earth)$ the size of snowflake. α_{gr} is replaced in the quantum phase transition $\hbar \to \hbar_{gr}$ with a universal coupling strength $\alpha_{gr} = beta_0/4\pi < 1/4\pi$: the perturbation series converges!!

What kind of quantum superpositions should one consider?

Gravitational fields have infinite range and are not screened. This suggests that long range quantum coherence induced by them is possible.

1. The notion of MB carrying dark matter in the TGD sense is an essential notion. Scaled versions of magnetic bodies carrying quantum coherent dark matter with $\hbar_{eff}$. For gravitational quantum coherence one has $\hbar_{eff} = \hbar_{gr}$. Quantum coherence of MB would induce the coherence of ordinary matter forcing its quantum gravitational coherence.

2. In TGD gravitationally quantum coherent states would not be superpositions of shifted 3-geometries. Coherent and large change of the self-interaction energy takes place in the scaling. Therefore superpositions of scaled versions of 3-D surfaces are more natural.

3. Ordinary phase transitions such as melting and evaporation involve density fluctuations, which would be induced by scalings. Quantum superposition of states with different densities at thermal criticality induced by quantum criticality.

4. Water as a liquid has a very special role: it has hundreds of thermodynamic anomalies. The strongest ones are in the physiological temperature range. There is evidence that several phases are simultaneously present. Could this reflect the presence of several dark phases at the MB.

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Chapter 4

New Results about Microtubules as Quantum Systems

4.1 Introduction

This article was written around 2014 but at the end of the article there is an addition about the discovery published 2024 that living matter (microtubules) seems to allow quantum coherence in mesoscales.

Around 2014, the latest hot news in quantum biology was the claim about corroboration of the Penrose Hameroff Orch OR theory (`http://www.kurzweilai.net/discovery-of-quantum-vibrations-in-microtu`) [J1]. In my humble opinion the news suffers from rather heavy hyping. If the observation by the group led by Anirban Bandyopadhyay about detection of quantum vibrations in microtubule scale (their lengths vary up to 50 μm) can be replicated ,and one can speak about a breakthrough in quantum consciousness. However, the results do not prove Orch OR, which involves poorly defined vision about quantum gravitational description of state function reduction, so that most predictions are just order of magnitude estimates relying on Uncertainty Principle.

The biological half of the theory relies on microtubules and for this side of the theory the claimed finding would of course be a victory. Indeed, there is a meeting in Amsterdam devoted to Orch OR theory of consciousness motivated by this finding (`http://www.brakkegrond.nl/programma/1253/Penrose_Bandyopadhyay_Hameroff/Lezing_Microtubuli_het_grote_debat_over_het_bewustzijn/#eng`). Unfortunately, I could not find any article about the findings of Bandyopadhyay online. I managed however to find two years old Youtube talk of Bandyopadhyay summarizing earlier experimental results supporting the vision about microtubules as macroscopic quantum systems (`https://www.youtube.com/watch?v=VQngptkPYE8`) [J4] to be discussed below. The talk describes in informal manner results, most of which can be found also in the articles [J19, J20, J22].

The findings reported in the talk give support for the general TGD inspired view about TQC and allow a rather detailed model in the case of microtubules. The idea is that flux tubes form a 2-D coordinate grid consisting of parallel flux tubes in two different directions: the guess that they could consist of helical Fibonacci flux tubes and their mirror images is not however convincing. Crossing points would be associated with tubulins and the conformational state of tubulin could define a bit coding whether the braid strands defining coordinate lines are braided or not (swap or not). In this manner any bit pattern at microtubule defines a particular TQC program. If also conformations are quantum superposed, one has "quantum-quantum computation" . It however seems that conformation change is irreversible chemical reaction [J17] so that this option is not feasible.

The TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. Coordinate grids can be fixed on the basis of the experimental findings and there are 8 of them. The interpretation is in terms of different resolutions. The grids for A and B type lattices are related by 2π twist for the second end of the basic 13-unit for the microtubule. An attractive interpretation for the resonance frequencies is in terms of phase transitions between

A and B type lattices. If A type lattices can be generated only in phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence, which isa strong objection against the Penrose-Hameroff model.

This would fit very nicely with the general vision about frequencies as passwords inducing not only directed attention but activities in target - also TQCs! The increase of Planck constant could be associated with the phase transition to A-phase making possible high T_c dark superconductivity for which evidence is observed! One can even deduce estimates for $h_{eff}/h = n$ if one requires that AC photons have energy above thermal threshold: $n = h_eff/h = f_{visible}/f_AC$ would be the estimate. For biophoton energies one would obtain something like $n \simeq 10^8 - 10^9$, which pops up in different contexts in the TGD framework.

This picture generalizes in the fractal universe of TGD. One can form layers of 2-D coordinate grids and connect them by vertical flux tubes to obtain 3-D grid defining TQC. The brain is known to have grid-like architecture and neurons could by quantum computation produce bit/qubit-defining swap or not/superposition of swap and not-swap for a larger scale TQC. One would have fractals of TQCs. One can even think 4-D grids in the Euclidean spacetime regions (predicted in TGD Universe) with 6 bits defining the swaps at each crossing point: could this have something to do with the genetic code?

A further idea is that 1-braid TQC generalizes in a natural manner to 2-braid TQC in the TGD framework (for 2-braids see [K53]). The knotting occurs for string world sheets defining the orbits of braid strands - say magnetic flux tubes idealized to strings. In the case of microtubules this option suggests itself strongly. The emergence of MTs could have meant emergence of 2-braid TQC and the increase of abstraction level in the information processing. Note that 2-braiding is possible only if string worlds sheets "live" in 4-D space-time: for superstrings "living" in higher-D space-time this is not possible.

About 10 years later (2024), Babcock et al [**?**] reported on the evidence for a mesoscale quantum coherents consisting of microtubules, and this finding seems to be taken rather seriously also by the mainstream. During these 10 years, the TGD inspired quantum biology has developed considerably [L145, L150, L167] and in this article I combine the recent TGD based view of the findings of Bandyopadhyay and of Babcock et al.

4.2 Theoretical ideas

The theoretical ideas of three models relevant to the experiments of Bandyopadhyay will be discussed first. The theories are the Penrose-Hameroff theory, Bandyopahdyay's theory and TGD as it was for a decade ago.

4.2.1 Penrose-Hameroff theory

Approximately two decades ago Penrose and Hameroff proposed a model that they called Orchestrated Objective Reduction (Orch OR) [J27]. Besides the highly speculative quantum gravity related ideas, the model assumes that microtubules are quantum coherent systems essential for consciousness. For the importance of microtubules one can find a lot of qualitative support. A I believe that microtubules are important for consciousness and I have developed ideas about the role of microtubules [K73]. Personally, however, I find it difficult to believe in the reduction of consciousness to microtubular level, but see microtubules as one particular layer in the hierarchy of conscious entities. Personally, I would prefer fractality over the naive length scale reductionism.

Many objections [J17] against the biological feasibility of Orch OR (`http://en.wikipedia.org/wiki/Orchestrated_objective_reduction`) [J27] have been raised. For the latest response of the authors to the criticism see [J25]. There are two basic challenges: one should formulate precisely what Orch OR really means and be able to identify the qubit.

1. The basic vision about quantum superposition of space-time geometries gives rise to consciousness as something analogous to quantum computation. State function reduction would thus reduce to a mechanism rather than being something irreducible. Most quantum physicists would disagree about this. The quantum superposed geometries would be protein conformations. Since there is no theory of quantum gravity, the proposal boils down to the ad hoc estimate for the time τ for Orch OR to take place claimed to be $\tau = \hbar/E_G$, where

E_G is the difference of gravitational energies for the superposed geometries. The estimates favor nuclear scale 5 fm and one needs a coupling between nano-scale physics of electrons and physics nuclei and London forces are suggested to be responsible for this coupling. It deserved to be mentioned that the gravitational energy for a blog of water with radius around 10^{-4} meters - the size scale of a large neuron - is about Planck mass so that gravitation and biology might relate. In my own proposal involving large gravitational Planck constant assigned to space-time sheets mediating gravitational interaction, Planck mass might serve as a threshold above which large values of Planck constant would emerge [K94, K75].

2. Concerning the identification of qubit there is a long list of suggestions. The superposition of tubulin conformations was one of the first proposals. Reimers [J17], who has criticized heavily Orch-OR proposal, reports that irreversible chemical reaction is responsible for selecting conformation so that quantum superpositions would not make sense. Conformational switching could however be involved with classical computational aspects of biological information processing and Hameroff has proposed before Orch OR that microtubules could act as classical cellular automatons.

   Also other proposals for qubit have been made. Quantum fluctuations generating London force between electric dipoles could somehow give rise to qubits. Also magnetic dipoles, nuclear spin, AC current flow, and synergistic modes have been mentioned. Also the identification of qubit as a helical conduction pathway has been proposed ("Oscillating London force dipoles in resonance rings in helical pathways through microtubule lattices"). It is difficult to imagine what the two superposed states defining qubit would be. For instance, could qubit correspond to electron current running in two different directions and is quantum superposition possible at criticality for a phase transition inducing the change of the current direction? For this option the information storage capacity of microtubule would be rather modest. In also difficult to see the claimed connection with topological quantum computation since braiding gives rise to entanglement between states at the ends of the braids.

Orch OR proposal involves several interesting ideas probably relevant for quantum consciousness.

1. Aromatic rings have probably some deep role in quantum consciousness. For instance, most psychoactive biomolecules and also DNA and three amino acids contain them. Hameroff and Penrose trace this role to the London force between aromatic rings and quantum fluctuations making them qubits. I am unable to imagine what the exact proposal is. In any case, what is known is that electrons at aromatic rings are delocalized.

   Comment: My own humble proposal is that electrons could be further delocalised at magnetic flux tubes in longer scales and make cyclotron BE condensates of dark electrons or their Cooper pairs possible. They would make possible the coupling between receptor-information molecule complexes and magnetic bodies at various levels of hierarchy. Hierarchy of Planck constants and negentropic entanglement suggests the existence of a new kind of state consisting of electrons (that is fermions) but analogous to Bose-Einstein condensate.

2. The idea about insulation provided by hydrophobic pockets of proteins against fluctuations destroying quantum coherence is nice and it would be natural to put aromatic rings into these pockets.

3. The needed long value of Orch OR decoherence time τ (originally assumed to correspond to 40 Hz thalamocortical resonance frequency) is one of the problems of Orc OR and the recent discovery of EEG like oscillations in kHz range [J21] is claimed to make the situation more tolerable.

   Comment: Fractal hierarchy of EEGs mediating communications between parts of biological body and corresponding magnetic body is basic prediction of TGD and the observation seems to provide evidence for this prediction.

4. Reimers et al challenges [J18] also Fröhlic Bose-Einstein condensation [J24] and claims that according to his own simulations the resulting state is extremely incoherent [J18]. There

are however models which give Bose-Einstein condensation [J2] and the in [J4] the experimental findings about assembly of microtubules are interpreted as Fröhlic condensation. The frequency inducing the condensation would be however 3 orders of magnitude lower than predicted by Fröhlich.

There is a further puzzling result (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2114131/pdf/jc10231067.pdf) [J16] in conflict with the assumption of Orch OR that brain microtubules are dominantly so-called A-type tubules. Brain microtubules are re-assembled in vitro form lattices of type B and for them the lattice must have surface discontinuities. This makes sense for microtubules which are partially fused together as in the structures consisting of cylinder whose surface is formed by 9 units consisting of 3 microtubules glued together along their sides. This would not allow Fibonacci helices proposed by Penrose and Hameroff to serve as conducting pathways defining the analogs of braid strands in their model for microtubule as a topological quantum computer (TQC) unless one is ready to give up helical symmetry. One way out of the difficulty would be that vitro results do not hold in vivo but Kikkawa et al has shown that all in vivo microtubules have lattice of type B (http://jcb.rupress.org/content/127/6/1965.abstract) [J14].

The above mentioned article concludes that only the lattice B is realized in nature. This lattice does not possess helical symmetry. After each full turn along sequence α or β tubulin sequence there is a shift as the figure 2 of the article demonstrates: this discontinuity is called seam in the article. Furthermore, these helices can be said to have periodicity 5. The helix-like curve satisfies the condition $z = 4a\phi/2\pi$ and the n^{th} tubulins along the vertical are located at $z(n) = na$, a the size of the tubulin. For $\phi = 2\pi$ one has $\Delta z = a$ rather $\Delta z = 0$ as figure 2 of the article shows. This discontinuity could have some important biological meaning.

Hameroff, Nip, Porter, and Tuszynski have an article about microtubules as topological quantum computation written in 2002 [J12]. They do not give any justification for why the conduction pathways should correspond to Fibonacci numbers but the article by Hameroff represents evidence that the important certain amino-acids crucial for consciousness inside tubulin molecules are located along the Fibonacci conduction pathways (http://www.quantumconsciousness.org/biosystemselsevier.htm) [J12].

2011 Hameroff and Penrose considered the possibility that microtubules could perform topological quantum computation. The proposal of Penrose and Hameroff (http://www.quantumconsciousness.org/biosystemselsevier.htm) [J12] assumes realization of braiding in terms of helical braids strands assignable to A-type microtubules (which according to experimeters do not exist in brain and - as it seems - in living matter in general). In the simplest realization the strands are parallel to each other and have horizontal periodicity characterized by 13 tubules. Also Fibonacci pathways with horizontal periodicity of 3, 5, and 8 are Fibonacci pathways. The strands with different periodicities can intersect and can therefore be braided. One can also construct left- and right handed variants of the strands and left- and right-handed strands intersect periodically with a period of 13. The experiments discussed in bneumtvideo however suggest a different kind of braidings.

In the intersection points braiding (swap) operation could be realized meaning that the first strand goes either over or below the second one. Gupta and Hameroff suggests that MAPs are responsible for this kind of swap and thus define the fundamental quantum gates for TQC (https://sbs.arizona.edu/project/consciousness/report_poster_detail.php?abs=1435) [J23]. Of course, also more complex gates can be imagined but swap is enough to build universal TQC. Official biology assigns to MAP many other functions associated with MAPs but also this function can be imagined. Penrose and Hameroff have also consider the possibility that topological qubits are represented in terms of quantum superpositions of helical pathways with 13-periodicity characterized by the gap between neighboring pathways.

4.2.2 The identification of Bandyopadhyay for conduction pathways

In his Youtube talk Anirban Bandyopadhyay (https://www.youtube.com/watch?v=VQngptkPYE8) [J4] discussed an identification of conduction pathways different from that of Penrose and Hameroff. In [J22] Gosh, Sahu, and Bandyopadhyay argue for evidence for massive global synchronization in brain and claim that experimental findings support the Penrose-Hameroff theory. In the article "Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly" [J19] it is reported that ordered water inside

microtubule is necessary for the conduction inside microtubule. According to the same article the tubulins inside microtubules have the same energy levels in chemical energy range as isolated tubulins which suggests that the mechanism binding tubulins to form MT is not chemical. In the article "Multi-level memory-switching properties of a single brain microtubule" [J20] it is reported that the hysteresis curve for current along MT as a function of voltage is an ideal square curve meaning that there is no dissipation involved with the change of the current direction. This would make MT an ideal memory device. Whether Penrose/HAmeroff have in mind the use of current direction as qubit remains unclear. In the video talk, Bandyopadhyay also refers to these results.

I consider only the general proposal discussed in the video lecture here: the Youtube representation gives concrete illustrations of conduction pathways.

1. It is assumed that there are two kinds of hexagonal tubulin lattices labelled as A and B. As found there is strong evidence that A-type tubules do not exist stably. For both types the tubulin dimers defining dipoles are nearly axial and define candidates for conduction paths with winding periodicity of 13 tubulin dimers. For B type one has rows made of α or β type tubulins along with α and β have an effective periodicity of five if one accepts discontinuity at after 2π rotation. One might think that this dictates the choice of the candidates for the conduction paths to consist of sequences of $\alpha - \beta$ dimers: for these sequences are along the microtubule. If hops occur between α and β this assumption is natural. The proposed pathways are however more general and - as it seems to me - based on rather an ad hoc mathematical rule.

2. The notion of helical conduction pathway is the starting point. For B-type tubules this notion must be modified. Presumably the criterion for what it is to be a helical pathway is that they are straight-lines connecting nearest neighbors to each other- this is natural if conduction is identified as hopping between neighboring tubulin molecules. The position of each pathway represented by a value of discrete dynamical variable replacing spin as representation of qubit -essentially the angle $\phi = n \times 2\pi/13$ is in question. There are 13 different values for ϕ. For A-type conducting pathways, the condition that one has a $\alpha - \beta$ sequence very probably gives the claimed pathways with periodicity 13. One can ask whether the pathways of type A are obtained by twisting the pathways of type B at the second end by 2π and whether living systems could be able to perform this twist to achieve phase transition between two states of the microtubule.

3. Instead of a single pathway one considers groups of parallel pathways consisting of translations of a fixed pathway with a fixed gap $\Delta\Phi_{gap} = n_{gap}2\pi/13$ along the circumference of the microtubule. I failed to understand the motivation for this: maybe the idea is that the additional degree of freedom makes possible the analog of spin degrees of freedom as the angular position of the pathway. One could also consider the possibility that the translations of a pathway define a braid: this braid would be however trivial since the pathways are parallel. If I have understood correctly, topological qubits would be represented as quantum superpositions of helical conduction pathways with the same gap $\Delta\phi = n_{gap} \times 2\pi/13$ between neighboring pathways. This is not what TGD suggests.

4. By $n = 13$ modulo arithmetics it can show that the series of pathways with $n = kn_{gap} \ \ mod \ \ 13$, $k = 1, 2, ...$ generates additional gaps. One says that the decomposition occurs. The addition of translated parallel pathways can also lead to a pair of pathways with $n_{gap} = 0$ or $n_{gap} = 1$ in which case pathways overlap or touch. This is not allowed. What this means physically is unclear to me. One could also avoid touching simply by allowing only the translates to be such that $kn_{gap} \leq 13$ holds true: even weaker condition can guarantee this.

4.3 The observations of the group of Anirban Bandyopadhyay from the TGD point of view

The observations of Anirban Bandyopadhyay are briefly summarized by Massimon Pregnolato at `http://www.quantumbionet.org/admin/files/MassimoPregnolato-RitaPizzi2011.pdf`. At this stage one can of course several models for the findings and in the following one option is selected.

1. The most plausible model is based on the notion of coordinate grid formed by longitudinal and transversal magnetic flux tubes whose crossing points are the points at which swap occurs or does not occur depending on the state of tubulin dimer. The grids associated with A and B tubules are obtained by a 2π twist for the upper end of the tubulin.

2. There are a large number of options for grids and they are identified on the basis of the experimental findings. Transversal coordinate lines would correspond to the 7-periodic parallel lines with either gap 2 or 3 (gap 4 lines decompose to gap 4 and gap 2 lines) and longitudinal coordinate lines to one of 4 line groups involving four gaps so that 8 coordinate grids are obtained and related by a 2π twist for A and B tubules respectively. Gaps could characterize measurement resolution.

3. For A-type microtubule one can consider also Fibonacci grids constructed from helical curves and their mirror images with periodicities 3,5,8,13 and arbitrary gaps but it seems that it is difficult to interpreted the resonance frequencies and understand their number for this option.

4.3.1 Fröhlich B-E condensation or something else?

Excitation at the resonance frequencies causes microtubules to assemble extremely rapidly. This is proposed to be due to Fröhlich condensation. The resonance frequency of AC stimulation leading to a rapid generation of microtubules in the length scale range $[.2 - 22.5]$ μm is around 8 MHz. There is correlation between resonance frequencies and lengths of microtubules and qubit sets that are possible.

Comment: The identification as formation of Fröhlich B-E condensate can be criticized. The frequency at which this would take place was predicted by Fröhlich to be around GHz rather than in the MHz range.

In the TGD framework AC stimulation could generate a flux tube grid or activate an existing magnetic flux tube grid forming a braid-like structure serving as a template for the formation of microtubules around it. If the formation of the grid corresponds to quantum criticality, the resonance frequencies could also generate phase transitions between A and B type states of the microtubuli. AC signals could also generate contacts to these flux tubes making possible supra currents. The formation of microtubules is known to proceed by the formation of vertical nucleotide polymers which are then glued together horizontally: flux tubes could serve as a template for the formation of the nucleotide polymer. The magnetic fields at flux tubes can be accompanied by helical electric fields (in this case both magnetic and electric fields are helical) and these fields could be responsible for the polarization of microtubule and induce the growth of microtubules in such a manner that the polarized alpha-beta tubulin always attaches in the same manner to the growing polymer. Fröhlich condensation would be a consequence of generation of flux tube coordinate grids defining microtubule skeleton- growth of the magnetic body would precede that of biological body.

The length of the tubule increases with resonance frequency which suggests that a single tubulin dimer is added to the polymer during each cycle. MHz range and formation time around a few seconds. This would mean something like 10^6 giving MT with length of order 10^{-4} meters. The order of magnitude is correct.

4.3.2 8 resonance frequencies in AC stimulation and 8 distinct interference patterns

Microtubules are reported to have 8 resonance peaks for AC stimulation (kilohertz to 10 megahertz), which appear to correlate with various helical conductance pathways around the geometric microtubule lattice. The explanation is proposed in terms of current pathways which are identified as topological qubits.

Comment: To me this terminology looks strange and confusing. Why not speak about braid strands or specify what topological qubit means if one is speaking about TQC? I am unable to understand why groups of parallel pathways are considered as topological qubits (TQs). The idea about parallel translates might however make sense.

As already explained, the notion of coordinate grid in the sense discussed is consistent with the findings. The resonance frequencies could correspond to phase transitions changing A-type coordinate grids to B-type or vice versa. Coordinate grid would define the basic architecture of TQC.

The second claim is that there are altogether eight distinct quantum interference patterns from a single microtubule, each correlating with one of the 8 resonance frequencies and pathways. According to the interpretation discussed in the talk 4 sets of four pathways representing quantum TQ each can exist simultaneously for type A microtubules claimed to be ideal for quantum computation. Lattices of type B exhibit 4 different pathways and are claimed to be ideal for communications. The lattices A and B are complementary in the sense that together they allow all possible pathways (this is not quite true: $n_{gap} = 12$ is lacking). The set of possible pathways depends on the length of MT.

Comment: Also this would conform with the TGD inspired model in which one has 8 coordinate grids for tubules of B and their deformations by twist to A type tubules. The 8 interference patterns would correspond to different coordinate grids. What coordinate grids are physically allowed coordinate grids depends on the length of the microtubule.

4.3.3 Observations about conductivity

There are also several observations about conductivity suggesting quantum coherence.

1. In assembled microtubules AC excitation at the resonant frequencies causes electronic conductance to become lossless, or 'ballistic', essentially quantum conductance, presumably along these helical quantum channels. Resonance in the range of kilohertz demonstrates microtubule decoherence times of at least 0.1 millisecond. Does this mean that AC signals at resonance frequencies are able to create these channels or groups of them?

   Or does this mean that the resonance signal transforms the microtubule to A (or B) type lattice which is highly conducting or even super-conducting (via magnetic flux tubes). The claim that A type lattice does not exist in vivo reduces to the statement that it does not exist stably in vivo. The AC signal at resonance frequency induces the twist taking lattice B into lattice A in which TQC is possible.

2. There are three frequency scales corresponding to kHz Hz, MHz and GHz ranges. The natural identification for these rather low frequency scales is in terms of cyclotron frequencies of dark electrons and possibly also various ions at magnetic flux tubes. The simplest identification would be in terms of three ranges for the strengths of magnetic field. I have proposed that .2 Gauss magnetic field define endogenous magnetic field explaining the effects of ELF em radiation on brain in terms of cyclotron transitions of biologically important ions, in particular Calcium ions for which cyclotron frequency would be 15 Hz (later an alternative explanation making essentially the same predictions has emerged). For electrons the cyclotron frequency would be .5 MHz so that for 16 times strong field would correspond to cyclotron frequency of 8 MHz appearing as resonance frequency. GHz frequency would require a magnetic field of .04 Tesla.

3. It is stated that the system cannot be classified as an insulator, semiconductor, or conductor. The reason would be that the two bands involved do not overlap as in conductors, are not completely separate with a large gap as in insulators, nor separate with a small gap. Instead the bands touch each other in a pointwise manner.

   Comment: Stimulus with the resonance frequency could regenerate the flux tubes or bridges to the flux tubes allowing the transfer of electrons to them. The ballistic resistance temperature independent resistance would be due to a very long free path or due to super-conductivity at the magnetic flux tubes - the latter is the TGD inspired hypothesis. This kind of behavior could result if the electrons can leak to the flux tube only if they have the same momentum as the Cooper Bose-Einstein condensate at the flux tube. Resonance condition would mean that the magnitude of the wave vector of electron is quantized in magnitude: this would also support the proposed interpretation.

4. It is claimed that conductance does not depend on microtubule length, is temperature independent, and has discrete values. Also ohmic dissipation is claimed to be negligible.

Comment: The interpretation could be in terms of superconducting current pathways defined by magnetic flux tubes that looks natural as already found.

The observation that water is necessary for MT conductivity [J19] suggests that the presence of water is essential for large h_{eff}. One of the many possibilities is that the flux tubes (which are closed) return through the interior of MT containing the ordered water. Also dark variants of genes realized as dark proton sequences dark nuclei could be involved.

4.3.4 Ferroelectric hysteresis

What is interpreted as ferroelectric hysteresis is claimed to demonstrate memory capacity in microtubules [J20]. Current viz. voltage over the microtubule exhibits square hysteresis. Suddenly all-in one jump, changing the direction of current at critical voltage, occurs. This is analogous to ferromagnetic or ferroelectric behavior but in a completely quantal manner.

One can ask whether the quantum superpositions of two current directions might represent qubit. If so, the information processing capacity of microtubule would be rather modest unless one seriously considered 2-braid TQC (recall however that in neuroscience a single neuron is assumed to represent bit).

It is not at all obvious that ferroelectric hysteresis is in question and TGD suggests a different interpretation for the hysteresis curve. The current as function of voltage could reflect quantum coherent current in Bose-Einstein condensate of electronic Cooper pairs with all Cooper pairs having the same momentum. Macroscopic quantum coherence would make the state stable against perturbations defined by the external voltage and only when the voltage exceeds critical magnitude the state would change its momentum to opposite values instantaneously. If the interpretation as cyclotron BE-condensate is correct one would have Cooper pairs with spin 1 at the same state and effectively only a single particle representing memory.

The assumption of Bose-Einstein condensate might be unnecessarily strong: negentropic entanglement might be enough. Dark electrons are negentropically entangled and the entanglement stores potentially conscious information. The degeneracy of the ground state essential for achieving stable enough entanglement also in standard approach to TQC. The negentropic entanglement would not be in spin degrees of freedom but in those labeling sheets of the covering of M^4 and CP_2 defined by the space-time sheet of electron. Anti-symmetry in these exotic degrees of freedom would make electrons bosons if seen from the perspective of standard physics and allow them to effectively B-E condense to the same state with respect to standard quantum numbers. Note that this proposal resembles somewhat the proposal of Hameroff and Penrose for topological qubits in terms of parallel current pathways with the same gap. In this case the negentropic entanglement could perhaps stabilize the state in the sense that NMP [K64] would not allow the quantum jump leading to the opposite direction of electron current to take place.

4.3.5 Dynamical instability of MTs

MTs are dynamically unstable and the length of MT changes in jumps. The conjecture of the talk is that some kind of language is involved. On the basis of few second time scales one can wonder whether the correspondence with language production could be rather direct. Could regions of type A contain the information communicated in speech, say the information needed to form words or sentences? If microtubules of type B are indeed responsible for communications, one can ask whether $A \to B$ phase transitions generate the signal in turn inducing the nerve pulse patterns correlating with internal speech. The connection with language could be realized also at gene level [K48].

I have proposed that a microtubule acts as a quantum antenna [K73] emitting radiation with frequencies $f_n = nc/L$, where L is the length of MT. The variation of the length of microtubule would predict frequency modulation of the radiation coding for potentially conscious information. The model for nerve pulse and EEG makes similar prediction [K85, K40]. Josephson frequency for cell membrane as Josephson junction is proportional to membrane voltage and the variations of membrane voltages due to oscillations and nerve pulse activity are coded to EEG via frequency modulation. Even ordinary speech involves frequency modulation as is clear by listening recorded speech with abnormally slow speed. If microtubules talk, the most natural language would be based on frequency modulation.

The system seems to be critical, maybe it is quantum critical in the TGD sense. At quantum criticality the dynamics involves a large number of length scales. In TGD framework quantum criticality would mean that the hierarchy of Planck constants is involved such that given length scales is proportional to the effective value of Planck constant. Maybe different lengths for flux tubes correspond to values of effective Planck constant $h_{eff} = nh$.

4.4 Evidence for mesoscopic quantum coherence in living matter

This section has been added 10 years after writing the original version of the article. Penrose-Hameroff Orch-OR proposal [J27] for a theory of consciousness raises microtubules in a special role. In the TGD framework also MTs could represent an important level in the scale hierarchy but would not be the only key players in the functioning of living systems. The key problem of all quantum theories of consciousness is whether and how the brain and biosystems in general can allow quantum coherence in mesoscales.

In the standard quantum theory this looks extremely implausible. Quantum Sabine Hossenfelder how tells in her video (see this) about the recently observed evidence for quantum coherence in mesoscales by Babcock et al [I35].

4.4.1 Experimental evidence for the mesoscale quantum coherence of living matter from superradiance

The abstract to the article of Babcock et al summarizes the findings.

Networks of tryptophan (Trp) an aromatic amino acid with strong fluorescence response are ubiquitous in biological systems, forming diverse architectures in transmembrane proteins, cytoskeletal filaments, sub-neuronal elements, photoreceptor complexes, virion capsids, and other cellular structures.

We analyze the cooperative effects induced by ultraviolet (UV) excitation of several biologically relevant Trp mega-networks, thus giving insights into novel mechanisms for cellular signaling and control.

Our theoretical analysis in the single-excitation manifold predicts the formation of strongly superradiant states due to collective interactions among organized arrangements of up to $\geq 10^5$ Trp UV-excited transition dipoles in microtubule (MT) architectures, which leads to an enhancement of the fluorescence quantum yield (QY) that is confirmed by our experiments. We demonstrate the observed consequences of this superradiant behavior in the fluorescence QY for hierarchically organized tubulin structures, which increases in different geometric regimes at thermal equilibrium before saturation, highlighting the effect's persistence in the presence of disorder. Our work thus showcases the many orders of magnitude across which the brightest (hundreds of femtoseconds) and darkest (tens of seconds) states can coexist in these Trp lattices.

From the article it is clear that the observed phenomenon is expected to be very common and not only related to MTs. From Wikipedia one learns that tryptophan is an amino acid needed for normal growth in infants and for the production and maintenance of the body's proteins, muscles, enzymes, and neurotransmitters. Trp is an essential amino acid, which means that the body cannot produce it, so one must get it from the diet.

Tryptophan (Trp) is important throughout biology and forms lattice-like structures. From the article I learned that Trp plays an essential role in terms of communications. There is a connection between Trp and biophotons as well. Trp's response to UV radiation is particularly strong and also to radiation up to red wavelengths.

What is studied is the UV excitation of the Trp network in the case of MTs. The total number of Trp molecules involved varies up to 10^5. The scales studied are mesoscales: from the scale of a cell down to the scales of molecular machines. The wavelengths at which the response has been studied start at about 300 nm (4.1 eV, UV) and extend to 800 nm (1.55 eV, red light) and are significantly longer than tubulin's scale of 10 nm. This indicates that a network of this size scale is being activated. The range of time scales for the radiant states spans an enormous range.

UV excitation generates a superradiance meaning that the fluorescence is much more intense than it would be if the Trps were not a quantum-coherent system. The naive view is that the response is proportional to N^2 rather than N, where N is the number N of Trp molecules. Superradiance is possible even in thermal equilibrium, which does not fit the assumptions of standard quantum theory and suggests that quantum coherence does not take place at the level of the ordinary biomatter.

In standard quantum physics, the origin of the mesoscale coherence is difficult to understand. Quantum coherence would be the natural explanation but the value of Planck constant is far too small and so are the quantum coherence lengths. The authors predict superradiance, but it is not clear what assumptions are involved. Is quantum coherence postulated or derived (very likely not).

4.4.2 The TGD based interpretation for the superradiance

I have considered MTs in several articles [L182] [K85, K73, K81]. In TGD, the rather obvious interpretation would be that the UV stimulus induces a sensory input communicated to the magnetic body (MB) of the Trp network: this signal is analogous to the EEG and in turn produces superradiance as a "motor reaction" of MB. The idea about MT as a quantum antenna is one of the oldest ideas of TGD inspired quantum biology [K73]. The communication would be based on dark photons involved also with the communications of cell membrane to the MB of the brain and with DNA to their MBs.

The Trp network could correspond to some kind of lattice structure or be associated with such a structure at the MB of the system. The notion of bioharmony [L24] [L111] leads to a model of these communications based on the universal realization of the genetic code in terms of icosa tetrahedral tessellation of 3-D hyperbolic space H^3 identifiable as light-cone proper time constant hyperboloid.

The icosa tetrahedral tessellation [L128, L165] is completely unique in that it has tetrahedrons, octahedrons, and icosahedrons as basic objects: usually only one platonic solid is possible. This tessellation predicts correctly the basic numbers of the genetic code and I have proposed that it could provide a realization of a universal genetic code not limited to mere biosystems. Could the cells of the Trp lattice correspond to the basic units of such a tessellation?

The work of Bandyopadhyay et al [J4, J22] (see also this) provides support for the hypothesis that there is hierarchy of frequency scales coming as powers of 10^3 (10 octaves for hearing in the case of humans) ranging from 1 Hz (cyclotron frequency of DNA) and extending to UV frequencies.

The hierarchy of field bodies could correspond to a hierarchy of MBs and electric field bodies (EBs). Gravitational MBs assignable to astrophysical objects [L145, L150] and EBs assignable to systems with long length scale electric fields [L167, L186] can be considered. They possess a very large value of the gravitational/electric Planck constant giving rise to a long length scale quantum coherence.

Gravitational MBs have a cyclotron energy spectrum, which by Equivalence Principle is independent of the mass of the charged particle. The discrete spectrum for the strengths of the endogenous magnetic field postulated by Blackman [J8] and identified as the non-Maxwellian monopole flux tube part of the magnetic field having minimal value of $2B_E/5 = .2$ Gauss would realize 12-note spectrum for the bioharmony [L111]. The spectrum of generalized Josephson energies assignable to the cell membrane depends only very weakly on h_{eff} whereas standard Josephson energy is independent of h_{eff} [L182].

Both cyclotron and Josephson frequency spectra are inversely proportional to the mass of the charged particle, which makes them ideal for communication between ordinary biomatter and dark matter. Frequency modulated signals from say cell membrane to the MB and coding the sensory input would propagate as dark Josephson photons to the MB and generate a sequence of resonance pulses as a reaction, which in turn can induce nerve pulses or something analogous to them in the ordinary biomatter [L187]. In a rough sense, this would be a transformation of analog to digital.

Authors also propose that superradiance could involve a shielding effect, analogous to what happens in the Earth's magnetic field and might be based on a similar mechanism.

1. In the standard description, the Earth's magnetic field catches the incoming cosmic rays, such as UV photons, to the field lines, and thus prevents the arrival of the radiation to the surface

of Earth. Van del Allen radiation belts are of special importance.

2. In the TGD description, a considerable fraction of incoming high energy photons and maybe also other higher energy particles would be transformed to their dark variants at the magnetic monopole flux tubes of the MB of the Earth with a field strength estimated to be $B_{end} = 2B_E/5$, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field. This mechanism would transform the high energy photons to low energy dark photons with much longer wavelengths which have very weak interactions with the ordinary biomatter. These in turn would be radiated away as ordinary photons and in this way become neutralized. The scaling factor for the wavelength would be $\hbar_{gr}/h$ if the gravitational MB of the Earth is involved.

   Something similar would take place in biological systems at cellular level. The UV photons would be transformed to dark photons with much longer wavelengths and radiated away as ordinary photons.

Can one identify a range of biological scales perhaps labelled by the values of $\hbar_{eff}/h$ coming as powers of 10^3.

1. The findings of Cyril Smith [J7] related to the phenomenon of water memory suggest that in living matter a scaling of photon frequency can take place with a scaling factor 2×10^{11} or is inverse. In the TGD framework, I christened this mechanism as "scaling law of homeopathy" (sounds suicidal in the ears of a mainstream colleague) [K50]. For a UV radiation with $\lambda = 300$ nm frequency $f = 1.24 \times 10^{15}$ Hz this would mean scaling down of frequency to 6.8 kHz and scaling up of wavelength to $.4 \times 10^5$.

2. The kHz scale is one of the preferred scales suggested by the work of Bandyopadhyay, suggesting also a hierarchy of the scaling factors $2 \times 11 - 3x$, $x = -1, 0, 2, ...$ Could there exist a hierarchy of biological scales differing by powers of 10^3? Could these scaling factors correspond to various values of h_{eff}/h_0?

3. In the TGD inspired quantum biology, the Earth's gravitational magnetic body plays a key role. Could one assign the length scale with $x = -1$ with the Earth's gravitational magnetic body having gravitational Planck constant [E1] equal to $\hbar_{gr} = GM_E m/\beta_0$, $\beta_0 = v_0/c \simeq 1$, where M_E is the mass of Earth? By the Equivalence Principle, the gravitational Compton length is independent of mass m of the particle and for Earth is about .5 cm, the size scale of a snowflake.

4. The scaling hierarchy in powers of 10^3 would predict besides .5 cm, the length scale 5 μm of cell nucleus, the length scale 5 nm characterizing the thickness of the lipid layer of cell membrane and of the DNA double strand, and the scale 5×10^{-12} m to be compared with the Compton length 2.4×10^{-12} m of electron. The scaling hierarchy would be naturally associated with the electron naturally. The wavelength scale corresponding to $x = -2$ is $\lambda = .4 \times 10^8$ m, which is equal to the circumference of Earth $2\pi R_E \simeq .4 \times 108$ m defining the lowest Schumann resonance frequency!

5. If $\beta_0 = v_0/c \leq 1$ is true, the scales with $x = 0, 1, ...$ cannot correspond to the values $\hbar_{gr}$ for β_0 coming as positive powers of 10^3 and its difficult to imagine hierarchy of masses as powers of 10^3.

   Could the electric Planck constants as counterparts of gravitational Planck constants [L167], defined as $\hbar_{em} = Qe^2/\beta_0$, where Q is the charge of a system analogous to the electrode of a capacitor [L186], give these scales as electric Compton length for electron? This would conform with the fact that cell interior and DNA are negatively charged.

There are good reasons to believe that these findings will be noticed by the people fighting with the problems related to quantum computers caused by the extreme fragility of quantum coherence in standard quantum theory. One might even hope that the basic assumptions of quantum theory could be questioned. The TGD based generalization of quantum theory could pave the way for building quantum computers and also raises the question whether ordinary computers could become in some sense living systems under suitable conditions [L170, L171, L169] (see this) about the recently observed evidence for quantum coherence in mesoscales by Babcock et al [I35].

4.5 Conclusion

The important conclusion suggested by the experiments of Bandyopadhyay is that microtubules - in particular, brain microtubules - are at least mesoscopic quantum systems. To my personal opinion, the interpretation in the talk of Bandyopadhyay is not convincing at the level of details, and the TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. A natural generalization of 1-braid TQC to 2-braid TQC is also highly suggestive in the TGD framework and could be seen as an evolutionary step assignable to the emergence of microtubules. The interpretation based on Fibonacci conduction paths fails to correctly predict the number of resonances. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in h_{eff} increasing phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence and why a super-conductivity-like state is generated.

A lot of progress has taken place after I wrote the comments about the work of Bandyopadhyay. The findings of Babcock et al support the view that much more general systems can have this property. On the theoretical side, the understanding of the role of the long range quantum coherence assignable to long range classical gravitational fields and electromagnetic fields in the TGD framework leads to further insights about quantum aspects of not only microtubules but also other biomolecules. In particular, the universal realization of the genetic code in terms of the completely exceptional tessellation of the hyperbolic 3-space H^3 (hyperboloid of future light-cone) suggest that the genetic code is realized in several scales and that the also the linearizations as 2- and even 3-D structures are possible and that genetic code is used also for communications between biological body and magnetic body using dark photons.

Chapter 5

A Possible Explanation of Shnoll Effect

5.1 Introduction

As I wrote the first version of this chapter about Shnoll effect for about decade ago [L12], I did not yet have the recent vision about adelic physics [L60, L59] as a unification of real physics and various p-adics and real number based physics to describe the correlates of both sensory experience and cognition.

The recent view is that the hierarchy of extensions of rational numbers induces a hierarchy of extensions of p-adic number fields in turn defining adele. This hierarchy gives rise to dark matter hierarchy labelled by a hierarchy of Planck constants and also evolutionary hierarchy. The hierarchy of Planck constants $h_{eff} = n \times h_0$ is and essential element of quantum TGD and adelic physics suggests the identification of n as the dimension of extension of rationals. n could be seen as a kind of IQ for the system.

What is also new is the proposal that preferred p-adic primes labelling physical systems could correspond to so called ramified primes, call them p, of extension of rationals for which the expression of the rational p-adic prime as product of primes of extension contains less factors than that the dimension n of extension so that some primes of extension appear as higher powers. This is analog for criticality as the appearance of multiple roots of a polynomial so that the derivative vanishes at the root besides the polynomial itself.

Before continuing it is good to make some confessions. Already in the earlier approach [L12] I considered two options for explaining the Shnoll effect: either in terms of p-adic fractality or in terms of quantum phase q of both. I however too hastily concluded that the p-adic option fails and choose the quantum phase option.

In the following both options are seen as parts of the story relying on a principle: the approximate scaling invariance of probability distribution $P(n)$ for fluctuations under scalings by powers of p-adic prime p implying that $P(n)$ is approximately identical for the divisions for which the interval Δ defining division differs by a power of p.

Second new idea is the lift of $P(n)$ to wave function $\Psi(n)$ in the space of counts. For quantum phase q_m, $m = p$, Ψ_m would have quantum factor proportional to a wave function in finite field F_p, and the notion of counting modulo p suggests that the wave function corresponds to particle in box - standing wave - giving rise to $P(n)$ representing diffraction pattern.

5.1.1 Basic facts about Shnoll effect

Usually one is not interested in detailed patterns of the fluctuations of physical variables, and assumes that possible deviations from the predicted spectrum are due to the random character of the phenomena studied. Shnoll and his collaborators have however studied during last four decades the patterns associated with random fluctuations and have discovered a strange effect described in detail in [E3] , [E3, E8, E9, E4, E10, E5]. The examples of [E3]. [E3] give the reader a clear picture about what is involved.

1. Some examples studied by Shnoll and collaborators are fluctuations of chemical and nuclear decay rates, of particle velocity in external electric field, of discharge time delay in a neon lamp RC oscillator, of relaxation time of water protons using the spin echo technique, of amplitude of concentration fluctuations in the Belousov-Zhabotinsky reaction. Shnoll effect appears also in financial time series [E12] which gives additional support for its universality. Often the measurement reduces to a measurement of a number of events in a given time interval τ. More generally, it is plausible that in all measurement situations one divides the value range of the studied observable to intervals of fixed length and counts the number of events in each interval to get a histogram representing the distribution $N(n)$, where n is the number of events in a given interval and $N(n)$ is the number of intervals with n events. These histograms allow to estimate the probability distribution $P(n)$, which can be compared with theoretical predictions for the spectrum of fluctuations of n. Typical theoretical expectations for the fluctuation spectrum are characterized by Gaussian and Poisson distributions.
2. Contrary to the expectations, the histograms describing the distribution of $N(n)$ has a distribution having several maxima and minima (see the figures in the article of Shnoll and collaborators (see `http://tinyurl.com/6kehe9b`). Typically -say for Poisson distribution - one expects single peak. As the duration of the measurement period increases, this structure becomes gets more pronounced: standard intuition would suggest just the opposite to take place. The peaks also tend to be located periodically. According to [E3] [E3] the smoothed out distribution is consistent with the expected distribution in the case that it can be predicted reliably.
3. There are also other strange features involved with the effect. The anomalous distribution for the number n of events per fixed time interval (or more general value interval of measured observable) seems to be universal as the experiments carried out with biological, chemical, and nuclear physics systems demonstrate. The distribution seems also to be same at laboratories located far away from each other. The comparison of consecutive histograms shows that the histogram shape is likely to be similar to the shape of its nearest temporal neighbors. The shapes of histograms tend to recur with periods of 24 hours, 27 days, or 365 days. The regular time variation of consecutive histograms, the similarity of histograms for simultaneous independent processes of different nature and occurring in different geographical positions, and the above mentioned periods, suggest a common reason for the phenomenon possibility related to gravitational interactions in Sun-Earth and Earth-Moon system.

In the case that the observable is number n of events per given time interval, theoretical considerations predict a distribution characterized by some parameters. For instance, for Poisson distribution the probabilities $P(n)$ are given by the expression

$$P(n|\lambda) \quad = \quad exp(-\lambda)\frac{\lambda^n}{n!} \quad . \tag{5.1.1}$$

The mean value of n is $\lambda > 0$ and also variance equals to λ. The replacement of distribution with a many-peaked one means that the probabilities $P(n|\lambda)$ are modified so that several maxima and minima result. This can occur of course by the randomness of the events but for large enough samples the effect should disappear.

The universality and position independence of the patterns suggest that the modification changes slowly as a function of geographic position and time. The interpretation of the periodicities as periods assignable to gravitational interactions in Sun-Earth system is highly suggestive. It is however very difficult to imagine any concrete physical models for the effect since distributions look the same even for processes of different nature. It would seem that the very notion of probability somehow differs from the ordinary probability based on real numbers and that this deformation of the notion of probability concept somehow relates to gravitation.

5.1.2 Quantum group inspired model for Shnoll effect

Usually quantum groups are assigned with exotic phenomena in Planck length scale. In TGD they are assignable to a finite measurement resolution [K113]. TGD inspired quantum measurement theory describes finite measurement resolution in terms of inclusions of hyper-finite factors of type

II_1 (HFFs) and quantum groups related closely to the inclusions and appear also in the models of topological quantum computation [B15] based on topological quantum field theories [A21].

Consider first the original version of the proposed model. If I would rewrite it now correcting also the small errors, the summary would be as follows. This slightly revised model can be included as such to the new model.

1. The possibility that direct p-adic variants of real distribution functions such as Poisson distribution might allow to understand the findings was discussed also in the original version. The erratic conclusion was that this cannot the case. In fact, for $\lambda = 1/p^k$ the sum of probabilities $P(n)$ without normalization factor is finite, and the appriximate scaling symmetry $P(n) \simeq P(p^r n)$ emerges for $k = 1$. p-Adicity predicts approximate p-periodicity corresponding to the periodic variation of n_R with the lowest pinary digit of n.

2. It was argued that one should replace the integer $n!$ in $P(n)$ with quantum integer [A15] $(n!)_{q_m}$, $q = exp(i\pi/m)$, identified as the product of quantum integers $r_{q_m} = (q^r - q^{-r})/(q - q^{-1})$, $r < n$.

   This however leads to problems since r_{q_m} can be negative. The problem can be circumvented by interpreting $n!$ as p-adic number and expanding it in powers of p with pinary digits $x_k < p$. For $m = p$ the replacement of x_k with quantum integer yields positive pinary digits.

   The resulting quantum variant of p-adic integer can be mapped to its real counterpart by a generalization of canonical identification $x = \sum x_n p^n \to \sum x_n p^{-n}$. Whatever the detailed definition, quantum integers are non-zero and positive. The quantum replacement $r \to r_{q_m}$ of the integers appearing in rational parameters in $P(n|\lambda_i)$ might therefore make sense. It however does not make sense in the exponents like λ^n and $\lambda = p^k$, $k > 1, 2, ..$, is forced by convergence condition.

3. I proposed also another modification of quantum integers x_{q_m}, $x < p = m - 1$ appearing in as pinary digits by decomposing x into a product of primes $s < p$ and replacing s with quantum primes s_{q_p} so that also the notion of quantum prime would make sense: one might talk about quantum arithmetics [K74, K72]. This is possible but is not necessary.

5.1.3 Adelic model for Shnoll effect

At the first re-reading the original model looked rather tricky, and this led to a revised model feeding in the adelic wisdom [L60, L59]. One implication hierarchy of Planck constants $h_{eff}/h_0 = n$ with n identified as the dimension of Galois extension.

One also ends up to the proposal that preferred p-adic primes p correspond to so called ramified primes of the extension of rationals inducing the extensions of p-adic number fields defining the adele. This kind of prime would naturally define a small-p p-adicity associated with Shnoll effect, which would thus serve as a direct signature of adelic physics.

1. The first observation in conflict with the original belief is that one can actually define purely p-adic variant of the Poisson distribution $P(n|\lambda)$ by replacing $1/n!$ with its image $(n!)_R$ under canonical identification. For instance, for Poisson distribution one must have $\lambda = p^{-k}$, $k = 1, 2, ..$ for both real and p-adic distributions to nake sense. The sum of the probabilities $P(n)$ is finite. Poisson distribution with trivial quantum part is determined uniquely.

2. One can also consider quantization $P(n) = |\Psi(n)|^2$, suggested by the vision about quantum TGD as complex square root of thermodynamics and hierarchy of Planck constants making possible macroscopic quantum coherence in arbitrarily long scales. The complexity of $\Psi(n)$ could genuine quantum interpretation. Quantum factor of $\Psi(n)$ allows interpretation as a wave function in finite field F_p representing the space of counts modulo p. The existence of quantum p-adics requires $m = p$. Scaling by p is not a symmetry but multiplication by $0 < k < p$ and shift by $0 \leq k < p$ act as symmetries analogous to rotations and translations acting on waves functions in Euclidian 3-space.

3. The objections against Shnoll effect lead to an additional condition - or should one say principle - stating that the $P(n)$ is approximately invariant under scalings $n \to p^k n$. This could be seen as a manifestation of p-adic fractality in turn reflecting quantum criticality of TGD Universe.

4. Taking n as the observable simplifies p-adicization crucially since the highly non-unique p-adicization of classical observables is avoided. One could speak of quantum measurement in the space of counts n defining universal observables. In quantum measurements the results are typically expressed as numbers of counts in given bin so that this kind of p-adicization is physically natural. The division of measurement interval would define an ensemble and n would be measured in each interval. State function reduction would localize $\Psi(n)$ to n in each interval.

This picture leads to an alternative and simpler view about Shnoll effect. The scaling invariance is an essential additional condition now.

1. The factorials $n!$ appearing in $P(n) = (d^n f/dx^n)/n!$ identified as coefficients of Taylor series of its generating function developed in pinary expansion for $p = m$. In this expansion one must invert powers of p in $(n!)_R$ and could also replace the coefficients of powers of p with quantum integers or replace even primes in their prime composition with quantum primes. For given norm $(n!)_R$ has period p approximately.
2. The n:th derivative $X(n) = d^n f/dx^n$ appearing as coefficient of $1/n!$ is replaced with $X(n)_R/X(n)_p$ giving approximate periodicity and scaling invariance $n \to pn$.
3. Quantum phase is associated with the ansatz stating $P(n) = |\Psi(n)|^2$. In the "diffractive" situation quantum counterpart corresponds to $|(kn)_{q_m}|^2$, $0 < k < p-1$. This gives rise to periodicity with period $m = p$.

The universal modifications of the probability distributions $P(n|\lambda_i)$ considered predict patterns analogous to the ones observed by Shnoll. The p-adic prime $p = m$ characterizes the deformation of the probability distribution and implies approximate p-periodicity, which could explain the periodically occurring peaks of the histograms for $N(n)$ as function of n.

One can imagine several explanations for the dependence of the time series distribution $P(n)$ on the direction of the momentum of alpha particle [E4, E10] and on the dependence of $P(n)$ on time.

1. The change of ramified prime p induced by the change of the extension of rationals would affect the periods. An interesting question is whether the effects understood in terms of the effect of the measurement apparatus on many-sheeted space-time topology and geometry on p. Can one speak about measurement of p and of extension of rationals?
2. The extension of rationals (and thus p) need not change. The "quantum factor" of Ψ in $P(n) = |\Psi(n)|^2$ has part depending on q_p. The dependence on q_p could change without change in p so that the extension of rationals need not change. One could speak about measurement of an observable related to the quantum factor of Ψ. A more concrete model relies on wave function proportional to $(kn)_{q_p} \propto q_m^{kn} + q_m^{-kn}$ - analog to a superposition of plane waves with momenta k propagating to opposite directions in the space of counts and producing in $P(n)$ diffraction pattern proportional to $(qn)^2_{q_p}$. Change of momentum k by scaling or shift induced by variation of the gravitational parameters or time evolution could be in question.

The p-adic primes p in question are rather small, not much larger than 100 and the periods of $P(n)$ provide a stringent test for the proposal. If p corresponds to ramified prime as adelic physics suggests, it can be indeed small.

5.1.4 Quantum gravitational model of the Shnoll effect

One can criticize the above described models as too formal. What comes to mind is that the states split into several states with different decay rates. The basic problem is to understand how extremely weak gravitational interaction can have such drastic effects on the states of even nuclei.

The third number theoretic model is much simpler and is based on the notion of the spectrum of effective Planck constants. The rates depend on the value of effective Planck constant and this could explain the decomposition of peaks to several ones. Gravitational quantum coherence in astrophysical scales is predicted and the gravitational Planck constant of even the Milky Way can affect the rates. In this framework the Shnoll effect could be seen as a direct empirical evidence for the hierarchy of Planck constants.

To sum up, I cannot avoid the thought that fluctuations regarded usually as a mere nuisance could be actually a treasure trove of new physics. While we have been busily building bigger and bigger particle accelerators, the truth would have been staring directly at our face and even winking eye to us.

For the reader not familiar with TGD the article series in Prespace-time journal [L6, L7, L10, L11, L8, L5, L9, L1] and the two articles about TGD inspired theory of consciousness and of quantum biology in Journal of Consciousness Research and Exploration [L4, L3, L2] are recommended. Also the online books at my homepage provide the needed background.

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` [L23].

5.2 Adelic view about Shnoll effect

In the sequel the adelic model for Shnoll effect is developed. The earlier model - with errors corrected - can be seen as a variant of this model.

5.2.1 General form for the deformation of $P(n|\lambda)$

Could Shnoll effect be a direct manifestation of adelic physics [L60, L59]? In TGD framework adelic physics is motivated as physics of cognition and sensory experience, and this could explain why Shnoll effect is associated even with financial time series. Instead of starting to make ad hoc guesses, consider first what kind of constraints adelic physics could pose on the deformation.

1. The basic idea is that since the effect is universal, the form of the probability distribution $P(n|\lambda_i)$ should be modified in a universal manner, which depends on the experimental situation only very weakly.

2. Adelic physics suggests that the deformation of probability distributions $P(n|\lambda_i)$ could depend on small p-adic prime p identifiable as ramified prime and on integer m defining defining quantum phase $q_m = exp(i2pi/m)$ and giving rise to effective angle resolution in terms of allowed phases as roots of unity.

   The first guess is that m could give rise to the periodic occurrence of the maxima and minima in the deformed distribution due to the m-periodicity of n_{q_m}. p-Adic prime p would define finite length scale resolution: it turns that also the map of factorials $n!$ interpreted as p-adic numbers by canonical identification to their counterparts gives an approximately p-periodic modulation of $P(n)$.

3. According to the standard definition quantum integers are real and given by $n_q = (q^n - q^{-n})/(q - q^{-1})$. The problem is that n_{q_m} vanishes if n is divisible by m so that one cannot replace the factorials appearing in Poisson distribution (say) with their quantum counterparts. The solution of the problem is the interpretation of n as p-adic integer and the replacement of pinary coefficients with quantum integers n_{q_p} $(m = p)$, which are positive. One could also decompose them into a product of prime factors and replace them with their quantum counterparts n_{q_p}.

   In the power λ^{-n} one could consider the replacement of n with n_{q_p} but this does not work in the p-adic case because p^{-n_q} in general does not belong to a finite extension of p-adics used. In the p-adic case $\lambda = 1/p^k$ turns out to be the only possible option. For $k = 1$ one obtains approximate scaling invariance $n \to pn$.

4. The hierarchy of Planck constants makes possible quantum coherence in all scales. This inspires the idea that the probabilities $P(n)$ are moduli squared for a complex probability amplitude $\Psi(n)$: $P(n) = |\Psi(n)|^2$. Ψ_n could have having "quantum factor" Ψ_q containing a phase depending on n.

   The simplest option is that quantum factor is has phase $U(n) = q_m^n$ or its power. This does not give any effect visible in $P(n)$. A more general options is a quantum factor $\Psi_q = \sum c_k q_m^k$. In this case on obtains interference effects in the modulus squared. Complex quantum integer $n_q = (q^n - q^{-n})/(1 - q)$ as a multiplicative factor would give rise to a diffractive factor $sin^2(n\pi/m)/sin^2(\pi/m)$ in $P(n)$.

Speaking about amplitude for fluctuations and quantum diffraction in an ensemble defined by a division of the range of observable or a division of time interval to smaller intervals is of course quite a generalization of quantum mechanical thinking but it is interesting to look whether this could lead to sensible predictions. One could however whether the slow variations of the fluctuation patterns could correspond to different outcomes for quantum measurements measuring p-adic prime P and m.

Usually objections are the best manner to proceed and now the objections leads to an approximate scaling invariance $n \to p$ of $P(n)$ suggested also by the p-adic fractality implied by the quantum criticality of TGD Universe.

1. The first objection is that the findings of Shnoll are special in the sense that the replacement of observable with its diffeomorph cannot preserve the character of distribution $P(n)$. One can however claim that in practice the choice of observables is highly unique from physical constraints. Only simple scalings of the observable can be considered in same cases.

2. Second objection is that replacing the interval ΔO for observable with $\Delta O/m$ cannot leave the general shape of the distribution invariant. The naïve guess is that one has $P(n) \to P(nm)$ for large enough values of n. This condition in a suitably restricted form can be posed as a constraint. The natural assumption is that the condition holds true only for the p-adic scalings $m = p^k$.

   This condition can be used as a constraint on $P(n)$. $P(n)$ would depend on n only through functions of n invariant under p-adic scalings $n \to pn$. An example about scaling invariant is provided by the function $x_R = n_R/n_p$, where n_p is the p-adic norm of n and n_R is obtained by canonical identification $n = \sum n_k p^k \to n_k p^k \to n_R = \sum n_k p^{\to} n_k p^{-k}$.

   Any function of x_R is invariant under p-adic scalings and one can construct analogs for Gaussian, Poisson distribution, etc... by replacing n with x_R. Periodicity with period p is obtained if one replaces the p-adic unit nn_p with $nn_p \ mod \ p$. Since the higher pinary digits do not affect strongly the behavior of x_R, approximate p-periodicity is obtain in any case.

3. The factorial $n!$ appears in probability distributions having Taylor series as a generating function. A little calculation below using Legendre's theorem shows that apart from an approximately periodic multiplicative function of n with period p one has $p^{-n}/(n!)_R = p^{-s(n)}$, where $s(n)$ is the sum of the pinary digits of n in the expansion in powers of p. $s(n)$ is invariant under scalings $n \to p^k n$. Therefore the deformed Poisson distribution is unique from the approximate scaling invariance and given apart from normalization by $P(n) = p^{-n}/(n!)_R = p^{-s(n)}$.

4. What about more general scalings $n \to kn$? Under the scalings $n \to kn$ for k not divisible by p, the norm of n is invariant. The rough scaling behavior of $P(n)$ is however un-affected. The lowest pinary digit is replaced in $n \to n+1$ with $n + k \ mod \ p$ so that approximate p-periodicity is still present.

Consider next quantum phases.

1. The dependence on the quantum phase $q_m = expi(ipi/m)$, $m = p$, cannot be invariant under p-adic scalings. The reason is that scaling by p takes all powers of q_p to unit and is thus not a bijection.

   One can however consider different kind of symmetries. The integers $n \ mod \ p$ form finite field G_p in which multiplication and sum define transformations analogous to rotations and translations acting naturally as symmetries in the space of probability amplitudes defined in the space of counts $n \ mod \ p$ - modulo arithmetics means finite phase resolution for n represented as a phase. The wave functions can be interpreted as elements of finite-field algebra analogous to group algebra consisting of probability amplitudes in group.

   One can interpret the plane waves q_p^{kn} as analogs of plane waves with momentum k. Multiplication and translations by r would correspond naturally to symmetries analogous to rotations and translations in Euclidian space.

2. $\Psi(n)$ would have "quantum factor" expressible as a wave function in the space of counts n. For plane wave q_p^{kn}, the plane wave would not be visible in $P(n)$. The superposition $q_p^{kn} + q_p^{-kn}$ of two plane waves propagating in opposite directions in the space of counts

modulo p is proportional to quantum integer $(kn)_{q_p} = sin^2(kn\pi/p)/sin(\pi/p)$ defining the analog of diffraction pattern. One has the analog of standing wave in a box having $n = 0$ and $n = p$ as its boundaries.

This is really nice mathematics but is "quantum factor" really needed? Can one do using just the deformation of say Poisson distribution or its quantum analog obtained by replacing $n!$ interpreted as p-adic integer with its quantum counterpart? Or is "quantum factor" all that is needed? Or does this depend on situation? The following is just a list about the questions, which pop into mind and reflect my confusion more than my understanding.

1. The "quantum factor" of $\Psi(n)$ - to be distinguished from "classical factor" depending on n without any analysis to pinary digits interpreted as p-adic or quantum p-adic integers - can be regarded as a wave function in finite field F_p for the lowest pinary digit of n. $n_{q_p}^2$ gives the probability for the count $n \ mod \ p$. The modulo p condition for the pinary digit of n can be interpreted as particle in box condition $0 < n \ mod \ p < p$ so that states correspond to standing waves propagating in the space of counts and representable as sums of plane waves with wave vector $0 \leq k < p$ propagating in opposite directions. This implies that quantum part of $P(n)$ is universal and give by $n_{q_p}^2 = sin^2(kn\pi/p)/sin^2(\pi/p)$. Diffractive pattern results. Also p-periodicity is obtained from modulo p arithmetics. Approximate scale invariance $n \to p^k n$ is not obtained. This could explain Shnoll effect.

   "Quantum factor" alone is non-realistic since the probabilities for large values of n must be small. Should one interpret the "classical factor" of Ψ as a wave function for the remaining pinary digits defining n_{rem}? This would give the needed decrease for large values of n: $p^{-s(k)}$ for Poisson distribution. Now approximate scaling p-adic scaling invariance would be true as also p-periodicity in the lowest pinary digit.

3. Does it make sense to talk about separate wave functions for the lowest pinary digits as wave functions for $n_{rem} = n \ mod \ p^k - m \ mod \ p^{k-1}$ so that one would have product $P(n) \propto \prod_k (n_k)_{q_p}^2$ of single digit wave functions? Physical intuition tells that the lowest digits are the most important ones and cannot be independent. Could one consider lowest k pinary digits as single entity with $m = p^k$ and generalize quantum group picture by using quantum integers $n_{q_{p^k}}$ with p^k-periodicity?

4. Note that for $p > n$ one would have only single pinary digit and $P(n) \propto n_{q_p}^2 = sin^2(n\pi/p)/sin^2(\pi/p)$? For $n > p$ but near to it $P(n)$ one would have single maximum: this would be nearer to what one expects with Gaussian intuition. Could one think of the analog of p-adic length scale hierarchy so that the increase of p would lead from quantum description to a classical description? Do ramified primes of extension determine this kind of hierarchy? The number of pinary digits in "quantum factor" would correlate with the measurement resolution for n.

5.2.2 Deformation of Poisson distribution as an example

Consider next the p-adic modification of $P(n)$ based on canonical identification, which I gave up in the original approach since I erratically concluded that the sum of probabilities without normalization fails to converge.

1. Adelic physics suggests that prime p and quite generally, all preferred p-adic primes, could correspond to ramified primes for the extension of rationals defining the adele. Ramified prime divides discriminant $D(P)$ of the irreducible polynomial P (monic polynomial with rational coefficients) defining the extension (see `http://tinyurl.com/oyumsnk`).

   Discriminant $D(P)$ of polynomial whose, roots give rise to extension of rationals, is essentially the resultant $Res(P, P')$ for P and its derivative P' defined as the determinant of so called Sylvester polynomial (see `http://tinyurl.com/p67rdgb`). $D(P)$ is proportional to the product of differences $r_i - r_j$, $i \neq j$ the roots of p and vanishes if there are two identical roots.

   Remark: For second order polynomials $P(x) = x^2 + bx + c$ one has $D = b^2 - 4c$.

   Ramified primes divide D. Since the matrix defining $Res(P, P')$ is a polynomial of coefficients of p of order $2n - 1$, the size of ramified primes is bounded and their number is finite. The larger coefficients $P(x)$ has, the larger the value of ramified prime can be. Small discriminant

means small ramified primes so that polynomials having nearly degenerate roots have also small ramifying primes. Galois ramification is of special interest: for them all primes of extension in the decomposition of p appear as same power. For instance, the polynomial $P(x) = x^2 + p$ has discriminant $D = -4p$ so that primes 2 and p are ramified primes.

2. One can consider a p-adic modification of $n!$ by expanding $n! \equiv x$ as series $x \sum x_n p^n$ in powers of the ramified prime and mapping the result to a real number by canonical identification $\sum x_n \to \sum x_n p^{-n}$. The outcome is approximately periodic for large n since the lowest pinary digit gives dominating contribution and is periodic with period p. There would be two approximate periodicities for the peaks corresponding to p.

   Remark: Canonical identification is applied in p-adic mass calculations [K59] [L102] and at the level of scattering amplitudes it would map Lorenz invariants appearing in the scattering amplitudes expressible in terms of rational functions with coefficients which are rational (or in an extension of rationals) to their real counterparts.

3. Also the powers of λ should make sense p-adically, and the replacement of λ by a power of p indeed makes sense p-adically. In the case of Poisson distribution this would predict

$$P(n) \propto \frac{p^{-nk}}{(n!)_R} \quad .$$

   for $\lambda_R = p^{-k}$.

4. $n!$ contains some power $\nu_p(n!)$ of p given by Legendre's formula (see `http://tinyurl.com/jdvwaph`):

$$\nu_p(n!) = \sum_{i=1}^{\infty} [\frac{n}{p^i}] \quad ,$$

   where $[x]$ denotes the value of floor function replacing xt with the largest integer smaller than x. The p-adic norm of the $n!$ equals to $p^{-\nu_p(n!)}$ so that the sum of probabilities converges for all values of k of one has $\nu_(n!) < p$. It seems that this is the case quite generally. In fact, there is in the same sources also another formula for $\nu_p(n!)$ making this manifest.

$$\nu_p(n!) = \frac{n - s_p(n)}{p-1} \quad .$$

   Here $s_p(n)$ is the sum of pinary digits of n expressed as power series of p. For $k = 1$ the n:th term is $p^{-s_p(n)}$ divided by the canonical images of a p-adic number with unit p-adic norm.

   Since $s_p(n)$ increases in step-wise manner, one obtains asymptotically a periodically modulated series with period p since the canonical image of $n!$ approaches periodic function. The generalization to any $P(n)$ expressible as n:th term in a Taylor series of some function serving as generating function for $P(n)$ is obvious.

As already explained, one can modify this distribution by adding to $\Psi(n) = \sqrt{P(n)}$ "quantum factor" as a wave function in the space of counts modulo p forming a finite field and particle in box analogy gives essentially $(kn)_{q_p}$ as quantum factor characterized by momentum k leading to diffraction patter described by $(kn)^2_{q_p}$. This standing wave quantum factor could be universal and describe modulo p counter.

5.3 Explanation for some findings of Shnoll

One should be able to undertand both the many-peaked character of the distributions as well as their spatial and temporal variation involving correlations with the gravitational physics of Sun-Earth and Earth-Moon systems.

The really difficult problem is to understand how astrophysical objects could affect microscopic physics in even nuclear scales where physics is local.

In the sequel two kinds explanations inspired by number theory are considered. The first model is rather formal. The second model relies on the notion of gravitatonal Planck constant introduced by Nottale and explains the rate variations as being induced by the variation of the Planck constant.

5.3.1 The temporal and spatial dependence of the distributions

One should also understand the variation of the shape of the distribution with time and its spatial variation.

1. The correlation of the fluctuation periods with astrophysical periods assignable to Earth-Sun system (diurnal period and period of Earth's orbit) suggests that the gravitational interaction of the measurement apparatus with Sun is involved. Also the period 27.28 days which corresponds to sidereal period of Moon measured in the system defined by distant star. In [E3] , [E3] this period is somewhat confusingly referred to as synodic period of Sun with respect to Earth (recall that synodic period corresponds to a period for the appearance of third object (say Moon) in the same position relative to two other objects (say Earth and Moon)). Therefore also Moon-Earth gravitational force seems to be involved. Moon-Earth and Earth-Sun gravitational accelerations indeed have roughly the same order of magnitude.

   That gravitational accelerations would determine the effect conforms with Equivalence Principle. The most natural dimensionless parameter characterizing the situation is $|\Delta \mathbf{a_{gr}}|/\mathbf{a_{gr}}$ expressible in terms of $\Delta R/R$ and $\Delta r/r$, where R *resp* r denotes the distance between Earth and Sun *resp.* Earth and Moon, and the ratio R/r and cosine for the angle θ between the direction vectors for the positions of Moon and Sun from Earth. The observed palindrome effect [E5] is consistent with the assumed dependence of the effect on the distances of Earth from Sun and Moon. Also the smallness of the effect as one approaches North Pole conforms with the fact that the variations of distances fro Sun and Moon become small at this limit.
2. In 24 hour time scale it is enough to take into account only the Earth-Sun gravitational interaction. One could perform experiments at different positions at Earth's surface to see whether the variation of distributions correlates with the variation of the gravitational potential. The maximal amplitude of $\Delta R/R$ is $2R_E/R \simeq .04$ so that for $\Delta p/p = k\Delta R/R$ one would have $\Delta p/p = .04k$. Already for $p \sim 100$ the variation range would be rather small. For $\Delta m/m$ one expects that analogous estimate holds true.
3. One observes in alpha decay rates periodicities which correspond to both sidereal and solar day [E4]. The periodicity with respect to solar day can be understood in terms of the periodic variation of Sun-Earth distance. The periodicity with respect to sidereal day would be due to the diurnal variation of the Earth-Moon distance. Similar doubling of periodicities are predicted in other relevant time scales.
4. In the case of alpha decay the effect reveals intricacies not explained by the simplest model [E4, E10]. In this case one studies random fluctuations for the numbers of alpha particles emitted in a fixed direction. Collimators are used to select the alpha particles in a given direction and this is important for what follows. Two especially interesting situations correspond to a detector which is located to North, East, or West from the sample. What is observed that the effect is different for East and West directions and there is a phase shift of 12 hours between East and West. In Northern direction the effect vanishes. Also other experiments reveal East-West asymmetry called local time effect by the authors [E8, E9].

The distribution for the counts of alpha particles in a given angle depend on time and the time dependence is sensitive to the direction angle of the alpha particle. This might be however only apparent since collimators are used to select alpha particles in given direction. The authors speak about anisotropy of space-time and Finsler geometry [A1] could be considered as a possible model. In this approach the geometry of space-time would be something totally independent of measurement apparatus.

One can identify a candidate for a scalar on which the magnitude of effect should depend.

1. At quantitative level the distribution for counts in a given direction can depend on angles defined by the vectors formed from relevant quantities. These include at least the tangential rotational velocity $v = \omega \times r$ of the laboratory at the surface of Earth, the direction of the velocity v_α of alpha particle with respect to sample actually reflecting the geometry of collimators, the net gravitational acceleration a_{net} caused by Earth, Sun, and Moon, and the direction of acceleration g in the Earth's gravitational field.
2. The first task is to construct from these vectors a scalar or a pseudo-scalar (if one is ready to allow large parity breaking effects), which vanishes for North-East direction, has opposite

signs for East and West direction and has at least approximately a behavior consistent with the phase shift of 12 hours between East and West. The constraints are satisfied by the scalar

$$X = E \cdot a_{net} \ , \ E = \frac{(v \times g) \times v_\alpha}{|(v \times g) \times v_\alpha|} \ . \tag{5.3.1}$$

Unit vector E changes sign in East-West permutation and also with a period of 12 hours meaning the change of the roles of East and West with this period in the approximation that the net acceleration vector is same at the opposite sides of Earth. The approximation makes sense if the change of sign induces much large variation than the change of the Earth-Sun and Earth-Moon distances. If the parameters of the model are even functions of X, the predicted effect can be consistent with the experimental findings in the approximation that a_{net} is constant in 24 hour time scale.

This could explain the difference in the fluctuations associated with alpha particles emitted in East and West direction and the fact that there is no effect in North direction. $v \times g$ points to North and North direction for v_{alpha} has $E = 0$ so that the magnitude of E proportional to the sine of the angle between North and v_α should dictate the magnitude of the effect.

5.3.2 TGD based model for the Shnoll effect in alpha decay

In TGD framework the space-time is topologically non-trivial and dynamical in macroscopic scales and the presence of collimators making possible to select alpha particles in a given direction affect the geometry of many-sheeted space-time sheets describing the measurement apparatus and therefore the details of the interaction with the gravitational fields of Earth, Sun, and Moon. As a consequence, the value of $p = m$ should reflect the geometry of the measurement apparatus and depend only apparently on the direction of v_α. If this interpretation is correct, a selection of events from a sample without collimators should yield distributions without any dependence on the direction of v_α.

The situation is sensitive to the value of $p = m$ in the model described above. The changes should be such that the parameters of the smoothed out real probability distribution are not affected much. For instance, in the case of q-Poisson distribution the value of $p = m$ should change in such a way that $\langle n \rangle = \lambda$ is not unaffected much. The change of p would affect the positions of the peaks but small changes of p would not mean too dramatic changes. Periodic time dependence of these parameters would explain the findings of Shnoll. Gravitational interactions in Sun-Earth-Moon system and therefore the periodic variations of Sun-Earth and Earth-Moon distances is the first guess for the cause of the periodic variations.

In the case of alpha decay Shnoll effect is associated with temporal fluctuations in the number n of the measured events in time interval ΔT characterized by $P(n)$. $P(n)$ is reported to depend on the gravitational accelerations assignable to Earth-Moon and Earth-Sun systems. It is claimed that this dependence on gravitational parameters is quite general. In TGD framework this looks natural since gravitational flux tubes and gravitational Planck constant h_{gr} play a central role in TGD inspired biology. These accelerations have same order of magnitude.

There are two possible sources for the effect in the proposed model.

1. Classical option: the representation $P(n) = |\Psi(n)|^2$ is not assumed. If one accepts the proposed scaling invariant ansatz, the only parameter affecting the p-adic part of the deformation determined by canonical identification is the value of p. Thus the change of p and presumably of also extension of rationals would be involved. p-periodicity is approximate.

2. Quantum option: $P(n) = |\Psi(n)|^2$ is assumed. The existence of quantum p-adics requires $p = m$ so that the space of counts modulo p is finite field G_p. The quantum factor of wave function $\Psi(n)$ in the space of counts the most general quantum phase dependent combination $\sum c_k (kn)_{q_p}$ in $\Psi(m)$, the parameters c_k appear as additional quantal parameters besides the parameters fixing the original distribution $P(n)$ (Gaussian, Poisson,..). For quantum factor the p-periodicity in n is exact. Particle in box description for modulo p counter property suggests standing wave interpretation so that wave function would be $|(kn)_q|^2$ with k having interpretation as an analog of momentum. The outcome would be diffraction pattern

$sin^2(kn\pi/p)/sin(\pi/p)$. The value of k could be seen as analogous to G_p-valued momentum varying from measurement to measurement.

In this case the slow variations of $P(n)$ could reflect slow change of c_k even when P remains unaffected. For instance, a scaling of complex quantum integer n_q to $(kn)_q$, $0 < k < p$ would induce permutation of the peaks of the diffraction pattern. The interpretation would be as finite field permutation induced by multiplication. Also finite field translation of n_q to $(n+k)_q$. This is the minimal option and suggests that genuine quantum effect is in question: the value of k could be seen as analogous to Z_m-valued momentum varying from measurement to measurement.

Suppose that the emitted alpha particle propagates along a magnetic flux tube. A natural question is whether the direction of a_{net} corresponds to a direction of flux tubes at which the gravitational effects of Sun and Moon sum up.

Classical option: The parameters λ_i - such as the parameter defining Poisson distribution - determining $P(n|\lambda_i)$ could depend on X but only through $P(X)$ in the model obeying the scaling invariance $n \to pn$.

The dependence could be through $p = p(X)$ would affect the approximate p-periodicity. A purely p-adic deformation would require that the ramified prime p depends on X so that gravitational effects modify decay rates directly via the relative direction of the alpha particle flux tubes and various kinds of gravitational flux tubes. The extension of rationals assignable to the flux tubes along which alpha particles propagate would depend on X. Alpha particle interactions with gravitational flux tubes via wormhole contacts and this should determine the value of p.

Quantum option: If P and extension are not affected, only the diffractive quantum degrees of freedom remain under consideration.This would provide the minimal model. In quantum sector the quantum part of the distribution could depend on X, say by a scaling of the momentum $k \to r(X)k$ or shift $k \to k + r(X)$ modifying the diffraction pattern. Since the change is slow, shift looks more plausible option having interpretation as a discrete version of slow classical dynamics. Now the peaks of diffraction pattern would be permuted.

1. The dependence of the scaling factor $r(X)$ on the parameter X appearing in $n \to r(X)n$ in quantum factor would be given by piecewise constant function and discontinuities would occur at certain values of X. X is of form

$$X = vv_\alpha g a_{net} \times cos(\theta_1)sin(\theta_2)sin(\theta_3) \ .$$

   Here θ_3 is the angle between v and g, θ_2 is the angle between $v \times g$ and v_α and θ_1 is the angle between E and a_{net}. X has dimension $(v^2/T^2)^2$.

2. If only the relative directions matter, one could try to assign the ineger $r(X)$ to the quantity

$$X_0 = cos(\theta_1)sin(\theta_2)sin(\theta_3) \ .$$

   X_0 does not depend on the absolute values of various parameters such as v_α, which is presumably the observable measured.

3. Some unit should be chosen for the trigonometric functions involved. $cos(2\pi/m)$ *resp.* $sin(2\pi/m)$ is the first$P$ guess for the unit of $cos(\theta_1)$ *resp.* $sin(\theta_i)$, $i = 2, 3$ so that $n(X_0)$ would be given by

$$n(X_0) = [\frac{cos(\theta_1)sin(\theta_2)sin(\theta_3)}{cos(2\pi/m)sin^2(2\pi/m)}] \ .$$

To sum up, the minimal model for the Shnoll effect would be based on the modification of diffractive part by scaling $n \to r(X)n$ so that diffraction peaks are permuted but also the change of $p = m$ can be consider.

5.3.3 What can one say about values about the period of $P(n)$?

The basic prediction is that the presence of an approximate period $p = m$ identified as ramified prime for extension of rationals. In one of the experiments (see `http://tinyurl.com/6kehe9b`

Fig.1 of [E3], [E3]) the histogram for $N(n)$ has peaks, which seem to occur periodically with a separation Δn of about 100 units. If these periods correspond to P, its value must be smaller than 100. The nearest primes are $p = 89, 97, 101, 113$. In **Fig.** 2 of same reference one has also periodicity and p must be near 10. Hence there are good hopes that the proposed model might be able to explain the findings.

There is an intriguing empirical finding possibly related to the value of p and to the dependence on gravitational fields bringing in basic periods of solar system.

1. The fluctuations appear with temporal periods of 24 hours, 27 days and 365 days. Quite recently I learned about 160 minute period which appears in astrophysics in very wide range starting from solar oscillations and ending to the physics of quasars [L85]. TGD inspired interpretation relies on the observation that Fe^{2+} cyclotron frequency in endogenous magnetic field $B_{end} = .2$ Gauss playing key role in TGD inspired quantum biology is 10 Hz and in the interstellar magnetic field with average value of 2 nTesla this frequency corresponds to a period of 160 minutes. Cosmic alpha rhythm could be in question!
2. What is intriguing that 24 hours corresponds to 3^2-multiple and 27 days to 3^5-multiple of this period! Does this mean that $p = 3$-adicity is involved with Shnoll effect $p = 3$ would be a ramified prime of the extension in question. 3-adicity is also observed to be characterize big steps in evolution besides 2-adicity [K70].

5.3.4 Are these models too formal?

The proposed rather formal models in principle have the potential of explaining the findings of Shnoll but detailed numerical work is required to find whether the model works also at the level of details.

1. Taking n as the observable simplifies p-adicization crucially since the p-adicization of classical observables is avoided. One could speak of quantum measurement in the space of counts n defining a universal observable. In quantum measurements the results are typically expressed as numbers of counts in given bin so that this kind of p-adicization is physically natural.

   The division of measurement interval would define an ensemble and n would be measured in each interval. State function reduction would localize Ψ_n to n in each interval.
2. The universality of the modified distributions would reduce to the interpretation of the integer n in the distribution $P(n|\lambda)$ as a p-adic integer mapped by canonical identification to a real number n_R appearing as argument of $P(n|\lambda)$. Same can be applied to $n!$.

   It is essential that the sum of probabilities without normalization factor converges and that the distribution is approximately scaling invariant under $n \to p^k n$. Approximate scaling invariance can be interpreted in terms of fractality implied by the quantum criticality of TGD Universe.
3. One can consider also the quantum variant of p-adic integer n mapped to n_R by canonical identification. The parameter m defining quantum group and being possible for possible "quantum factor" in the complex square root of $P(n)$ having interpretation as wave function satisfies $m = p$ from the condition that the canonical images of quantum p-adics are positive. There are 2 candidates for quantum-padics depending on whether the pinary digits are interpreted as quantum integers as such or mapped to a product of quantum primes.

   Various additional rational-valued parameters characterizing the probability distribution can be mapped to (possibly quantum-) p-adics mapped to reals by canonical identification. The parameters taking care of the converge such as the parameter λ in Poisson distribution must be mapped to a power of p in p-adic context.
4. The small value of p-adic prime p involved can be understood in TGD framework in terms of adelic physics suggesting that preferred primes are so called ramified primes of extension of rationals. For given irreducible polynomial determining the extension one can calculate the ramified primes from the discriminant of the polynomial.

   Model can be applied to the results of Shnoll.

1. The model makes rather detailed predictions about the periodically occurring positions of the peaks of $P(n)$ as function of p based on number theoretical considerations and in principle allows to determine these parameters for given distribution.
2. The value of p could be characterized by the sum a_{net} of gravitational accelerations assignable to Earth-Sun and Earth-Moon systems and could vary. If the value of p is outcome of state function process, it is not determined by deterministic dynamics but should have a distribution. If this distribution is peaked around one particular value, one can understand the findings of Shnoll.

   The periodic variations occurring with both solar and sidereal periods could be understood in two ways. The slow variation of $p = m$ could explain the slow variation of the distributions with position and time. An alternative explanation would be based on slow dependence of quantum factor of $\Psi(n)$ on gravitational parameters and on time. For instance, one could have wave functions proportional $(kn)_{q_m}$, $k = 1, , ...p$, so that the change of k would permute the diffraction peaks.
3. Various effects such as the dependence of the probability distributions on the direction of alpha particles selected using collimators and 12 hour phase shift between the directions associated with East and West direction could be perhaps understood as direct evidence for the effects of measurement apparatus on the many-sheeted space-time affecting either the value of p or the "quantum factor": say the dependence of k on the momentum parameter X defined earlier.

However, one has good reasons to argue that these models are very formal and the connection with the empirical findings is rather loose.

5.3.5 Shnoll effect and quantum gravitation

Thanks for Ed Oberg for sending an email in which he mentioned Shnoll effect. I have discussed the Shnoll effect from the TGD point of view in [L181]. Now I must say that the number theoretical ideas involved with explanation look a little bit too formal an approach when one wants to understand the splitting of the distribution for the number of counts per time interval in say alpha decays. A more direct connection with physics would be badly needed. Therefore I decided to take a fresh look on Shnoll effect with inspiration coming from the increase of the understanding of quantum gravitation in the TGD framework [L175, L176].

1. For instance, alpha decay rates are studied: overall decay rates or in fixed direction for alpha rays. Number of counts per time interval τ varies. Poisson distribution becomes many-peaked.
2. Is there a dependence on the period τ? How many peaks? Are the numbers of peaks the same for various values of τ? The natural assumption is that there are several rates. If so, the number N at the maximum of the peak I is $N = rate(I) \times \tau$.
3. There are periodicities of the peak structure related to sidereal time and solar time. There are correlations with the dynamics of the Sun, Earth, and even galaxy. There is also a dependence on the direction of the alpha ray.
4. The splitting of the decay rates as the emergence of almost degenerate states of nuclei would be the simplest explanation. The astrophysical correlations suggest that this should be due to the gravitational effects.

The recent TGD view of quantum gravitation could provide a simple explanation.

1. A splitting of the state of the emitting nucleus to N states occurs such that the N states have different decay rates. Where does this degeneracy come from? Could the degenerate states be dark variants of the ordinary nucleus in the TGD sense and therefore have different values of h_{eff}. The gravitational Planck constants $\hbar_{gr}$ for astrophysical objects are suggested by the observed astrophysical correlations.
2. Why would these almost degenerate states of nuclei have different alpha decay rates? These rates are determined by nuclear physics. In the TGD framework, the only variable parameter is effective Planck h_{eff} which affects the rates in higher order in perturbation expansion. Lowest order is not affected. In higher orders the effect is non-trivial and could be large for strong interactions.

3. The quantum gravitational effects characterized by $\hbar_{gr}$ are expected to be the largest ones. Could the almost degenerate nuclei be attached to gravitational flux tubes of different astrophysical objects and have different effective/gravitational Planck constants? Sun, Earth, Moon, galaxy, and planest come first in mind.
4. The Shnoll effect depends on the directions and distances of the Sun and Moon and there is a periodic variation. The dependence on the sidereal time suggests that even galactic gravitational fields matter. Since the attachment of the local system to the gravitational flux tube is required, the probability for the presence of a gravitational flux tube connecting Earth and the gravitational source is what matters. The probability is proportional to the density of flux tubes per unit area and decreases with the distance between the Earth and the source. This could explain the periodic variations of the rates.
5. This model applies also to electromagnetic interactions and could explain the Shnoll effect in chemistry. The basic prediction is that the splitting of the Poisson distribution is qualitatively similar independent of the system studied.

It is perhaps fair to conclude that the explanation of the Shnoll effect in terms of gravitational quantum coherence in astrophysical scales is the more plausible option. The study of fluctuations could open a completely new field of research and a very abstract form of quantum theory. From TGD point of view this could mean theoretical and experimental work to deduce and test the predictions of adelic physics.

5.4 Appendix: p-Adic primes as ramified primes, quantum p-adics, and quantum primes

The following describes still rather speculative ideas about the physical role of number theory inspired by adelic physics.

5.4.1 Preferred p-adic primes as ramified primes?

As I wrote the first version of this chapter, I had not yet developed the vision about adelic physics. Adelic physics corresponds to a hierarchy of extensions of rationals inducing extensions of p-adic number fields and the proposal is that ramified primes of extension correspond to preferred p-adic primes.

1. Adelic physics suggests that prime p and quite generally, all preferred p-adic primes, could correspond to ramified primes for the extension of rationals defining the adele. Ramified prime divides discriminant $D(P)$ of the irreducible polynomial P (monic polynomial with rational coefficients) defining the extension (see `http://tinyurl.com/oyumsnk`).

   Discriminant $D(P)$ of polynomial whose, roots give rise to extension of rationals, is essentially the resultant $Res(P, P')$ for P and its derivative P' defined as the determinant of so called Sylvester polynomial (see `http://tinyurl.com/p67rdgb`). $D(P)$ is proportional to the product of differences $r_i - r_j$, $i \neq j$ the roots of p and vanishes if there are two identical roots.

   Remark: For second order polynomials $P(x) = x^2 + bx + c$ one has $D = b^2 - 4c$.
2. Ramified primes divide D. Since the matrix defining $Res(P, P')$ is a polynomial of coefficients of p of order $2n - 1$, the size of ramified primes is bounded and their number is finite. The larger coefficients $P(x)$ has, the larger the value of ramified prime can be. Small discriminant means small ramified primes so that polynomials having nearly degenerate roots have also small ramifying primes. Galois ramification is of special interest: for them all primes of extension in the decomposition of p appear as same power. For instance, the polynomial $P(x) = x^2 + p$ has discriminant $D = -4p$ so that primes 2 and p are ramified primes.

   Remark: All polynomials having pair of complex conjugate roots have $p = 2$ as ramified prime.
3. What does ramification mean algebraically? The ring $\mathcal{O}(K)/(p)$ of integers of the extension K modulo $p = \pi_i^{e_i}$ can be written as product $\prod_i \mathcal{O}/\pi_i^{e_i}$ (see `http://tinyurl.com/y6yskkas`).

If p is ramified, one has $e_i > 1$ for at least one i. Therefore there is at least one nilpotent element in $\mathcal{O}(K)/(p)$.

Could one interpret nilpotency quantum physically?

1. For Galois extensions one has $e_i = e > 1$ for ramified primes. e divides the dimension of extension. For the quadratic extensions ramified primes have $e = 2$. Quadratic extensions are fundamental extensions - kind of conserved genes -, whose further extensions give rise to physically relevant extensions.

   On the other hand, fermionic oscillator operators and Grassmann number used to describe fermions "classically" are nilpotent. Could they correspond to nilpotent elements of order $e_i = e = 2$ in $\mathcal{O}(K)/(p)$? Fermions are building bricks of all elementary particles in TGD. Could this number theoretic analogy for the fermionic statistics have a deeper meaning?

2. What about ramified primes with $e_i = e > 2$? Could they correspond to para-statistics (see `http://tinyurl.com/y4mq6j22`) or braid statistics (see `http://tinyurl.com/psuq45j`)?

   Both parabosonic and parafermionic fields of order n have the representation $\Psi = \sum_{i=1}^{n} \Psi_i$. For parafermion field one has $\{\Psi_i(x), \Psi_i(y)\} = 0$ and $[\Psi_i(x), \Psi_j(y)] = 0$, $i \neq j$, when x and y have space-like separation. For parabosons the roles of commutator and anti-commutator are changed.

   The states containing N identical parafermions are described by a representation of symmetric group S_N with N rows with at most n columns (anti-symmetrization). For states containing N identical parabosons one has N columns and at most n rows. For parafermions the wave function is symmetric in horizontal direction but the modes are different so that Bose-Einstein condensation is not possible.

   For parafermion of order n operator $\sum_{i=1}^{n} \Psi_i$ one has $(\sum_{i=1}^{n} \Psi_i)^n = \prod \Psi_1\Psi_2...\Psi_n$ and higher powers vanish so that one would have $n+1$-nilpotency. Therefore the interpretation for the nilpotent elements of order e in $\mathcal{O}(K)/(p)$ in terms of parafermion of order $n = e - 1$ might make sense.

   It seems impossible to build a nilpotent operator from parabosonic field $\Psi = \sum_i \Psi_i$: the reason is that the powers Ψ_i^n are non-vanishing for arbitrarily high values of n.

3. Braid statistics differs from para-statistics and is assigned with quantum groups. It would naturally correspond to quantum phase $exp(i\pi/p)$ assignable to the exchange of particles by braid operation regarded as a homotopy permuting braid strands. Could ramified prime p would correspond to braid statistics and the index $e_i = e$ characterizing it to parafermion statistics of order $e - 1$? This possibility cannot be excluded since this exotic physics would be associated in TGD framework to dark matter assigned to algebraic extensions of rationals whose dimension n equals to h_{eff}/h_0.

Why the primes, which do not split maximally in given extension would be physically special?

1. Do ramified primes possess exceptional evolutionary fitness and are ramified primes present for lower-dimensional extensions present also for higher-dimensional extensions? If higher extensions are formed as extensions of already existing extensions, this is the case. Hierarchy of polynomials of polynomials would to this kind of hierarchy with ramified primes of starting point polynomials analogous to conserved genes.
2. Quadratic extensions are the simplest ones and could serve as starting point extensions. Polynomials of form $x^2 - c$ are the simplest among them. Discriminant is now $D = -4c$.
3. Why $c = M_n = 2^n - 1$ allowing $p = 2$ and Mersenne prime $p = M_n$ as ramified primes would be favored? Extension of rationals defined by $x = 2^n$ is non-trivial for odd n and is equivalent with extension containing $\sqrt{2}$. $c = M_n = 2^n - 1$ as a small deformation of $c = 2^n$ gives an extension having both 2 as M_n as ramified primes.

   For $c = M_n$ the number of ramified primes is smallest possible and equal to 2: why minimal number of ramified primes would give rise to a fittest extension? Why smallest number of fermionic p-adic mass scales assignable to the ramified primes would be the fittest option?

   The p-adic length scale corresponding ro M_n would be maximal and mass scale minimal. Could one think that other quadratic extension are unstable against transforming to Mersenne extensions with smallest p-adic mass scale?

5.4.2 p-Adic topology and canonical identification

p-Adic physics has become gradually a central part of quantum TGD [K100] and the notion of p-adic probability has already demonstrated its explanatory power in the understanding of elementary particles masses using p-adic thermodynamics [K59]. This encourages the attempt to understand Shnoll effect in terms of an appropriate modification of probability concept based on p-adic numbers.

p-Adic topology [A3] is characterized by p-adic norm given by $|x|_p = p^{-k}$ for $x = p^k(x_0 + \sum_{k>0} x_k p^k)$, $x_0 > 0$. This notion of nearness differs radically from its real counterpart. For instance, numbers differing bya large power of p are p-adically near to each other. Therefore p-adic continuity means short range chaos and long range correlations in real sense. One might hope that p-adic notion of nearness allow the existence of p-adic variants of standard probability distributions characterized by rational valued parameters and transcendental numbers existing also p-adically such that these distributions can be mapped to their real counterparts by canonical identification mapping sum of probabilities to the sum of the images of the probabilities.

In the case of p-adic thermodynamics [K59] the map of real integers to p-adic integers and vice versa relies on canonical identification and its various generalizations and canonical identification is also now a natural starting point.

1. The basic formula for the canonical identification for given prime p characterizing p-adic number field Q_p is obtained by using for a real number x pinary expansion $x = \sum x_n p^{-n}$, $x_n \in \{0, p-1\}$ analogous to decimal expansion. The map is very simple and given by

$$\sum_n x_n p^{-n} \to I(x) = \sum_n x_n p^n \quad . \tag{5.4.1}$$

   The map from reals to p-adics is two-valued in the case of real numbers since pinary expansion itself is non-unique ($p = (p-1)\sum_{k\geq 0} p^{-k}$ as the analog of 1=.99999.. for decimal expansion). The inverse of the canonical identification has exactly the same form. Canonical identification maps p-adic numbers to reals in a continuous manner and also the inverse map is continuous apart from the 2-valuedness eliminated if one introduces pinary cutoff which is indeed natural when finite measurement resolution is assumed.

2. The first modification of canonical identification replaces pinary expansion of real number in powers of p with expansion in powers of p^k: $x = \sum x_n p^{-nk}$, $x_n \in \{0, p^k - 1\}$ and reads as

$$\sum_n x_n p^{-nk} \to I_k(x) = \sum_n x_n p^{nk} \quad . \tag{5.4.2}$$

3. A further variant applies to rational numbers. By using the unique representation $q = r/s$ of given rational number as ratio of co-prime integers one has

$$I_k(q = \frac{r}{s}) = \frac{I_k(r)}{I_k(s)} \quad . \tag{5.4.3}$$

5.4.3 Quantum integers

TGD based motivation for the notion of quantum integer comes from the fact that the so called hyper-finite factors of type II_1 (HFFs) play a key role in quantum TGD and allow to formulate the notion of finite measurement resolution in terms of inclusions of HFFs [K113] to which the quantum groups assignable to roots of unity are closely related. The findings of Shnoll would therefore relate to the delicacies of quantum measurement theory with finite measurement resolution.

In TGD framework one can consider modifications of the notion of quantum integer [A15]. One can ask what is the quantum counterpart of p-adic integer. One an also wonder whether prime decomposition of ordinary integers could generalize in some manner. Ordinary integers are positive and on can ask whether quantum integers should also have this property.

The quantum group is parameterize quantum phase

$$q = q_m = exp(i\phi_m) \ , \ \phi_m = \frac{\pi}{m} \ . \ m \geq 3 \tag{5.4.4}$$

appear in TGD framework and the long standing intuitive expectation has been that there might exist a deep connection between p-adic length scale hypothesis and quantum phases defined by roots of unity defining algebraic extensions of p-adic numbers.

The standard definition of quantum integer has problems

The first thing to do is to see whether the standard notions of quantum integer and quantum factorial [A15] could allow to get rid of the problems.

The definition of quantum integers for $q = q_m$ is given by

$$n_{q_m} = \frac{q_m^n - \overline{q}_m^n}{q_m - \overline{q}_m} = \frac{sin(n\phi_m)}{sin(\phi_m)} \ . \tag{5.4.5}$$

For $n \ll m$ one has

$$n_{q_m} \simeq n \ . \tag{5.4.6}$$

These quantum integers are real. This property makes quantum integers a good candidate if one wants to generalize the notion of Poisson distribution and more generally, any probability distribution $P(n|\lambda_i)$ parameterized by rationals. The rule would be very simple: replace all integers by their quantum counterparts: $n \to n_q$.

The proposal has however some problematic features.

1. n_q is negative for $n \ mod \ 2m > m$ so that in the case of Poisson distribution modified by replacing $n!$ by its quantum counterpart one would have negative probabilities in real context. In the p-adic context there is no well-defined notion of negative number so that one might avoid this difficulty if one can map p-adic probabilities to positive real probabilities. Quantum integers have unit norm p-adically so that p-adic Poisson distribution makes sense for $N_p(\lambda) < 1$.
2. n_{q_m} vanishes for $n = m$ always. Therefore $n_q!$ defined as a product of quantum integers smaller than n vanishes for all $n > m$. One way out is to restrict the values of n to satisfy $n < m$. This number theoretic cutoff would mean in the p-adic case that the sum of p-adic probabilities is finite without the condition $N_p(\lambda) < 1$.

Quantum p-adicity guarantees positivity of quantum integers

The elegant solution to the negativity problem comes from a simple observation. If one has $m = p$, the quantum integers $n_{q_m} = (q^n - q^{-n})(q - q^{-1})$ ($q_p = exp^{i\pi/p}$) are positive for $n < p$, vanish for $n = p$ and become negative at $n = p + 1$. Scaling invariance $n \to np$ is not obtained. One has however more general invariance. For $m = p$, the integers $0 \leq k < p$ and therefore the phases q_m^k behave elements of finite field G_p and the scaling $r \ \ mod \ \ p \neq 0$ for the quantum factor of Ψ acts as a permutation in the set formed by them. One has Z_p invariance. Also translations $n \to n + r$ act as symmetries of G_p.

This suggest the interpretation of n as a p-adic integer so that one can write $n = \sum n_k p^k$. Assume $m = p$. The pinary coefficients $0 \leq n_k < p = m$ satisfy $n_k < m$ so that their quantum counterparts are positive. One can regard them as numbers in algebraic extensions of p-adic numbers defined by the q_m. One can call these numbers quantum p-adics.

One can also map quantum p-adics to reals by using identification map as such. The same map is used also for algebraic extensions of p-adic numbers. There are however restrictions on p and m: m must be such that q_m does not allow representation as non-vanishing ordinary p-adic number. For $p = m$ the condition is satisfied.

Should quantum integers allow a factorization to quantum primes

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Physics as a generalized number theory vision [K100] suggests a way to circumvent above described problems.

1. Quantum integers defined in the standard manner do not respect the decomposition of integers to a product of factors- that is one does not have

$$(mn)_q = m_q n_q \quad . \tag{5.4.7}$$

The preferred nature of the quantum phases associated with primes in TGD context however suggests that one should guarantee this property by hand by simply defining the quantum integer as a product of quantum integers associated with its prime factors:

$$n_q \equiv \prod (p_i)_q^{n_i} \text{ for } n = \prod p_i^{n_i} \quad . \tag{5.4.8}$$

This would guarantee that the notion of primeness and related notions crucial for p-adic physics would make sense also for quantum integers. Note that this deformation would not be made for the exponents of integers for which sum is the natural operation.

2. This definition has problems. The quantum primes can have negative sign and if m is prime, quantum prime p_{q_m} vanishes. For $m = p$ allowing the definition of quantum p-adics and their real counterparts, one can restrict prime decomposition to the primes appearing as factors of the pinary digits $k < p$ of quantum primes.

Acknowledgements: I am grateful for Dainis Zeps for references related to Shnoll effect.

Part II

MORPHOGENESIS

Chapter 6

TGD view of Michael Levin's work

6.1 Introduction

This article was inspired by the work of Michael Levin's group in biology. I have already earlier (2014) commented the work of Levin [I82, I83, I116] in the article [L25]. To my view, these discoveries profoundly modify the views of the role of genes and lead to a completely new vision about morphogenesis about which genetics cannot tell much.

The amazing discoveries by Michael Levin and others related to morphogenesis (such as the discovery of xenobots as synthetic life forms) could lead to the correct track not only in biology and neuroscience but also in attempts to define and construct AI and artificial life.

The articles [I84, I86, I78, I25, I72, I85] provide a good view of the vision of Levin. Interested readers can listen the interviews and talks of Levin in web.

I started with the interview of Michael Levin at `https://youtu.be/XheAMrS8Q1` with title "The electrical blueprints that orchestrate life" . The talk "Plasticity without genetic change: bioelectric embryos & synthetic proto-organisms" (`https://www.youtube.com/watch?v=5ChRM4CEWyg`) gives a summary of the role of bioelectricity in embryos and about the synthesis of artificial organisms known as xenobots.

The talk "Understanding the Collective Intelligence of Cells: bioelectrical navigation of anatomical morphospace" at (`https://www.youtube.com/watch?v=jLiHLDrOTW8` provides a view of morphogenesis as a navigation in morphospace towards the final morphology as a goal represented as a memory.

The talk of Josh Bongard titled "A xither of xenobots: demolishing dichotomous thinking with synthetic proto-organisms" (`https://www.youtube.com/watch?v=7EA2AqSO5tQ` discusses the implications of the findings for fields like AI. The talk is about brain/body -, genotype/phenotype -, and tape/machine dichotomies, which have made a real progress in ortodox AI difficult, if not impossible. The article [I72] discusses the same topics.

The approach of Michael Levin does not mention quantum biology at all. At least from the perspective provided by the TGD inspired view of quantum physics and quantum biology, the findings are however extremely inspiring. In the sequel, I will discuss these findings and the theoretical vision inspired by them, and also the interpretation of findings in the framework of TGD inspired theory of consciousness and of quantum biology. These findings provide crucially important bits of data for a further development of the already existing TGD view of morphogenesis [L25, L160, L150, L145]. Also the interpretation of the zero energy ontology (ZEO) [L96] becomes more precise.

6.1.1 About the basic vision and experimental findings of Michael Levin

The basic challenge is to understand how organisms evolve from embryo to their final shape. Genetics applies at the level of a single cell and does not offer clues of how genes might determine the shape and size of the organism. Therefore the dogma that genotype determines phenotype has remained an unproven hypothesis. Already the emergence of epigenetics has made clear that genes are not enough: the same genome has very many transcriptions, which can vary in a very rapid time scale for a given organism. The work of Levin's group has shown that the correspondence

between genotype and phenotype is even more flexible: one can even create new life forms using a given genome (zenobots).

Does bioelectricity code for morphogenesis?

The underlying idea is that the dynamics of the brain as a collective of neurons has evolved from the morphogenesis of cell groups. Instead of a communication using nerve pulses patterns, the communications use the distribution of membrane potentials (hyperpolarization and depolarization). Static gap junctions in turn take the role of much more dynamic synaptic contacts.

1. Dynamical patterns of membrane voltages assignable to cell membranes, which are determined by the voltages assignable to voltage gated ion channels and pumps, connectivity of cell groups determined by the distribution of gap junctions, plus long range potential gradients controllable by the patterns of membrane potentials, seem to act as a new control level which also controls the epigenetic level. The membrane voltage pattern and distribution of gap junctions are controlled in the experiments of Levin's group using biochemical tools.
2. The potential gradients in the scale of the organism or organ associated with the embryo in turn determine the morphogenetic goal as an analogue of memory in the same way as voltage gradients correlate with the state of the brain.
3. Electric signals as oscillation patterns of membrane potentials between cells mediated via gap junctions are proposed to actualize an analog of a computer program. This signalling is also referred to as conversation, which would be something less deterministic. The program would code the destiny of the cell group.
4. Self-organization in some sense is involved. Dissipation takes care that self-organization leads to a very few final states from a larger number of initial states. It is not however clear whether biological self-organization can be described by the standard picture in which self-organizing dissipates incoming energy and ends up to a thermal non-equilibrium. Related question concerns homeostasis: how is the system able to stay near a critical state, which is by definition unstable? Here self-organized criticality is a suggestive notion and to my best understanding not very well-defined.

Some astonishing findings

Manipulation of gap junction distributions and very specific ion channels has led to a handful of very astonishing findings providing deep insights of the basic mechanism of morphogenesis.

1. Planarians are animals which create offspring by replicating. They can be split even to 200 pieces cuch that every piece develops to a full-grown planarian. One might say that planarians do not experience aging at all. Long length scale electrical gradient rather than genome determines the positions of head and tail. Knowing also when to stop the growth is very important. How this is realized is not understood. Does the morphology of an adult planarian have a representation serving as a template in growth?

   It is possible to manipulate the ion channels and gap junctions such that electrical field configuration changes and the split planarian develops to two planarians having two heads. This feature is preserved in further splittings of the planaria.

   Also the memories of the parent planarian (defined as behavioral patterns) are inherited by the daughter planarians. The development of larva to a butterfly is a second example. The phenotype and also the brain of the larva are dramatically changed in the transition but the memories of the larva are preserved. This suggests that the memories are not presented at the level of the brain.
2. The gut cells of frogs, whose membrane potentials and gap junctions have been appropriately manipulated to give rise to long range electric gradients, can generate a functioning ectopic eye located outside the head. Also other organs, even those usually bot possessed by frog, can be generated in this way.
3. In Picasso frogs the embryo is mixed so that various parts of the embryo are in the wrong places. The embryo however develops into a normal frog. Therefore morphogenesis cannot be a hardwired set of movements. There is minimization of error and goal directed behavior.

Computer scientists would talk of a computation determining the large scale anatomy, with computation interpreted as a search of the goal configuration in morphospace and represented as a stable memory. Conscious theorists would talk of a goal directed behavior as intentional behavior.

4. Xenobots are a completely novel life form evolving from appropriately manipulated frog embryos involving removal of a fraction of cells. Genetically unaltered cells coalesce and are liberated from the rest of the body. Novel bodies are different from tadpoles and epigenesis is different. For instance, cilia have a different function. In the frog, they transfer the mucus whereas xenobot uses the cilia for swimming.

6.1.2 Giving up genetic determinism

The basic belief is that genotype determines the phenotype. Only adaptations can change the phenotype. Programming by machine code serves as a metaphor. The computer itself is modified in the programming. The emergence of computer languages meant a revolution and information science was born. There was no need to modify the hardware anymore. Computer programs, represented as input signals, defined the computation. Only the simplest functions are realized as programs at the level of hardware and their functional composition gives rise to programs in accordance with the Turing paradigm.

One can say that most of the recent biology studies only the machine code level. Genes code for the basic building bricks (proteins). Biological systems would be like computers determined by the genetic code. Genetic determinism reflects this belief. This approach leaves open how the behaviors analogous to running computer programs emerge. Machine code metaphor would suggest they are determined completely by the hardware, genes.

The revolutionary idea is that there exists an analog of higher level computer languages based on electric fields. Bio-electric programs would correspond to electrical signalling. Morphology would be based on patterns of electric voltages assignable to cell membranes determining potential gradients in longer scales. For the early embryo these gradients would code for the morphology.

The examples mentioned in the introduction allow us to deduce conclusions of this programming.

1. The morphology of an adult planarian is coded by the long scale electric fields of the embryo. Also the memories interpreted as behaviors are inherited in the replication of planarians by splitting. This means that the morphogenesis is goal directed and goal corresponds to a stable memory.

   If the long range potential pattern of adult planarian is manipulated to produce 2-headed planarian after the splitting, the planarian is not affected. Therefore one can say that the memory of the electric field pattern matters but that in the splitting the memory is replaced by a new one. Also the descendants of split planarians have two heads so the memories are inherited in splitting.

2. The example of Picasso frog tells that even dramatic perturbations are not able to prevent the development towards a correct goal. Goal is indeed a stable memory coded by the electric state of an early embryo and the system is able to make error corrections.

3. The gut cells or frogs, when appropriately manipulated to modify the connectivity determined by gap junctions and the long range electric fields can develop to ectopic eye. Also other organs can be generated in this way. Even organs not usually possessed by planarians, such as fish fins, can be generated. Xenobots are novel life forms with the same genome as the frog.

   These findings imply that the memory telling the goal can be rewritten and does not depend on gene expression. The same genome corresponds to the entire morphospace consisting of different organisms with different functions. Epigenetic level is however differently realized.

These findings are consistent with the proposal that goal is represented as a memory which is characterized by long-term stability, lability (rewritability), latency (conditional recall: the 2-headed planaria is generated only if the planarian is gut first), and discrete set of possible outcomes.

This inspires the computational hypothesis. Goal is computed. Electric signalling and classical long range potential gradients define an analog of genetic code and one can wonder whether some kind of morphic code based on the grading of the membrane potential exists. Difficult

questions relate to the realization of the memory. How it can be stable if the organism itself is evolving. Some kind of time travel would be required for memory recall. Is it a conscious memory?

6.1.3 Xenobots challenge the dichotomous thinking in biology and AI

The talk of Josh Bongard having title "A xither of xenobots: demolishing dichotomous thinking with synthetic proto-organisms" (https://www.youtube.com/watch?v=7EA2AqSO5tQ discusses the implications of the findings of Levin's group for fields like AI. The topic of the talk are brain/body -, genotype/phenotype -, and tape/machine dichotomies, which, according to Bongard, have made a real progress in ortodox AI difficult, if not impossible.

1. Brain/body dichotomy states that the brain tells the body how to move. In this picture, the body is a dead robot, hardware, and the conscious brain is the central intelligence, the software, which determines how the body moves. This view has dominated the view about AI. Although this view is plagued by several paradoxes due to the fact that nerve pulse transmission is quite too slow to realize the multiple feedback needed to actualize the commands of the brain, it still dominates the thinking.

   The talk illustrates the basic failure of robotics by videos of falling robots. This illustrates the basic difference between robots and living matter. Humans do not fall down although they are about to fall down all the time. This is because of homeostasis. Living matter is a critical system which by some mechanism is able to remain near the criticality. Robots are not such systems and they fall down.

   Biology suggests how to make this view more realistic by assuming that both the brain, software and the hardware can adapt. For rigid robots only the brain adapts. The talk describes smooth robots whose shape can vary. The challenge is to have a moving robot and a genetic algorithm indeed allows to find brain/body adaptation strategies. The genetic algorithm indeed discovers unexpected strategy in a situation making movement possible. Brain actually adapts very little for the model considered.

2. Genotype/phenotype dichotomy more or less equivalent with genetic determinism states that genotype determines phenotype. Epigenesis means the failure of the strictest form of this dichotomy. Xenobots mean much more dramatic failure. Same genome can give rise to different organisms.

   AI has played an important role in the development of the Xenobots and a simple in silico model of the xenobot consisting of skin tissue and muscle tissue is discussed. In this model skin selves receive impulses from random actions of motor parts and are able to generate coherent motion. How this happens looks like a mystery. The mystery is much deeper: how selfish cells having only personal goals are able to transform to unselfish parts of an organism. This remains one of the deepest challenges of biology and the notion of emergence remains only a magic word without actual content.

3. Tape/machine dichotomy is central in computer science. Turing machine serves a a mathematical model of computer. Tape would represent the program and the machine would produce from the input table the output buble. Self-replication machines are Turing machines able to replicate. The talk represents a simple model for von Neumann self-replicator, which consists of 4 parts A,B,C, and D representing the tap. A makes a copy of A+B+C and B then makes the copy of D and combines A+B+C and D together. This kind of self-replication is called kinematic self-replication.

   In living matter this dichotomy is far from obvious although the notions of input as a generalized sensory percept and output as motor action make sense. In living matter the self-replication is very different and takes place by growing. There is no obvious identification of tape and machine.

   Xenobots represent a biological actualization of a kinematic self-replication. Few generations of xenobots are possible. Genetic algorithm has been used to develop a simulation of self-replicating xenobots.

6.1.4 Brief comparison of Levin's views with the TGD view

Despite very different starting points, there are many similarities between Levin's views and TGD view.

1. Levin emphasizes the importance of cognition and also introduces the notion of self. Levin also talks of collective intelligence (swarm intelligence) and cognition and argues that all intelligence is basically collective intelligence.

   TGD inspired quantum theory of consciousness predicts self hierarchy. In the TGD framework, number theoretic physics involving p-adic and adelic physics provides a mathematical framework for the description of cognition. One can say that number theory becomes part of physics. $M^8 - H$ duality would actualize the duality between the view about physics as geometry and physics as number theory.

   One of the predictions is hierarchy of Planck constants identifiable as dimensions of algebraic extensions of rationals assignable to polynomials of real argument, which define space-time surfaces by $M^8 - H$ duality. This number theoretic holography involves almost deterministic holography at space-time level implying in biology an almost exact structure-function duality. Once one knows the 3-D surface, the 4-D space-time surface is almost uniquely determined as an analogue .bvcx of Bohr orbit.

   Number theoretic vision leads also to a universal mechanism for the formation of bound states, which would also describe the formation of quantum coherent units from parts, such as selfish cells.

2. The experiments of Levin's group demonstrate the failure of genetic determinism and genetic reductionism. For a given genome one can have a large number of very different phenotypes involving different epigenomes. Genes would be only a hardware or lowest level of biological scale hierarchy and higher levels would control the lower levels rather than being determined by the gene level. Examples are genetic level, transcriptional level (epigenesis), morphogenetic level, physiological level, neurological level, and even higher levels. Multiscale competency is the term used by Levin. This means self-organization and slaving hierarchies.

   In TGD these hierarchies correspond to fractal hierarchies of space-time sheets (MBs and EBs), p-adic length scale hierarchies, hierarchy of effective Planck constants labelling dark phases of ordinary matter, various algebraic hierarchies for symmetry algebras associated with TGD, to the hierarchies of inclusions of extensions of rationals, to the hierarchies of hyperfinite factors of type II_1, and self hierarchies as hierarchies of conscious entities, selves.

3. Levin proposes electric coding of morphogenesis based on membrane resting potentials and that gap junctions connecting cells to each other give rise to connected morphogenetic units. For instance, cancer cell population would disconnect from the population. Furthermore electric signalling between cells based on membrane oscillations would be essential for morphogenesis.

   TGD suggests that ordinary genetic code is only a special case. The genetic code is universal and there is a hierarchy of realization of genetic code. One fundamental realization of the genetic code would be in terms of so-called icosa-tetrahedral tessellation of H^3 [L128] and it would induce various realizations at the space-time level. Dark genes would provide 1-D realization and cell membranes might provide 2-D realization of the genetic code and even 3-D realizations can be considered.

   Realizations of genetic code in terms of dark proton sequences with codon realized as dark proton triplet and dark photon sequences with codon realized as dark photon triplet are predicted.

   In TGD, cell membranes correspond to electric bodies (EBs) and the proposal is that they act as Josephson junction communicating with the magnetic body (MB) using dark Josephson radiation and a cyclotron resonance mechanism transforming frequency modulated Josephson radiation to a sequence of pulses. Besides ordinary nerve pulse patterns, patterns of pulses in mV scale assignable to gap junction connected cell groups are predicted [L150] inspired by the experimental work of Prakash et al [I94, I92, I93] and Adamatsky [I21] and the TGD view of quantum gravitation [L145] predicting that quantum gravitational coherence is possible in arbitrarily long scales and is especially important in quantum biology.

4. The notion of morphospace corresponds in the TGD framework to the "world of classical worlds" (WCW) [K89] [L136, L163], which in the number theoretic vision has unique number theoretic discretization using appropriate extension of rationals.
5. In TGD, the notion of cognitive light-cone introduced by Levin corresponds to causal diamond (CD) [L96, L144] [K117], which is the basic notion in zero energy ontology (ZEO) providing a new ontology of quantum theory solving the basic paradox of quantum measurement theory. CDs form a fractal hierarchy.

   Consider now the basic differences.

   The basic difference is that Levin does not mention quantum theory at all. In the TGD framework, quantum theory is based on ZEO [K117] rather than the standard ontology of quantum mechanics, which relies on the identification of subjective time and geometric time of physicists. ZEO has rather non-trivial implications such as the prediction that in the ordinary state function reductions (SFRs) the arrow of time changes. These implications are crucial for understanding consciousness and biological self-organization. The views of free will and consciousness are different. Levin suggests what he calls a technological approach to Mind [I85]. The engineering based approach is proposed to lead to the notion of self, to explain cognition, and also even free will as an illusion, and perhaps even consciousness. Self would be determined by the morphogenetic or some other goal, and would be in principle an experimentally testable notion. Levin assumes that cognition is universal and appears in all scales. Also in TGD cognition is fundamental and number theoretical physics (adelic physics) [L59, L60] is needed to describe the mathematical correlates of cognition. This leads to the view the physics as geometry and physics as number theory are complementary descriptions of physics [L104, L105, L163, L157] The ZEO based quantum measurement theory extends to a theory of consciousness. In the TGD framework, Sslf as it is identified by Levin, would correspond to the unchanging part of self, kind of "soul". Self is predicted to also have a changing part determined by the generalized sensory input and motor actions. The unchanging part of self would by holography serve as a memory dictating the goal of the evolution of self, in particular in morphogenesis.

Note: I give the references to the articles related to TGD, which appear at my homepage. The articles have been published also in the journals founded by Huping Hu (PSTJ, JCER, and DNADJ) and the list of the published articles can be found at my homepage (`https://www.tgdtheory.fi/tgdmaterials/curri.html`). The reason is that the articles at homepage are updated versions of original ones.

6.2 Levin's vision

In the following I try to summarize Levin's view of cognition and the big vision about implications of the new view of morphogenesis. The articles [I84, I86, I78, I25, I72, I85] provide a good view of the vision of Levin. The interviews and talks of Levin provide the best way to get a view of Levin's vision and the following only tries to summarize the most important points. The following interviews and talks provide a good overall view of Levin's work.

1. The electrical blueprints that orchestrate life (`https://youtu.be/XheAMrS8Q1c`)
- Plasticity without genetic change: bioelectric embryos & synthetic proto-organisms (`https://www.youtube.com/watch?v=5ChRM4CEWyg`)
- Understanding the Collective Intelligence of Cells: bioelectrical navigation of anatomical morphospace (`https://www.youtube.com/watch?v=jLiHLDrOTW8`)
- Biology, Life, Aliens, Evolution, Embryogenesis & Xenobots (`https://www.youtube.com/watch?v=p3lsYlod5OU`)

6.2.1 Technological approach to Mind

Levin proposes what he calls a technological approach to mind [I85]. Levin suggests an active engineering approach in which new structures are constructed and studied instead of a passive study of existing structures.

1. Levin suggests definitions for the notions of cognition, intelligence [I86, I78] and of self [I84]. It remains unclear to me whether cognition is assumed to involve consciousness.
   (a) There would be no privileged substrate of cognition. This might be taken to mean that cognition is something universal. This also suggests panpsychism.
   (b) Intelligence is identified as the ability to solve problems in abstract spaces.The abstract spaces correspond to spaces of possible goals of the system in various scales and form a hierarchy. Problem solving means achieving a goal in the space considered. The same goal achieved by different means: this would be the basic characteristic of intelligence. Ordinary 3-space, morphospace and physiological represent basic examples of spaces. One can also talk of genetic and transcriptional spaces. The goal space at a given level can "bend" the space at the lower level so that the agents at the lower level start to collaborate instead of behaving in a selfish manner. In organisms, selfish genes become unselfish. In cancer just the opposite happens and means that the cancer cells as a subsystem quite concretely separate from the system.
   (c) Somewhat cryptically, the notion of self is identified as boundaries of goals that the system is capable of pursuing. More concretely, one might also say that the developmental goal of the organ or organism assigns self to it.
2. Developmental bioelectricity is another key notion. It is identified as a phylogenetic precursor of brain dynamics, a physiological medium for the software of life, and a medium of the cognition of morphogenetic swarm intelligence of cells. All intelligence is basically collective intelligence in which the subsystems start to collaborate to reach the collective goal.
3. Evolution would be greatly potentiated by multi-scale competency architecture [I25]. Evolutionary step would not be finding a solution to a problem but building a new kind of machine solving more complex problems. Increase of the scale and emergence of a new evolutionary level would be in question.

   Selection by evolutionary pressures and random mutations drive the evolution in the Darwinian view. Levin expresses his view by saying: "where the goals come from, if not from selection?". One can of course ask whether the increase of complexity closely related to intelligence is a basic evolutionary goal of the Universe. This view seems to be in conflict with the second law however.

6.2.2 Levin's view of cognition

Multiscale competency architecture

Multiscale competency [I25] architecture is a key notion used by Levin.

1. Evolution uses multi-scale competency architecture to evolve machines that solve problems. The meaning of machine is however different from that in the recent technology [I72]. One could translate "multi-scale competency architecture" to a fractal slaving hierarchy in which higher levels whose dynamics is in longer spatial and length scales interact with lover levels and receive information from these levels and control them.

   Scaling is a key aspect of evolution. Evolution step means the emergence of a system characterized by larger spatial and temporal scales of coherence and of higher complexity and consisting of the already evolved systems, which start to co-operate. The spans of memory and anticipation increase.
2. DNA specifies cellular hardware but is controlled by agential materials inducing different epigenetic patterns.
3. Dynamics is robust due to anatomical homeostasis. Morphogenesis can be seen as an intelligent behavior of a cellular collective solving problems in anatomical morphospace. Computationalist would say that problem solving reduces to a search in the morphospace in order to reach a goal.
4. The cognitive glue that harnesses cells towards large scale outcomes ("bends" the lower levels to collaborate) is developmental bioelectricity. Goals are represented by long scale electric

patterns generated in the embryonic stage and are identifiable as pattern memories utilized by collective intelligence of the organ. The experimental work of Levin et al makes it possible to read and write pattern memories.

Collective intelligence of cells

https://www.youtube.com/watch?v=jLiHLDrOTW8

Usually one distinguishes between centralized intelligence (brain would be the basic example) and collective/distributed/swarm intelligence. Levin proposes that all intelligence is collective intelligence.

The proposed multiscale competency [I25] in which higher level "bends" lower levels to co-operate, could be translated as a slaving hierarchy involving "bosses". One can also speak of a nested cognition.

There is a high multiscale competency already at the level of a single cell and in this case the smaller subunits are subsystems of the cell down to the level of genes. Single cell morphology and behavior are indeed very complex. The cell can detect bodies in its environment by generating vibrations which are reflected from objects. Kind of sonar is in question and allows us to build a map of the environment. The cell is able to reach the desired targets of the environment using this information.

Levin lists the following key aspects of collective intelligence.

1. Navigation in morphospace towards the goal and multiscale competency architecture (slaving hierarchy) makes this possible. Higher level morphospaces "bend" the lower level morphospaces forcing them to collaborate.
2. Goal-directedness involves recognizing, building, and controlling and communicating with agents in possibly unconventional embodiments (non-standard phenotypes). Self is defined as a cognitive boundary identified as the goal of the system.
3. Anatomical control reflects the collective intelligence of cells navigating in the morphospace. Bioelectric networks and their proto-cognitive medium (ancestor of brain function) $\rightarrow$ impact on biomedicine. The term "proto-cognitive" suggests that ordinary cells are not assumed to cognize. The goal of an organ or organism is coded by the electric field patterns during early embryo stage and can be regarded as a memory.
4. Synthetic bioengineering as a construction of new bodies and new minds corresponds to the active, engineering aspect of the approach. What is new and racial is that the novel organism does the job itself when the goal is given.

   The novel life forms have no evolution behind them and their possibility suggests that same genomes can give rise to widely different organisms and that also different life forms can give rise to similar organisms. This view forces us to reconsider what evolution is.

   One can imagine applications to biomedicine and robotics, and one can ask whether the term robot is anymore appropriate. This vision raises deep questions in ethics, which is based on the view that life forms are products of long evolution and has been strongly human centered. What are the universal principles of ethics, is the question.

The basic critical question is that the notions of cognition, intelligence, self, multiscale competency, goal, and evolution are not defined at the deeper, presumably quantum physical level. Quantum physics as we now understand it, does not of course allow the formulation of these notions. The same applies to the notions of memory, and self, goal or intention. These notions would require a theory of conscious experience telling what distinguishes living systems from dead systems (if such even exist).

6.2.3 The dream

The dream of Levin [I85, I72] is to understand, recognize, create, and relate to truly diverse intelligences regardless of composition or origin story. Besides understanding of familiar creatures one would understand colonial organisms and swarms, even say something universal about exobiological agents. This would make possible synthetic biology, bio-inspired AI.

Communication with cell groups allows rewriting of the morphogenetic goals. Rewriting would be like activating one particular program module in the hierarchy of program modules. This module would call lower levels modules and in this way recruit the agents at the lower levels of the scaling hierarchy. No knowledge of the details of the process at lower levels would be required. This approach is a diametric opposite to the usual approach based on gene level manipulations.

One can even dream of the emergence of an anatomical compiler, which assigns to a plan of an organism, generated using AI utilizing the available empirical data, a new organism with desired functions. This dream is of course very far from reality. Levin mentions as an example the chimeric embryo formed from azoloti larva and frog larva. The existing models cannot predict what the outcome of the morphogenesis in this case could be.

Regenerative medicine would provide obvious applications for this kind of compiler. Consider only birth defects, degenerative diseases, aging, and cancer. Reprogramming a multicellular level could allow to normalize tumors, repair birth defects, induce regeneration of limbs, etc... Levin mentions also the development of electroceutical drugs based on chemical manipulations of cell membranes. What ions? What ion channels? These would be the basic questions?

Aso other than biochemical tools for the programming of the morphic goal might be possible but this would require a deeper understanding of how the goal identified as a memory is represented. Here quantum biology could come to rescue. One should understand how the goal as memory is defined at quantum level and how the manipulation of the voltages assigned to ion channels affect the goal.

One can imagine applications to computer science, say bio-computers for which search corresponds to finding a goal in the morphospace. Whether this can be realized using ordinary computers or even quantum computers relying on the standard quantum theory, is of course far from obvious.

The goal directed behavior could involve the feedback loop involving sensory perceptions about the state of the organism, which are compared with the goal, and generate feedback as a control signal.

One can also imagine a neuro-inspired view of sensory perception as a pattern recognition and completion in which the morphogenetic goal is represented by standardized mental images representing the possible outcomes of pattern completion. One could also consider the bio-inspired analogue of machine learning.

6.3 TGD view of morphogenesis

The TGD inspired view of life and consciousness leads to a view of morphogenesis discussed in detail in [L160] (2022). The discoveries of Levin's group described in [I82, I83, I116] have been discussed in [L25] (2014).

6.3.1 A possible TGD based view of morphogenesis

The basic notions relevant to the TGD description of morphogenesis.

1. The notions of magnetic and electric bodies (MBs and EBs). Magnetic flux tubes and possibly also sheets form a network connecting cell membranes and higher level membrane like structures. They correspond to EBs formed by light-like outer boundaries of 3-D surfaces representing the bodies of the network.
2. The phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$, tentatively identified as dark matter, play a key role in the TGD inspired quantum biology. These phases can reside at MB and EB. In the models considered hitherto MB is in a key role but it is clear that EB has an important role.
3. The notion of genetic code is generalized. One can speak of dark code with codons realized in terms of dark proton - and dark photon triplets. In the number theoretic vision dark genes are realized as 3N-protons and photons. The so-called icosa tetrahedral tessellations of hyperbolic 3-space H^3 define a candidate for a universal realization of the genetic code. The genetic code could be realized at the level of cell membranes in terms of ion channels. One representation for the codons as 6-bit sequences could be as graded membrane potentials. The 2-D pattern

of codons would define a set of 2-D genes. Electrical manipulations affect these genes and they become dynamical. This could also define what might be called "morpho-genes".

4. The electric programming of cell groups by electrical manipulation could affect the 2-D genetic codons, which would define the morphogenetic program. This would be possible at the early embryo state during which the system would be quantum critical. The fixing of membrane potentials of ion channels and pumps could fix the frequency of dark Josephson radiation from cell membranes to MB for them and select parts of MB for which cyclotron frequency is same as for the ion channel. This would map the electric pattern of the cell membrane to MB. After this period the situation would stabilize.

5. Zero energy ontology (ZEO) and holography might play a key role. The basic problem is to understand how a goal is realized as a memory. In ZEO the initial state as a superposition of 3-surfaces at the passive boundary of CD would remain invariant during the evolution of the zero energy state. It would naturally define the counterpart of memory and dictate to almost deterministically the evolution of self by "small" state function reductions (SSFRs). The memory would correspond to the part of self which is not changed during the evolution by SSFRs.

   The comparison of the zero energy state defining self would in the simplest model be based on communications to the passive (past) boundary of self with negative energy signals with reversed arrow of time. The feedback would be a positive energy signal back to the future. This process essentially pattern recognition and completion and would gradually lead to the goal. This picture is completely general and morphogenesis would have only one particular application. One can consider more complex models in which the information about the goal at the MB is preserved and sensory communication could be also in standard time direction whereas the feedback would be in the opposite time direction. "Big" SFRs (BSFRs) would be involved in both cases.

   Pairs of BSFRs involving temporary change of the arrow of time could be involved with large error corrections. Note that the sensory communications to the geometric past and the feedback can be seen as a pair of BSFRs at a lower level of hierarchy.

6.3.2 How the membrane potentials and gap junction connections could define morphogenetic program?

The behavior of the planaria is goal directed. There are reasons to assume that this is quite generally true.

Facts

1. The membrane potentials and gap junction connection network during the early embryonic stage code for the goal of the organism in morpho-space.
2. After this period, various perturbations, even very dramatic such as mixing of the parts of the embryo, do not prevent achieving the goal and the system is able to correct its errors. There are several ways to achieve the goal: this is interpreted as intelligent behavior.
3. If planaria is cut in pieces, the pieces grow to full individuals so that the memory of the goal is represented in such a way that the splitting does not affect it.
4. The modifications of the membrane potential of a full grown planaria and gap junction network do not affect the goal. One can say that the system goal corresponds to a stable memory of what point of the morpho-space the system should reach.
5. If membrane potential is manipulated and the planaria is cut after the modification, the resulting planaria have a new goal coded by the new pattern of membrane potentials and gap junction network. For instance, the modification can give rise to 2-headed planaria. If one assumes that the development corresponds to an analog of a computer program, one can say that the modifications lead to new morphology only if the planaria is split.

How could one realize this picture in the TGD framework? In accordance with earlier vision, it is natural to assume that MB, or actually a hierarchy of MBs, defines a slaving hierarchy

with levels labelled by the values of h_{eff} defining scale hierarchy assignable to hierarchy of causal diamonds (CDs), which are analogs of cognitive light-cones of Levin.

Especially important levels of the hierarchy are labelled by gravitational Planck constant $\hbar_{gr} = GMm/v_0$ originally introduced originally by Nottale [E1]. Here M corresponds to either Earth mass or solar mass and m corresponds to particle mass. The large values of $\hbar_{gr}$ make possible gravitational quantum coherence in long length scales, even Earth scale. The gravitational Compton length $\Lambda_{gr} = BM/v_0$ does not depend on the value of the particle mass m and the cyclotron frequencies of charge with mass m does not depend on m: this conforms with Equivalence Principle. This view leads to a view about the role of quantum gravitation in biology [L150, L145, L152].

Questions related to the electric coding of the goal

There are several questions to be addressed.

1. Why electric modifications have effect only if they are done during the early embryonic state?

   The possible explanation is that the MB during the early embryonic period is quantum critical and therefore highly sensitive to perturbations of the biological body represented as modifications of gap junction network and membrane potentials. During this stage the classical pattern of membrane potentials correlates strongly with the state of the MB, which defines the goal as memory. Quantum criticality is later lost and further modifications do not affect the goal anymore.

2. How the organ/organism remembers the goal and how the memory can be stable? Here ZEO provides a possible explanation. Zero energy states are pairs of ordinary 3-D states at boundaries of causal diamond CD and represented by superpositions of space-time surface. Holography, which is forced in TGD by the general coordinate invariance, forces almost deterministic correlation between the 3-D states at the opposite boundaries of CD.

   The sequence of SSFRs preserves the state at the passive boundary of CD and passive boundary but affects the active boundary and the states at it and the temporal distance (geometric time) between boundaries of CD increases: this correlates the flow of subjective time as SSFRs with the increase of the geometric time. The sequence of SSFRs defines the notion of self as a generalization of the Zeno effect. The state which is unchanged in Zeno effect is replaced with the memory about the goal.

   By almost deterministic holography, the state at the passive boundary defines the goal of the system towards which it evolves.

6.3.3 How the potential gradient is generated?

The generation of potential gradients is essential in morphogenesis. Potential gradients play a key role also in the brain functions and the direction of the gradient correlates with the state of consciousness. Potential gradients accompany DNA and microtubules. Hyperpolarization occurring during sleep corresponds to a reduction of the level of consciousness. On the other hand, the direction of a long scale electric field determines whether the brain is conscious or not. Therefore the polarization at the level of neuronal membranes correlates with the direction and strength of the electric field. Why this should be the case, is actually far from obvious, and TGD suggests that new physics, involving quantum gravitation, is involved.

From the videos, I concluded that the potential gradient is generated by manipulating the membrane potentials and that the change of the membrane potential of a given cell is constant and is the same at the two sides of the cell membrane defined by direction of potential gradient. I failed to understand how the variation of membrane potentials in this way can generate a potential gradient along part of the body. The manipulation of membrane potentials of cells such that membrane potential is constant for the entire cell membrane does not generate potential gradient.

Potential gradient means that cells are in an electric field for which potential increases in a given direction and is approximately constant inside a given cell. The simplest expectation is that the membrane potential is modified by the same constant amount for the entire cell.

The membrane potentials should be modified in such a way that the membrane potential is different at different sides of the membrane in the direction of the voltage gradient? Intuitively it is implausible that one could achieve a different effect on the opposite sides of a membrane by using the biochemical methods considered for which cell groups are targets and a single ion channel is selected.

Typically the second end of a structure carrying a longitudinal electric field is negatively charged and the second end is positively charged. How is this polarization generated? It seems impossible to generate it by manipulation of the membrane potentials since the change of potential over over distance defined by the cell is not affected at all unless the charge densities at the cell exteriors are rearranged to generate the gradient.

Does the generation of the potential gradient have anything to do with the manipulation of membrane potentials or is the mechanism indirect? It seems that in the case of the brain this is the case.

In the case of axonal microtubules, I have considered a new physics based mechanism based on quantum gravitation in the TGD sense. The mechanism would also generate a change of polarization in the axonal membrane since the effective microtubular charge in the interior of the axon would change.

1. The proposal is that very long "gravitational" hydrogen bonds with length even of order of Earth scale are possible due to the large value of gravitational Planck constant $\hbar_{gr}$. Ions would be transferred from the microtubule to these long hydrogen bonds and go outside the axon-microtubule system so that the effective charge of the microtubule would change and the transverse electric field created in this way affects the membrane potential. This could give rise to a propagating depolarization giving rise to hyperpolarization.
2. In this way it is also possible to create a longitudinal electric field in, say, the head-tail direction of the organism. This mechanism would be at work also in the case of the brain and relate to the DC currents of Becker [J6]. If the modification of membrane potentials generates a voltage gradient, the manipulation of the membrane potential must induce an effective charging of the cell interior. The number of ions transformed to long hydrogen bonds depends on the value of the membrane potential and that the effective charge depends on the value of the membrane potential being for instance proportional to it.

   This could allow the MB to control the polarization based on the modification of membrane potentials. Actually MB, would keep it constant at the morphogenetic level. In the case of the brain the direction could be changed when the organism falls asleep (BSFR).
3. What the analogue for the choice of a subroutine in the manipulation of embryo or split planarian could mean in TGD? Ionic channels define Josephson junctions and for large values of h_{eff} Josephson frequencies can be even in ELF scale. These frequencies correspond by resonance condition to cyclotron frequencies of dark ions at MB. The resonance condition selects a part of MB to which communication of sensory data is possible and which can control the organism by resonance mechanism. The frequency modulated signal is transformed to a pulse pattern and this pulse sequence could define an analog of nerve pulse pattern [L150]. The empirical findings [I94, **?**, I93, I21] and the TGD view of the role of quantum gravitation lead to identification of new kinds of pulses with the voltage scale in mV scale.

   The goal of the organ is characterized by an electric field pattern, which in turn is dictated by the membrane potentials assignable to channels, pumps and gap junctions. How could the electric field pattern achieve this? The cells along the linear structure send Josephson signals to different parts of MB. Flux tubes whose thickness and therefore B varies?

   Part of the organism corresponds to MB. The magnetic field strength at MB corresponds to the value of voltage at the cell membrane to guarantee resonance in communications. Voltages define a map of an organism at MB. This map is realized only at quantum criticality when the organism is very young and its MB is highly sensitive to the pattern of electric voltages..

6.3.4 How the state of the MB can serve as a template for evolution?

The model for the generation of sensory perceptions, regarded as states of subsystems defining selves, generalizes as such to the development of morphology. The MB contains the representations of possible mental images in sensory perception.

1. In sensory perception, the MB carries a representation of standardized mental images. The sensory input to the MB generates a virtual sensory input to sensory organs, which is determined by the difference between the actual sensory input and desired one. This difference is minimized and the process leads to the standardized mental image nearest to the original sensory input.

   The process continues until the difference is small enough. The signalling from the MB is based on dark photon signals so that the process is roughly million times faster than ordinary nerve pulse communications so that standardized mental images emerge rather rapidly.

2. In the case of morphogenesis, the morphogenetic goal replaces standardized mental images so that the situation is much simpler. The SSFRs define sensory input to the MB and virtual sensory input is replaced with an analog of a motor action, which tends to drive the system towards the goal in the morphospace. There are good reasons to propose that motor actions quite generally correspond to pairs of BSFRs (as analog of death or sleep) changing the arrow of time temporarily and also having interpretation as quantum tunneling events.

   The dissipation with the reversed arrow of time looks like self-organization with respect to the original arrow of time and leads to the final state as an analog of self-organization pattern. After the second BSFR the system starts to evolve in the original arrow of time. This pair of BSFRs is analogous to sleep, which is known to have a healing effect.

   This mechanism would be used in all biologically relevant scales [L193] and would be a basic mechanism of homeostasis making it possible for a critical system to stay near criticality by changing the arrow of time repeatedly. This mechanism saves from the basic problem of robotics: robots tend to fall down since the vertical position is unstable. Note that also the dissipation in standard helps to achieve the final state as a self-organization pattern but is not enough if the system is critical as living systems are.

   Morphogenesis would be like carving a statue. MB is the sculptor and starting from a rough sketch and proceeding to shorter scales. Now this process from long to short scales would process downwards in the hierarchy of MBs.

3. If the passive boundary of CD codes for the goal, the sensory input to it should correspond to signals travelling with a reversed arrow of time. Their generation requires BSFR of the system generating them and a pair of BSFRs would define the signal to the MB at the boundary and the response. Is the same mechanism involved with sensory perception?.

What happens in the splitting of the planaria?

One can say that in the splitting of planaria replication of planaria takes place. What does this mean in ZEO? Does it correspond to BSFR, SSFR or something different. Or are two new CDs identifiable as perceptive fields of new organisms created.

1. A natural guess is that MBs and EBs replicate. One of the basic questions in ZEO is whether new CDs can emerge. Since the zero energy states have indeed zero energy at the limit of infinitely large CD, nothing prevents their creation in SFRs. This is prevented by the conservation laws in the standard ontology but not in ZEO. The creation of a CD would correspond to a quantum jump which cannot be regarded as either BSFR or SSFR.

   It however seems obvious that standard ontology is a good approximation due to the formation of CD networks in which the CDs are connected by particle lines to form an analog of the Feynman diagram with CDs representing vertices. There the CDs of split planaria would be connected to the CD of the non-split planaria by "particle lines" .However, In principle the generation of CDs from vacuum is possible without a violation of the conservation laws.

2. The simplest model explaining the findings about the regeneration of planaria from split planaria assumes that each split planaria is accompanied by its own CD and its passive boundary provides the memory determining by holography the growth of planaria as an analog of almost deterministic computer program (quantum superposition of them). The non-split planaria of the geometric past and its CD could still continue to exist and make BSFRs and evolve. This would happen even in astrophysical scales and explain stars older than the Universe and the galaxies older than the Universe detected by James Webb telescope [L156].

6.3.5 Some questions

The findings of Levin et al raise interesting questions in the TGD framework.

1. Chinese medicine talks of acupuncture points and meridians. Could these notions be reduced to the hypothesis that ordinary cells form networks analogous to CNS such that communications take place by the analogs of nerve pulses (miniature potentials) in the scale mV scale for which empirical evidence indeed exists [I94, I92, I93, I21] and is discussed from the TGD viewpoint in [L150]. Could the disorders at this level correspond to the loss of quantum coherence at the level of MBs and EBs caused by the reduction of the value of h_{eff} naturally caused by the failure of the metabolic energy feed needed to preserve the distribution of the values of h_{eff}. This would lower the "IQ" of MB and the control would fail. Could the splitting of the gap junctions be due to the same reason?

   This would suggest that the healing of disorders could reduce to the control of communications between EBs and MBs and basically to the control of Josephson frequencies (membrane potentials) and cyclotron frequencies (magnetic field strengths coded by the thickness of the monopole flux tube). Besides chemical tools other tools can be imagined. For instance, irradiation at desired frequencies might be such a tool avoiding the side effects of the chemical tools [L69].

2. The vision of ZEO has developed slowly and the question whether BSFR and SSFR are the only quantum jumps or whether new CDs can be created from vacuum. The model for the splitting of planaria suggests an affirmative answer to this question.

3. A second open question has been whether the passive boundary of CD carries conscious information. The holography of consciousness suggests that the conscious experience at a given level of the self hierarchy remains constant between two subsequent SSFRs. The quantum state at the passive boundary is unaffected in SSFRs so that one can argue that there is no conscious experience giving information of the passive boundary. Could "silent wisdom", determining the goal of the self by holography, characterize the contribution of the passive boundary. Could the state of the passive boundary define "Self" or "soul" as a conscious experience, which tends to be masked by the contributions of the active boundary of CD. This "Self" would be changed in BSFRs.

6.4 About the recent findings of Michael Levin's group

I watched a video discussing two articles just published in Nature (thanks to Marko Manninen for the links). Besides Michael Levin present was Gizem Gumuskaya from the team behind the first article [I43] "Motile Living Biobots Self-Construct from Adult Human Somatic Progenitor Seed Cells". Also Angela Tung from the team behind the second article [I57] "Embryos assist morphogenesis of others through calcium and ATP signaling mechanisms in collective teratogen resistance" participated in the discussion.

It seems that the findings of Levin's group [I82, I83, I116] are really revolutionizing biology. The Darwinian vision of life as a struggle for existence is being replaced by life as survival based on cooperation, where conscious collective intelligence plays a key role. The findings suggest that life forms can be artificially created for various purposes: the applications in medicine can only be guessed at.

I have written a couple of articles [L25, L75, L184] about the observations of Levin's team. These ideas are emerging outside of biology as well: I have considered Gershing's vision of self-building machines from a TGD perspective in the article [L177].

6.4.1 A summary of the findings

A brief summary of the approach and findings of Levin's team [I82, I83, I116] is in order.

Epigenesis as means to produce new phenotypes

Instead of genetic engineering, epigenesis would serve as means to produce new phenotypes.

1. Epigenesis can produce completely different outcomes even though the genes are the same: genetic determinism must be given up. Electric fields of the cell membranes in the embryonic stage control epigenesis, but in the adult phase they no longer have an effect. Different phenotypes can be produced in a controlled manner. How epigenesis is realized under the control of electric fields is a mystery.
2. In the approach of Levin's team, there is no need to construct new genomes as in genetic engineering: the same end result, the phenotype, can be achieved with several genomes. Genetic determinism, i.e. the idea that the whole organism is encoded in genes, would be simply wrong. The protein-coding parts of the genes determine the protein level, but the phenotype would be determined by morphogenesis, which would be based on epigenesis.

   A fascinating question is how independent the phenotype actually is on the genome. This kind of independence would be analogous to the substrate independence of AI based consciousness. In TGD this would conform with the idea that the magnetic body (MB) is the boss and controls the biological body so that the genetic code would be basically a code used by communication and control signals.
3. Epigenesis means that the same basic genome can code for a wide variety of mRNA molecules, which in turn code for proteins: even an mRNA chain does not determine proteins unambiguously, but can be split into parts (slicing), some of which determine a protein. This makes cell differentiation possible, only a small fraction of the genes is expressed, just like only a small part of the modules of a word processing program are in active use.

   The realization of epigenesis relies on chemical modifications of DNA, such as DNA methylation and histone modification, which prevent normal gene transcription locally. Epigenetic expression can vary even on a time scale of hours. On the other hand, epigenetic modifications can be passed on to subsequent generations. What controls epigenesis is not understood. It is not even clear what epigenesis should include: should one just say that epigenetic is all that is not genetic. The notion of morphogenetic code emerges naturally.

Membrane potential as a new control level during embryonic stage

1. Already the earlier observations of Levin's team demonstrated that there is a completely new level of control that has been ignored before: the electric fields associated with the cell membrane, which are central to neuroscience but ignored in biology. Only the embryonic stage is sensitive to the effects of the electric fields so that these electric fields can control epigenesis only during this stage. The vision is that there is a multi-level control hierarchy above the genes that could extend even to the population level.

   For instance, in the case of frogs it is possible to induce dramatic modifications of the phenotype such as several heads or no head at all. These modifications are stable and inherited by the next generations.
2. This inspires the idea of creating life forms, biobots, but without applying genetic engineering. Only epigenesis is utilized and has been controlled by manipulating the electric fields of the cell membrane in different ways, for example chemically or using external electric and magnetic fields at the scale of the embryo.

From frog embryos to human cells and populations of embryos

Earlier simple life forms such as frog embryos were studied, but now human cells have been the target and the earlier observations are made also now.

1. In the past, xenobots were studied as artificial life forms built from frog cells. For example, cells taken from epithelial tissue can be used. The important thing is that the system is sensitive to the control of the electric field of the cell membrane only in the embryonic stage and the genetic expression stabilizes after that.
2. Now anthrobots [I43] have been studied as artificial life forms formed from human cells. The spheroid shape group of cells generated under normal conditions is transformed by external stimuli so that the usually inward-directed cilia point outward and the structure can move with their help. Embryo is turned inside-out.

3. The population formed by the embryos has also been studied [I57] and unexpected collective effects have been observed. The collective survives a perturbation better than a mere individual. The vision of vulgar Darwinism about life as a struggle for existence (to which also our materialistic view of society relies on) is simply wrong.

6.4.2 TGD view of the findings

Consider now a summary of what has been observed from the TGD perspective.

Structure determines function

It seems that at the level of the organism, the 3-D structure determines the function and that these functions are a discrete set in the studied situations. This is highly non-trivial but in line with the TGD vision, which differs from the standard physics in the sense that holography is realized at the space-time level.

3-D surfaces in $H = M^4 \times CP_2$ identified as a generalization of point-like particles of quantum field theories is the starting point of TGD. The 4-D spacetime surface is determined from the 3-D surface providing holographic data and is therefore analogous to the Bohr orbit. The almost deterministic Bohr orbit is analogous to the notion of function of biology, a genetic program determined the structure having 3-D holographic data as a counterpart. Quantum states are superpositions of these Bohr orbit-like space-time surfaces.

What distinguishes TGD from other quantum theories is that there is no path integral so that one avoids the usual divergences and classical physics becomes an exact part of the theory.

In particular, the fact that there seems to be a very small number of different structures and associated functions conforms with holography.

At the quantum level, biological functions are time evolutions that obey statistical determinism. What distinguishes biosystems from deterministic computers is that statistical determinism can be violated because quantum coherence in all scales is possible. Quantum coherence in time scales longer than say the EEG periods implies this violation. This is what makes matter alive. An interesting question is whether this violation can take place also for ordinary computers.

Cells behaviour depends on the size of the population

1. A surprising result of [I57] is that cells behave differently depending on the size of the population. Furthermore, cells, embryos, etc... are cooperative social beings helping each other to survive. For example, in a population, a single cell recovers from damages much better than a solitary cell. This happens only if the entire population has experienced the same perturbation. Cells survive better in a larger population and develop differently in them.
2. This strongly suggests the presence of collective consciousness and intelligence, which is much more than what is thought to be, for example, the swarm intelligence of AI systems. The magnetic body (MB) as a conscious entity could provide the TGD realization of collective intelligence and produce a hierarchy of levels of consciousness. The bigger the population, the larger the value h_{eff} as a measure of algebraic complexity and quantum coherence scale also at the level of the individual: this would explain why the increase in population size makes individuals smarter too.
3. When a single cell of the population is damaged, it generates a Ca^{++} wave that spreads to the environment and induces ATP production and Ca^{++} secretion. This involves the transfer of information, which makes it possible for the population to react as a coherent entity, a kind of life form. If the Ca^{++} wave or the generation of ATP is blocked, the embryos behave as if they were alone.

   Communication need not involve mere chemical signals, as the standard biology would predict. It is not understood how the mere presence of other individuals helps in the healing process.
4. What could be this unknown means of communication? This brings to mind the observations of Blackman and other pioneers: ELF radiation at the cyclotron frequency of Ca^{++} in the case of mammals affected both behavior and brain physiology. In the TGD framework, the generation of a Ca^{++} wave could correspond to the communication induced with the help

of Ca^{++} ions to a certain layer of the system's magnetic body. Communication would take place at the cyclotron frequency and its multiples, which in Blackman's experiments was 15 Hz and would indicate the presence of an endogenous magnetic field of .2 Gauss, which is 2/5 of the nominal value of the Earth's magnetic field.

Ca^{++} waves could act like neurotransmitters are believed to do, that is by activating communication lines from cells to the MB. The embryos would become a coherent unit through these connections. The MB would control the entire system. Quantum entanglement in the scale of MB would be present making the population a coherent unit: mere classical communications are not enough.

5. A nerve impulse would do the same between neurotransmitters. Here one should think critically about the previous TGD view of the role of nerve impulses. According to the TGD view of brain [L51], nerve pulses do not correspond to fundamental communications. Rather, neurotransmitters would simply connect the magnetic flux tubes associated with pre- and postsynaptic neurons to form one long channel along which dark photons with large h_{eff} would propagate from the sensory organs to the cortex and from cortex to the MB.

   A more general alternative would be that dark photons signals to the hierarchy of layers of the MB of the brain take place also from the activated neurons along the neural pathway and not only from the cortical neurons. The activated neurons, the neuronal pathway, would have a quantum coherent and quantum entangled entity at the level of MB and define an association chain at the level of conscious experience. Neuronal synchrony would relate closely to this quantum coherence.

Morphogenetic code

The proposed communications should involve a morphogenetic code, which is not understood.

1. TGD inspires the idea that the genetic code as a universal code defines also the morphogenetic code [L75, L160]. Dark codons of DNA, RNA,.. and their counterparts would be realized as dark proton triplets in various scales. Dark genes with N codons would correspond to 3N dark protons. Communications would rely on dark 3N-photons (N would correspond to the number of codons of gene) as analogs of bound states of 3N dark photons would realize the genetic code in the sense that that they would induce 3N-resonant transitions between dark genes as dark 3N-protons.
2. Also the communications between dark and ordinary information molecules would rely on the resonance mechanism. The idea that dark genes are mere copies of ordinary genes does not look attractive. Actually, dark DNA, RNA, etc could be almost independent of their chemical variants and participate in quantum information processing not directly visible at the level of ordinary biomatter. Only in the communications with ordinary gene or its part, dark information molecules could transform to a state corresponding to the ordinary information molecule or its part.
3. The realization of the genetic code could be universal and could correspond to the so-called icosa tetrahedral tessellation of the hyperbolic 3-space and it would appear in all scales, not only in biology [L165].

Hierachy of collective intelligences

Levin proposes that collective intelligence is present in several scales. TGD predicts the existence of several scale hierarchies based on a new view of spacetime and a number-theoretic vision of TGD as dual to geometric vision.

I have built a model for the birth of language [K118] based on the observation that the appearance of a few crucial genes was crucial for the emergence of language. The proposal is that this meant the appearance of a layer of MB with a considerably larger h_{eff}. A collective level of consciousness on a much larger scale was born. Language would make possible the communication between individuals and promote the birth of these larger collectively conscious structures. Language in human society would have a role similar to that of Ca^{++} waves in the collective behavior of embryos [I57].

Somewhat surprisingly, Levin does not speak at all about the possible role of quantum theory in biology. I think it would be important to build a bridge from the observations of Levin's group to the models of quantum biology. The team's findings force us to take quantum coherence at long scales seriously.

Typically, theories of consciousness do not have much to say about this aspect. One reason, of course, is that standard quantum theory doesn't have much to say.

Chapter 7

TGD View about Water Memory and the Notion of Morphogenetic Field

7.1 Introduction

This article was inspired by the proposal of Savelev *et all* published since 2019 that there exists what they call DNA resonance code [I112, I110, I111]. (see `https://cutt.ly/KAe6BOd`, `https://cutt.ly/rArqdlA`, and `https://cutt.ly/EArqzSL`).

7.1.1 Motivations for the introduction of morphogenetic field

Morphogenesis is one of the very poorly understood problems of biology. The mystery is how the genes can encode for the shape of the organism and guide the morphogenesis. It is extremely difficult to understand the coherence of living organisms in terms of mere biochemistry alone and the basic mechanisms of bio-catalysis are still poorly understood. Even taking into account electromagnetic fields, it is very difficult to understand how stochastic dynamics, which seems unavoidable in the standard physics, could explain morphogenesis.

This has motivated the introduction of the notion of morphogenetic field. Support for its existence and hints about its nature come from several unexplained findings made already by Gurwitch. Beloussov, Burkalov and many others continued the work of Gurwitch [I37] and produced evidence for the existence of the morphogenetic field.

Water memory is a strange phenomenon, which still induces highly emotional responses in the mainstream community although the basic objection has long ago become obsolete: if water forms representations of molecules the extreme dilution produces no problems. Benveniste and Montagnier [I51] involving the basic procedure used to produced homeopathic remedies have produced evidence that the morphogenetic field is electromagnetic and generated by DNA and interacting with it: the low frequency spectrum of the bio-active molecules can be even recorded and it creates same biological effects as the real substance. The experiments also produce support for water memory and the basic method of homeopathy involving repeated dilutions and agitation plays a central role in the experiments. Montagnier has also produced evidence for the remote replication of DNA.

Also Peter Gariaev belongs to the pioneers and phantom DNA could have interpretation as a morphogenetic field: Gariaev talks about wave DNA [I40, I42, I65, I41]. I have written with Peter Gariaev an article about remote replication of DNA [K119].

Fröhlich condensates [J24, I60, I71] [J24] are analogous morphogenetic fields and would be generated by electric dipoles. They would explain the coherence of biosystems, which is very difficult to understand in the standard physics framework. No direct support for these fields has been found hitherto.

Miller and Webb [I90] proposed 2012 that the morphogenetic field is holographic and would be generated by DNA.

The authors of the articles [I112, I110, I111] that motivated this work, propose that morphogenetic field could be generated by DNA and might realize genetic code electromagnetically making it possible to transform the genetic information in terms of shape and form of the organism in morphogenesis.

7.1.2 The counterpart of morphogenetic field in the TGD framework

Quantum TGD brings in new physics elements crucial for TGD inspired quantum biology. The idea about p-adic physics as a description of correlates of cognition emerged around 1993. The systematic work with quantum biology and consciousness started around 1995 when I made also the first p-adic mass calculations. The first publication "Biological systems as quantum coherent systems" related to quantum biology appeared in CASYS2000 conference proceedings in 2020. During the first years of milleniums several ideas emerged, mention only the hierarchy of Planck constants as a possible explanation of dark matter, its number theoretical interpretation, and the notion of $M^8 - H$ duality.

This led gradually to what I call adelic physics. Adelic physics includes not only real numbers but also p-adic number fields and their extensions and was published 2017 [L59, L60] in a book by Springer. The notion of p-adic physics was originally inspired by the p-adic mass calculations and by the idea that p-adic number fields provide the correct language for the description of cognition. The requirement of number theoretical universality led to the realization that the hierarchy formed by extensions of rationals defines an evolutionary hierarchy behind the biological and other evolutionary hierarchies.

The articles published in the Journal of Non-locality and Remote Mental Interactions (2002-) and in Journal of Non-locality (2012-), both founded by Lian Sidoroff, give an idea about the evolution of TGD and TGD inspired quantum biology and consciousness theory. The articles published in journals founded by Huping Hu (2010-) give a view about the detailed evolution of ideas since 2010. In this article, as in all my articles and books about TGD, the references to TGD are to the updated versions of articles and books at my homepage.

Besides general problems, which might be regarded as philosophical, the anomalies of the physicalistic world view have served as the source of inspiration. Several poorly understood phenomena have played a central role in the "Poiroting-like" process leading to the development of TGD based views about quantum biology. Mention only the effects of ELF em fields on vertebrate brain [J8], biophotons [I96, I55], water memory [I126, I50, I52], Pollack effect [I63, I64, L27, I99, ?], and Comorosan effect [I105, I29]. The notion of syntropy by Fantappie [J30], which challenges the belief that the arrow of time is not always the same in living systems, has been also inspiring. Also the work of Rupert Sheldrake relating to morphic resonance [I101, I102] has been inspiring

In this article I will discuss the TGD based vision and the above listed phenomena, which are often forgotten. I have written during years several articles about morphogenesis from TGD point of view [L25, L44, L75, L47, L15] and I will compare the TGD based view with the proposed interpretation of morphogenetic field as em field generated by DNA and realizing genetic code discussed in the articles of Savelev *et al* [I112, I110, I111], and compare it with the TGD based models of genetic code realized in terms of dark nucleons and dark photons. The findings described in these articles and in the articles of Yolene Thomas [I126, I127] about water memory also provide new tests for the TGD based view. As always, this kind of process led to some new ideas and insights.

7.2 Basic ideas of TGD

In this secton I will describe briefly the basic ideas of TGD relevant to quantum biology, cognition and consciousness.

7.2.1 TGD view about space-time

1. The background comes from the new physics predicted by Topological GeometroDynamics (TGD). TGD emerged as a proposal for the unification of fundamental interactions [K3] and was based on the proposal that space-times are representable as 4-D surfaces in the 8-D space

$H = M^4 \times CP_2$, the product of Minkowski space and complex projective space CP_2. TGD can be also regarded as a generalization of string models obtained by replacing 1-D strings in 10-D space with 3-surfaces in H and identifying the orbit of 3-surface as a space-time region.

2. The new view of space-time and 3-space brings the shape of 3-surface as a new degree of freedom. This also implies new topological degrees of freedom not possible in general relativity, where the condition that space-time is a small deformation of M^4 does not allow them. Even Euclidean signature of the induced metric is possible and realized for the space-time surfaces representing elementary particles. Geometrization of classical fields of standard model and quantum numbers emerges. The notion of field body (magnetic body) is of key importance in TGD inspired quantum biology.
3. Holography is one of the key notions of TGD and also central in the TGD based model of living matter. Holography in the sense that 3-D data determine the space-time surface as a preferred extremal analogous to Bohr orbit follows from general coordinate invariance in the TGD framework [K52, K89] [L136].

   One aspect of holography is the hologram like character of the space-time surface. Space-time as a conscious hologram is indeed the basic idea of TGD inspired theory of consciousness [K21]. Space-time sheets of the many-sheeted space-time located inside causal diamonds (CDs) form a hierarchy defining cognitive representations with a varying degree of accuracy and abstraction level. In the TGD framework, this translates to the p-adic length scale hierarchy and $h_{eff} = nh_0$ hierarchy of phases of ordinary matter behaving like dark matter and follows as a prediction of adelic physics [L59, L60].

7.2.2 Number theoretical vision

The concrete realization of adelic physics involves $M^8 - H$ duality as a basic building brick. $M^8 - H$ duality [L104, L105, L110] realizes evolutionary hierarchy number theoretically, justifies the hierarchy of dark matter as $h_{eff} = nh_0$ phases of ordinary matter, provides a detailed understanding of p-adic length scale hypothesis, and predicts Galois confinement as a universal mechanism for the formation of bound states. All these notions are central in the TGD inspired quantum biology.

$M^8 - H$ duality

One of the key discoveries was $M^8 - H$ duality, which states that geometrization of physics has as dual its number-theoretization.

1. The details of M^8H duality have developed slowly during years via several side tracks. In this view, space-times correspond to both 4-surfaces in H and in the complexification of M^8. At the level of M^8 they correspond to "roots" of polynomials P of real argument having rational coefficients and continued to polynomials with octonionic argument. Associativity as is the dynamical principle determining the 4-surfaces in M^8 and requires associative (quaternionic) normal space.
2. It took a long time to realize, or rather to admit, that the "roots" correspond to 3-D mass shells of $M^4 \subset M^8$ rather than 4-surfaces as the naive expectation was. 4-D surfaced X^4 in M^8 are defined by holography, which provides an alternative explicit definition of $M^8 - H$ duality, which associates with $X^4 \subset M^8$ a 4-D space-time surface in H. The image of X^4 is a minimal surface [L141] H with singularities, which is analogous to soap film with frames.

   The space-time surface in H is a preferred extremal analogous to Bohr orbit, which means that, apart from singularities, it is a simultaneous extremal of both volume action and so called Kähler actio analogous to Maxwell action. This picture has a twistorial generalization and implies the twistor lift of TGD.
3. M^8 is analog of momentum space so that $M^8 - H$ duality, which maps the 4-surface in M^8 to space-time surfaces in H, can be seen as a generalization of momentum position duality of wave mechanics motivated by the replaced of point-like particles with 3-D surfaces. Cognitive representations as points of X^4 for which the momentum components are algebraic integers define a unique discretization of X^4. In the generic case their number is finite. At the mass shells $H^3 \subset M^4$ corresponding to the roots of P defining 3-D cross sections of X^4

the cognitive representation explode and can contain momenta with components which are algebraic integers and even rationals. One can say that intelligence as algebraic complexity is concentrated at 3-D mass shells and their images in H under $M^8 - H$ duality. This also explains why the world is experienced as 3-D.

4. Polynomial P with rational coefficients defines an extension of rationals partially characterized by its Galois group and by ramified primes appearing as divisors of the discriminant of the polynomial. The largests ramified prime is identified as the p-adic prime assignable to the space-time region. This notion emerged already around 1995 via p-adic mass calculations and the recent view gives justification for the p-adic thermodynamics and generalizes it to the level of scattering amplitudes. The functional composition of polynomials is an attractive general way to build many-particle states at the level of M^8 and leads to very detailed proposal for the transition matrix [L142, L143]. It is also analogous to composition of functions, which plays a key role in computationalism. Nature would be a computationalist in a number-theoretically universal sense.
5. Number theoretical universality requires that the momenta of fundamental particles (actually quarks) as points of mass shells in $M^4 \subset M^8$ are algebraic integers. Periodic boundary conditions however imply Galois confinement as an analog of quark confinement. The conditions require that the physical states are Galois singlets: in particular, the momentum components are ordinary integers in the scale defined by the p-adic prime. This gives a a universal mechanism for the formation of bound states [L134, L136].

Dark matter as $h_{eff} = nh_0$ phases

Number theoretical vision provides a justification for several key notions of TGD based quantum biology and introduced before the recent understanding of $M^8 - H$ duality [L104, L105, L136, L142, L143].

1. Number theoretical vision leads to an identification of dark matter as phases of ordinary matter with Planck constant $h_{eff} = nh_0$, where n is the dimension of extension of rationals defined by P. h_{eff} can be much larger than h. This proposal emerged considerably earlier (around 2007) and was motivated by the strange effects of ELF radiation on the behavior and physiology of vertebrates [J8].
2. h_{eff} hierarchy makes quantum coherence possible in arbitrarily long scales and magnetic bodies (MBs) of the systems would carry dark matter in this sense. MB has an onion-like structure with layers labelled by h_{eff} and layers would form a master-slave hierarchy with ordinary biomatter at the bottom.
3. The value of h_{eff} depends on the character of interactions mediated by the flux tube. $h_{eff}/h < 100$ could be associated with valence bonds and hydrogen bonds [L56] and more generally to flux tubes mediating electromagnetic interactions.

   Nottale hypothesis [E1] introduces gravitational Planck constant $\hbar_{gr} = GMm/v_0$, where $v_0 < c$ has dimensions of velocity. In the TGD framework $\hbar_{gr}$ is interpreted as a genuine Planck constant and reflects dark matter, which corresponds to a high-dimensional extension of rationals [K94, K75]. Note that the dimension of extension can be exponentially larger than the degree of the polynomial P: if the Galois group is the permutation group for roots, the dimension is $n!$.

   The large value of h_{gr} conforms with the long range of gravitational interactions and predicts quantum gravity in arbitrarily long scales. The gravitational Compton length $\Lambda_{gr} = GM/v_0$ for a particle with mass m is independent of m and of the order of the Schwartzschild radius for mass M. Also cyclotron energy $E_c = \hbar_{gr} ZeB/m = GMZeB$ is independent of m. Both these features conform with the Equivalence Principle and are expected to play a crucial role in quantum biology [K77] [L66, L138].

Could the TGD view of space-time allow us to understand genetic holography?

A living organism consists of cells that are almost identical and contain DNA that is the same for all of them but expresses itself in different ways. This genetic holography is a fundamental

property of living organisms. Where does it originate? Dark DNA associated with magnetic flux tubes is one of the basic predictions of the TGD inspired biology. One can say that the magnetic body controls the ordinary biomatter and dictates its development. Could one have a structure that would consist of a huge number of almost identical copies of dark DNA forming a quantum coherent unit inducing the coherence of ordinary biomatter? Could this structure induce the self-organization of the ordinary DNA and the cell containing it.

Could one understand this by using the TGD based spacetime concept. There are two cases to be considered. The general option is that f_i are analytic functions of 3 complex coordinates and 1 hypercomplex (light-like) coordinate of H and $(f_1, f_2) = (0, 0)$ defines the space-time surface.

A simpler option is that f_i are polynomials P_i with rational or even algebraic coefficients. Evolution as an increase of number theoretic complexity [L60] suggest that polynomials with rational coefficients emerged first in the evolution.

(a) For the general option (f_1, f_2), the extension of rationals could emerge as follows. Assume 2-D singularity X_i^2 (partonic 2-surface) at a particular light-like partonic orbit (m_i such orbits for f_i) defining X_i^2 as a particular root of f_i. If f_2 (f_1) is restricted to X_1^2 *resp.* X_2^2, and is a polynomial P_i^2 with algebraic coefficients, it has m_2 *resp.* m_1 discrete roots, which are in an algebraic extension of rationals with dimension m_2 *resp.* m_1.
Note that m_2 can depend on X_i^2 for the general option. Only a single extension appears for a given root and can depend on it. The identification of $h_{eff} = n_i h_0$ looks natural and would mean that h_{eff} is a local property characterizing a particular interaction vertex. Note that it is possible that the coefficients of the resulting polynomial are algebraic numbers.
For the polynomial option $(f_1, f_2) = (P_1, P_2)$, the argument is essentially the same except that now the number of roots of P_1 *resp.* P_2 does not depend on X_2^2 *resp.* X_1^2. The dimension n_1 resp. n_2 of the extension however depends on X_2^2 *resp.* X_1^2 since the coefficients of P_1 *resp.* P_2 depend on it.

(b) The proposal of the number theoretic vision of TGD is that the effective Planck constant is given by $h_{eff} = nh_0$, $h_0 < h$ is the minimal value of h_{eff} and n corresponds to the dimension n_E of the algebraic extension of rationals. As noticed, $n = n_E$ would depend on the roots considered and in principle $m_1 m_2$ values are possible. This identification looks natural since n_E defines the dimension of the extension. $n = m_1 m_2$ can be also considered for the polynomial option but looks artificial. For the general option, the degree of the polynomial P_1 can depend on a particular root X_2^2 of f_2 .

(c) The dimension n_E of the extension depends on the polynomial and typically seems to increase with an exponential rate with the degree of the polynomials. If the Galois group is the permutation group S_m it has $m!$ elements. If it is a cyclic group Z_m, it has m elements.

For the original view of $M^8 - H$ duality, single polynomial P of complex variable with rational coefficients determined the boundary data of associative holography [L104, L105, L178]. The iteration of P was proposed as an evolutionary process leading to chaos [L109] and led to an exponential increase of the degree of the iterated polynomial as powers mk of the degree m of P and to a similar increases of the dimension of its algebraic extension.

This might generalize to the recent situation [**?**] if the iteration of polynomials P_1 *resp.* P_2 at the partonic 2-surface X_2^2 *resp.* X_1^2 defining holographic data makes sense and therefore induces a similar evolutionary process by holography. This could give rise to a transition to chaos at X_i^2 making itself manifest as the exponential increase in the number of roots and degree of extension of rationals and h_{eff}.

One can consider the situation also from a more restricted point of view provided by the structure of H.

(a) The space-time surface in $H = M^4 \times CP_2$ can be many-sheeted in the sense that CP_2 coordinates are m_1-valued functions of M^4 coordinates. Already this means deviation from the standard quantum field theories. This generates a m_1-sheeted quantum coherent structure not encountered in QFTs. Anyons could be the basic example in condensed matter physics [K78]. m_1 is not very large in this case since CP_2 has extremely small

size (about 10^4 Planck lengths) and one would expect that the number of sheets cannot be too large.

(b) M^4 and CP_2 can change the roles: M^4 coordinates define the fields and CP_2 takes the role of the space-time. M^4 coordinates could be m_2 valued functions of CP_2 coordinates: this would give a quantum coherent system acting as a unit consisting of a *very* large number m_2 of *almost* identical copies at different positions in M^4. The reason is that there is a lot of room in M^4. These regions could correspond to monopole flux tubes forming a bundle and also to almost identical basic units.
If m_i corresponds to the degree of a polynomial, quite high degrees are required. The iteration of polynomials would mean an exponential increase in powers d^k of the degree d of the iterated polynomial P and a transition to chaos. For a polynomial of degree $d = 2$ one would obtain a hierarchy $m = 2^k$.

(c) Lattice like systems would be a basic candidate for this kind of system with repeating units. The lattice could be also realized at the level of the field body (magnetic body) as a hyperbolic tessellation. The fundamental realization of the genetic code would rely on a completely unique hyperbolic tessellation known as icosa tetrahedral tessellation involving tetrahedron, octahedron and icosahedron as the basic units [L128, L165]. This tessellation could define a universal genetic code extending far beyond the chemical life and having several realizations also in ordinary biology.

(d) The number of neurons in the brain is estimated to be about 86 billions: $10^{12} \simeq 2^{40}$. If cell replications correspond to an iteration of a polynomial of degree 2, morphogenesis involves 40 replications. Human fetal cells replicate 50-70 times. Could the m almost copies of the basic system define a region of M^4 corresponding to genes and cells? Could our body and brain be this kind of quantum coherent system with a very large number of almost copies of the same basic system. The basic units would be analogs of monads of Leibniz and form a polymonad. They could quantum entangle and interact.

(e) If $n = h_{eff}/h_0$ corresponds to the dimension n_E of the extension, it could be of the order 10^{14} or even larger for the gravitational magnetic body (MB). The MB could be associated with the Earth or even of the Sun: the characteristic Compton length would be about .5 cm for the Earth and half of the Earth radius for the Sun).

Could this give a recipe for building geometric and topological models for living organisms? Take sufficiently high degree polynomials f_1 and f_2 and find the corresponding 4-surface from the condition that they vanish. Holography=holomorphy vision would also give a model for the classical time evolution of this system as classical, and not completely deterministic realization of behaviors and functions. Also a quantum variant of computationalistic view emerges.

7.2.3 Zero energy ontology

Zero energy ontology (ZEO) [K117] [L96, L132] is a further key notion of TGD and of TGD inspired biology and consciousness theory.

(a) In ZEO quantum states as time= constant snapshot are replaced with a superposition of space-time surfaces as preferred extremals analogous to Bohr orbits.
In biology and neuroscience functions and behaviors as precise time sequences are typical and have preferred extremals realized as a minimal 4-surface with singularities as space-time correlates. Genes would not code only 3-D structures but also their time evolutions, which would be dictated by 3-D initial values (3-surface) by Bohr orbit property.
The motivation for the notion of morphogenetic field indeed is that biological processes look like computer programs or even better sequences of planned actions, rather than stochastic processes.

(b) ZEO leads also to a new view about state function reduction (SFR) solving the basic problem of the standard quantum measurement theory. The basic prediction is that time reversal occurs in ordinary ("big") SFRs (BSFRs) but not in "small" SFRs (SSFRs) which replace the repeated measurement giving rise to the Zeno effect. The sequence of SSFRs correspond to the flow of consciousness for self as a conscious entity. Any un-entangled

system can be regarded as self whose life corresponds to a sequence of SSFRs ending with BSFR changing the arrow of time and meaning reincarnation of self [L116, L124].
The basic implication of ZEO is that BSFRs in even macroscopic scales for subsystems look like deterministic classical time evolutions for the observer with opposite arrow of time [L83] and Minev *et al* indeed observed this in atomic scales [L83]. No transition zone from quantum to classical is needed. For instance, there is evidence that earthquakes could be regarded as macroscopic BSFRs.
This has also implications for the dynamics of DNA, in which time reversals might play a key role [L190, L192]. Quite generally, the phenomenon of quantum tunnelling could involve two sub-sequent BSFRs and tunnelling would correspond to a temporary change of the arrow of time [L136, L132].

(c) The possibility of time reversal forces to generalize thermodynamics and leads to a generalization of second law. Time reversed subsystem obeys second law in reversed time directions and from the point of view of the system breaks it. This suggests a new mechanism of self-organization (in particular biological) as time reversed dissipation taking place spontaneously rather than as a result of intricate programming as in a computationalistic framework. This suggests a new view about homeosatasis [L193].

(d) ZEO based theory of consciousness can be regarded as a generalization of quantum measurement theory based Negentropy Maximization Principle (NMP) [K64] [L130], which involves, besides ordinary entropy with matter, the p-adic entropies assigned with cognition which can be negative and tend to be so by NMP. The theory is consistent with the second law and explains the paradoxical looking findings of Jeremy England that biosystems seem to be maximal entropy producers.

7.2.4 Quantum criticality of TGD Universe

The notion of quantum criticality of TGD Universe was originally inspired by the question about how to make TGD unique if Kähler function $K(X^3)$ in WCW is defined by the Kähler action for a preferred extremal $X^4(X^3)$ assignable to a given 3-surface. Vacuum functional defined by the exponent of Kähler function is analogous to thermodynamical weight and the obvious idea with Kähler coupling strength taking the role of temperature. The obvious idea was that the value of Kähler coupling strength α_K is analogous to critical temperature so that TGD would be more or less uniquely defined. α_K is expected to have several values.
The precise meaning of quantum criticality is far from obvious. The recent progress in understanding the number theoretical aspects has however led to a considerable progress in this respect [L149].

(a) The exponent $exp(-K)$ of Kähler function K is the action for the preferred extremal (PE) as a space-time surface in H. PE has 3-surfaces X^3 and Y^3 as its ends at the boundaries of causal diamond (CD= cd $\times CP_2$) of H.

(b) Ideal holography would mean that Y^3 is fixed once Y^3 is known. PEs are however not completely deterministic but analogous to soap films with frames, which are known to allow non-determinism in the sense that frame does not define the soap film uniquely [L141, L149]. Hence X^3 does not fix Y^3 completely but there is a finite number of alternatives for given X^3.

(c) X^3 at the passive boundary of CD corresponds to a maximum of K under variations of X^3 in accordance with its passive character. Note that the WCW metric has zero modes not appearing in the metric of WCW so that the maxima could correspond to different values of zero modes. These could define the analog of spin glass energy landscape. Also transitions tranforming zero modes to non-zero modes and vice versa are possible.

(d) Y^3 at the active boundary of CD corresponds to a more general extremum of K with respect to variations of Y^3, a saddle point. This means criticality. The criticality corresponds to the classical non-determinism of preferred extremals. This leads to a vision about WCW homology as a generalization of Floer homology and characterizing the non-determism of the action [L149].

(e) The sequence of SSFRs can be seen as a process leading from a saddle point towards maximum of K, somewhat analogous to the thermodynamical process leading to a thermal

equilibrium as maximum of entropy. The non-determinism of SSFRs has as a correlate the classical determinism of preferred extremals.

It is now clear that the values of α_K is determined by the extension of rationals determined by polynomial P [L104, L105, L142, L143, L149].

(a) Space-time region $X^4 \subset H$ is the image of a 4-surface of M^8 under $M^8 - H$ duality. The 4-surface in M^8 is determined by a polynomial P and by holography which actually defines the $M^8 - H$ duality explicitly.

(b) The vacuum functional $exp(-K)$ for a maximum of K must be equal to number theoretical quantity associated with P. The most natural candidate is the discriminant D of P which is the product of squares of root differences for P: $exp(-K) = 1/D$. This condition predicts a spectrum of α_K appearing in K. p-Adic prime corresponds to the large primed dividing D.

7.3 Basic ideas of TGD inspired quantum biology and theory of consciousness

This section summarizes in more detail the ideas and concepts relevant for TGD inspired theory of consciousness and quantum biology.

7.3.1 Quantum criticality in biology

Quantum criticality [K34, K35, K36, K37] has become key concept of quantum TGD and TGD inspired biology. Quantum criticality allows to understand the hierarchy of Planck constants and also its relationship to p-adic length scale hypothesis, whose origin reduces to number theoretic vision about TGD [K112]. Dark matter phases characterized by $h_{eff} = n \times h$ accompany any quantum critical system, maybe even thermodynamimcally critical systems. The challenge is to find concrete realizations of quantum criticality in various scales. In biology biochemical realization is of special interest.

The basic aspect of quantum criticality is that the increase of h_{eff} occurs *spontaneously* since the process corresponds to increase of negentropy and NMP states that negentropic entanglement resources of the Universe are increasing as kind of Akashic records or cosmic library. At the level of selves this means that self "dies" and re-incarnates as its time reversal. Selves fight for survival and try to grow their negentropic resources to satisfy the requirements of NMP. This leads to metabolism and homeostasis characterizing living systems. The emergence of life would not be extremely rare accident but doomed to occur spontaneously sooner or later by basic law telling what happens in state function reduction in TGD Universe obeying Zero Energy Ontology (ZEO). Hence the process should occur spontaneously and increase h_{eff}.

(a) The basic question is how quantum criticality is realized biochemically. Are the molecules excited near to a critical energy at which a dark ion at magnetic flux tube is generated and a phase transition analogous to that leading from ordinary to fourth phase of water occurs? Or are large systems near criticality to a generation of dark phase as the general vision about quantum criticality of TGD Universe suggests.

(b) A natural assumption is that metabolic energy quantum should be able to induce the phase transition producing dark particles at criticality. Could dark photons in visible and UV range accompany criticality at the level of single molecule? Are cell membrane and neuronal membrane quantum critical systems and how they differ?

(c) Dark variants of biologically important ions residing at magnetic flux tubes are in fundamental role in TGD inspired quantum biology. In particular, dark proton states are proposed to give rise to the dark analogs of DNA, RNA, amino-acids, and tRNA. The pairing of ordinary DNA/RNA/amino-acids with their dark analogs is expected to be fundamental in biology and transcription and translation are proposed to take place at dark level as the recent experimental findings indicate. How is this pairing realized? How ordinary DNA becomes paired with dark DNA or is it already paired with it?

7.3.2 MB carrying dark matter as controller of ordinary biomatter

MB contains dark matter identified, as phases of ordinary matter characterized by EQ with a dimension $n = h_{eff}/h_0$ serving as a measure of the algebraic complexity of a given space-time region [L104, L105], and interpreted as a universal IQ. The scales of quantum coherence increase with h_{eff}. The layers of MB characterized by the value of n naturally form a master-slave hierarchy in which ordinary matter with the smallest Planck constant is at the bottom, and controlled by higher levels. The energies of systems increase with h_{eff} and since h_{eff} tends to be spontaneously reduced, an energy feed is needed to preserve the distribution of h_{eff}: the interpretation is as an analog of a metabolic energy feed.

MB acts as a "boss" controlling ordinary matter and induces self-organization [L91].

Anatomy of MB

MB has, as its body parts, magnetic flux quanta: flux tubes and flux sheets. There are two kinds of flux quanta. Flux can be vanishing, which corresponds to a Maxwellian regime. Flux can also be non-vanishing and quantized corresponding to a monopole flux. In the monopole case, the magnetic field requires no current for its creation. This option is not possible in the Maxwellian world. By fractality of the TGD Universe, these flux tubes play a key role at all scales [L84].

Also the Earth's magnetic field with nominal value of $B_E = .5$ Gauss has two parts.

(a) The monopole flux part (see **Fig. ??**) corresponds to the "endogenous" magnetic field $B_{end} = .2$ Gauss and explains the strange effects of ELF EM radiation on the physiology and behavior of vertebrates [J8].
The presence of this part explains the stability of the Earth's magnetic field. This field should have decayed long ago in a Maxwellian world since it is generated by currents which disappear.The contribution of the molten iron in the Earth's core to B_E decays but the changes of the orientation of B_{end} regenerate it [L32]. Also, magnetic fields that penetrate super-conductors as quantized fluxes and even those of permanent magnets (as opposed to electromagnets) may have a monopole part consisting of flux quanta.

(b) The interaction of MB with the gravitational field of Earth is discussed in [L139]. Intriguingly, the metabolic energy currency with the nominal value of .5 eV is rather close to the energy for the escape velocity of a proton. Could the transfer of ions from the surface of the Earth to MB be a standard process?

Evidence for dark charged particles

The notion of dark matter as a controller of biomatter preceded its justification based on number theory [L60, L59].

(a) The values of $h_{eff} = nh_0$ must be so large that the energies $E = h_{eff}f$ of dark photons with EEG frequencies are in the biophoton energy range (visible and UV) assignable to molecular transitions [K19, K28].

(b) What makes the large values of h_{eff} possible? Nottale's hypothesis [E1] introduces the notion of the gravitational Planck constant $\hbar_{gr} = GMm/v_0$, whose form is fixed by an Equivalence Principle (EP). In the TGD framework, $h_{eff} = h_{gr}$ is assigned to gravitational flux tubes [L66]. There are non-trivial implications that reflect EP.

   i. The cyclotron energy spectrum $E_c = n\hbar_{gr}eB/m = nGMeB/v_0$ does not depend on the mass m of the charged particle and is thus universal. The energies involved are proposed to be in the range of biophoton energies (at least) suitable for control of the transitions of the bio-molecule. One cannot exclude lower energies above thermal energy for physiological temperature.

   ii. The gravitational binding energies of a mass m for Bohr orbits around M do not depend on M at all [L139].

Also relatively small values of h_{eff} are possible.

(a) Electrons can also have dark phases, but now the value of h_{eff} would be much smaller and satisfy the generalized Nottale hypothesis $h_{eff} = h_{em}$, where h_{em} is the electromagnetic analogue of h_{gr} assignable to flux tubes accompanying valence bonds. This inspires a model of valence bonds [L56] predicting that the value of $h_{eff}/h_0 = n = h_{em}$ increases along the rows of the Periodic Table.
This picture can explain why molecules such as proteins containing atoms towards the right end of the rows of the Periodic Table are ideal carriers of metabolic energy. It also explains why ions, such as Ca^{++} involved with the control and communications of the cell membrane with the "large" part of MB and having very large $h_{eff} = h_{gr}$, are towards the left end of the rows.

(b) The energy scale of dark variants of valence electrons is proportional to $1/h_{eff}^2$ so that the orbital radii are scaled up and the identification as a Rydberg atom provides the only possibility in the standard physics model. Could dark valence electrons be in question? There is empirical evidence, known for decades, for the mysterious disappearance of valence electrons of some rare earth metals in heating. An article by Chatterjee *et al* [L57] discusses this phenomenon for Yb.
The finding [D8] about "misbehaving" Ruthenium atoms also supports the view that covalent bonds involve dark valence electrons. Pairs of Ru atoms were expected to transform to Ru dimers in thermo-dynamic equilibrium but this did not happen. This suggests that valence electrons associated with the valence bond of Ru dimers are dark in the TGD sense and the valence bonded Ru dimer has a higher energy than a pair of free Ru atoms. TGD based explanation [L57] could be justified by a resonant coupling of dark electron with an ordinary Rydberg state of the valence electron. In the lowest approximation, dark valence electrons have energies in the spectrum of ordinary valence electrons so that a resonant coupling with Rydberg states can be considered. The evidence found by Randell Mill [D9] for atoms with an abnormally large scale of binding energy suggests the formula $h = 6h_0$ [L43]. Atomic binding energies are proportional to $1/h_{eff}^2$ and Mills reports that the binding energy scale can be 4 times larger than for ordinary atoms. This would correspond to $h_{eff} = h/2$.

Pollack effect

In the Pollack effect (PE) [I99] negatively charged exclusion zones (EZs) are induced at the boundary between the gel phase and water by an energy feed such as IR radiation. The negative charge of EZ is explained as a formation of flux tubes carrying dark protons, which are interpreted as dark nuclei. Every 4^{th} proton should transform to a dark proton transferred to the flux tubes to explain the observations.

A simple model for linear dark proton triplets predicts their states to be in a 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and the numbers of codons coding for given amino-acid are predicted to be the same as for the vertebrate genetic code [L65, L82]. This suggests deep connections between nuclear physics and condensed matter physics, chemistry, and biology, which, in the reductionistic spirit, are considered separate disciplines.

EZs are able to remove impurities from their interior in conflict with the second law of thermodynamics (SL). The TGD based explanation is that the time reversal by BSFR at the level of MB [L96] also induces an effective time reversal in long time scales at the level of ordinary bio-matter.

PE explains the occurrence of a charge separation in living matter. DNA has one negative charge per nucleotide, microtubules are negatively charged, the cell is negatively charged, and ATP carries 3 units of negative charge. Therefore ZEO suggests that PE plays a key role in bio-control and macroscopic SFRs play a key role in living matter.

Basic differences between organic and in-organic matter

One of the basic differences between organic and in-organic matter would be the presence of dark protons and electrons.

(a) The notions of acids and bases would reduce to the presence of dark protons: pH would characterize the fraction of dark protons. Reduction and oxidation (the REDOX reaction) could be understood in terms of a transfer of dark electrons associated with valence bonds [L196].

(b) In biochemistry the density of dark protons would be much higher in PE [I63, I64, L27, I99, I128]. Dark ions could play a key role in TGD based view of biochemistry as the findings of Blackman and others suggest [J8].

Biocatalysis and water memory

Bio-catalysis and water memory [L18] remain mysteries in the bio-chemical approach. MB carrying dark matter could provide the needed mechanisms. Reconnection of flux tubes would be the basic mechanism of bio-catalysis and also explain water memory, which in the TGD framework forms the basis of the immune system [K50].

(a) According to the TGD view of catalysis, tentacle-like U-shaped flux tubes associated with MBs of reactants reconnect to a pair of flux tubes connecting the molecules [L73]. This happens if there is a cyclotron resonance for dark cyclotron radiation assignable to massless extremals (MEs) associated with these "tentacles". This requires that the flux tubes have identical magnetic field strengths and - by flux quantization - the same thickness. The same value of h_{eff} guarantees resonance. The next step is the shortening of the "tentacles" by a reduction of h_{eff} and the liberation of energy which "kicks" the reactants over the potential wall making an otherwise extremely slow process possible.

(b) The physics of water is plagued by anomalies [L18]. TGD suggests an explanation [L63] in terms of flux tubes assignable to hydrogen bonds [L63, L74]. These flux tubes could have $h_{eff} > h$ so that these flux tube could be long and give rise to long range quantal correlations. Water could be seen as a many-phase system. MBs assignable to water molecule clusters could mimic the cyclotron frequency spectrum of the invader molecule and make possible water memory and a primitive immune system based on reconnections of the "tentacles" of a water cluster and invader molecule [L113]. In this framework water would represent a primitive life form.

Comorosan effect

Comorosan effect [I105, I29] demonstrates rather peculiar looking facts about the interaction of organic molecules with visible laser light at wavelength $\lambda = 546\ nm$, which corresponds to photon energy 2.27 eV. As a result of irradiation molecules seem to undergo a transition $S \to S^*$. S^* state has anomalously long lifetime and stability in solution. $S \to S^*$ transition has been detected through the interaction of S^* molecules with different biological macro-molecules, like enzymes and cellular receptors. I have discussed Comorosan effect in [K116] but the discussion reflect the state of TGD for decades ago.

The typical result in the enzyme-substrate interaction is represented by the enhancement of the enzymic rate, when the respective enzyme substrate is previously irradiated for certain sharply defined times. These *efficient (irradiation) times* are enzyme dependent and can also depend on the biological origin of the enzyme.

The *intensity of laser light does not matter*. What is needed is that the intensity is above certain threshold. The original explanation in terms of saturation of effect (for large intensities of laser light the effect of laser light on organic molecules does not depend on the intensity) has turned to be unsatisfactory.

The effective times are always of the following type $t_i = i * 5$ sec, where i is certain integer. The general formula for the effective times is $t_k = t_m + (k-1)\tau_n$, $k = 1, 2, .., 6$, where t_m is the minimum radiation time inducing the first effect and τ_n is the period between two consecutive effects [I105, I29]. $t_m = m_E t_1$ and $\tau_n = n_E t_1$ are multiples of the basic time scale $t_1 = 5\ sec$: $t_k = (m_E + (k-1)n_E)t_1$. The integers m_E and n_E can be regarded as enzyme characteristics, depending however on the biological origin of the enzyme.

Consider the specific enzymic interaction $E + S \leftrightarrow ES \leftrightarrow E + P$, where E stands for enzyme, S for substrate and P interaction product. Assume that substrate S is subject to a sequence of distinct irradiations lasting for times $t_a, t_b, ...$ The following rules are found to hold true.

(a) The irradiations of the substrate performed after an irradiation with efficient time have no effect on the enzyme-substrate interaction.

(b) Any arbitrary irradiation of the substrate with irradiation time less than sixth efficient time t_6 performed prior to any other efficient time, is irrelevant for the enzyme-substrate interaction.

(c) Any arbitrary irradiation of the substrate lasting more than the sixth efficient time t_6 and performed prior to an efficient time precludes all other subsequent effects in enzyme-substrate interaction.

(d) Note that the time scales 5,10, 20 seconds have been observed in the clustering of RNA polymerase molecules [I38] discussed from TGD view point in [L67].

The work of Comorosan demonstrates that all irradiation times have nontrivial effect on organic molecules but that for effective times something very special must occur. One should understand what this "very special" is, derive Comorosan formula from a physical model and find a physical interpretation for the integers m_E and n_E appearing in the formula as well as explain the special role of $t > t_6$ irradiation times.

Comorosan effect suggests that communications to MB could take place even at the level of relatively simple biomolecules. One can get some grasp about the situation by considering simplest possible picture that one can imagine.

(a) It seems that laser light keep care that a connection from the system MB is generated and preserved a critical time for the phase transition to take place. The phase transition itself could correspond to increase of h_{eff}. The problem is to understand why the intensity of laser light does not manner. This suggests that the flux tube can receive the energy of the laser light energy with some fixed rate depending on the enzyme. The receiver could be the MB of enzyme and that it has a dead time after the receival of quantum of laser light.

(b) The proposal is that Josephson junctions are involved and the Josephson frequency $f_J = ZeV/h_{eff}$ defines the time scales in question.

(c) The assumption $\hbar_{eff})/\hbar = \hbar_{gr}/\hbar = GMm/v_0 = 2r_s(E)m/v_0$, where $M = M_E$ is the mass of Earth, $r_s(E) = .09$ m and $m = 2m_e$ as mass of electron Cooper pair, m_e is electron mass, allows to estimate the parameter $\beta = v_0/c$ assuming $f_J = E_J/h_{gr}$ is equal to Comorosan frequency $f_C = 1/T_C = .2$ Hz. For Josephson energy $E_J = 2eV \simeq .1$ eV of electron Cooper pair, this gives the estimate $h_{gr}/h \simeq 5 \times 10^{13}$. The value of β_0 would be $\beta_0 \simeq .93$ near its maximal value. This estimate is consistent with the estimate of [L135].

(d) There are two especially important cyclotron frequencies in endoenous magnetic field B_{end} with nominal value .2 Gauss.

   i. The cyclotron energy $E_c = \hbar_{gr} ZeB_{end}/m$ of a charged particle does not depend on its mass. For Fe^{++} ion f_c in the endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss equals alpha frequency $f_c(Fe^{++}) = f_\alpha = 10$ Hz. Cyclotron energy $E_c(Fe^{++}) = h_{gr} f_c = 2.5$ eV. Note that this energy is not far from the energy 2.27 eV of photons in the experiments of Comorosan suggesting that they were in energy resonance with dark Josephson photons or were in energy resonance with them. For $\beta_0 = 1$, one would have $E_c(10Hz) = 2.44$ eV. For $E_c = 2.24$ eV one would obtain $\beta_0 = 1.024 \geq 1$. Scaling of 10 Hz alpha frequency to 9.3 Hz would allow $\beta_0 = 1$ and $E = 2.27$ eV.

   ii. DNA cyclotron frequency $f_J(DNA)$ is another probably very important frequency. It depends only weakly on DNA length and the base-pair it has has average value 1 Hz which corresponds to energy .244 eV. This is roughly 1/2 of the metabolic energy quantum.

   iii. To sum up, for $\beta_0 = 1$, one can relate to each other f_C, $f_J(Fe^{++}, B_{end}) and f_J(DNA, B_{end})$, and the corresponding cycltron energies and the value of the membrane potential.

This model alone does not explain much. What happens looks like an outcome of a control action and should take place at the level of MB: the irradiation affects the MB of the E+S

complex, which responds at times t_k. One can also assume the TGD inspired view about biocatalysis and look at what this gives.

(a) The time $t_1 = 5$ s need not correspond to dark Josephson time for a given enzyme for which has 6 special irradiation times $t_k = t_m + (k_1)\tau_n$, $k = 1, ..., 6$, which are multiples $n_k t_1$ of t_1. This would scale up h_{gr} by n_k and v_0 would be scaled to v_0/n_k. Therefore one would have a spectrum of $v_0 = 1/n$, with each enzyme allowing 6 different values of n. t_1 would be minimal Josepson time corresponding to maximal $v_0 = c$.

(b) What could happen in the transition at t_k? Why certain multiples $n_k t_1$ would define thresholds at which enzyme activity increases? Could one interpret this in terms of MB controlling the E+S complex?
At these specific moments enzyme action would be affected. If enzymatic action involves a reduction of h_{eff} for flux tubes connecting E and S, one might think that the Δh_{eff} increases and more energy is provided to overcome the potential wall slowing down the reaction. Reaction becomes faster.

(c) Could the irradiation induce phase transitions increasing the h_{eff} for these flux tubes. Could these flux tubes be the flux tubes with $h_{eff} = h_{gr}$ and could the phase transition change the value of $v_0 = 1/n$ to new subharmonic and scale h_{gr} by n. The length of flux tubes would increase and the energy liberated in the shortening would be proportional to $\Delta h_{gr} \propto \Delta n$.
The irradiation corresponds to $f_c(Fe^{++} = 2.27$ eV all the time. If an increasing value of h_{gr} is associated with catalyst flux tubes, alpha frequency must be changed to is sub-harmonic $f_c(Fe^{++}/n$ in each phase transition bringing in longer length scales.

(d) Why the transitions should take at such precise values t_k of time characterizing the enzyme? h_{gr} has a number theoretic origin that reflects the polynomial deterministic dynamics at the level of M^8 analogous to Bohr orbit dynamics at the level of H. If quantum non-determinacy has the failure of string determinism for the space-time surface as 4-D soap films with frames as a correlate, one would expect that these phase transitions occur deterministically. One can also ask whether quantum jumps replace polynomial P with a new one.
Could the times t_k correspond to SSFRs or to the pairs of BSFRs giving rise to quantum tunnelling between the different phases at MB?
Why should t_k be some integer multiples of t_1. What comes to mind is time crystal structure associated with the 4-D soap film with frames.

(e) Threshold effect could be in question. The irradiation could play the role of metabolic energy feed. This might help to understand why the phase transitions occur at times t_k. For instance, the irradiation could transfer dark electrons at flux tubes as in the Pollack effect. It could also induce a phase transition of Bose-Einstein (BE) condensate at the magnetic body of the enzyme (phase transition of a spin glass-like structure analogous to spontaneous magnetization). The obvious possibility is the BE condensate of electron Cooper pairs. The increase of h_{eff} requires energy and when some minimum energy is feeded, the transition occurs.

(f) Could laser photons be transfered to the flux tube photons with a rate determined by the flux tube alone as a slow step of the process, where it forms an dark N-photon state. N would increase steadily and when the energy of this state exceeds a threshold defined by the Josephson energy $E_J = 2ZeV$ a Cooper pair is created, which means that MB sends an ordinary photon with this energy to the aromatic ring and kicks out a Cooper pair. The number of laser photons would be such that the energy exceeds the binding energy of p^2 electron pair in the aromatic ring. A rough estimate for this energy as $E \simeq 2(Z^2/n^2)E_H$, $E_H = 13.6$ eV would be about 122.3 eV and gives $N \geq E/22.7 \geq 54$.

(g) Why the number of transitions is 6? Could this relate to aromatic 6-ring as a basic object? The electron configuration of C is $[He]2s^2 2p^2$. There is one p^2 state as an candidate of the Cooper pair for each Carbon atom. Could the 6 steps correspond to a sequence of transitions in which one p^2 state becomes a dark Cooper pair.

Could base pairs act as Josephson junctions?

The basic idea is that each system has a "biological body" (BB) and MB and that BB sends sensory data to MB which in turn controls it. The idea about nuclear membrane as a communicator of sensory data to MB using dark Josephson radiation looks attractive. Is it enough to send the sensory data from the nuclear membrane only? Or could the sensory data from DNA be sent along flux tubes to the nuclear membrane to MB? Or could it be sent directly from DNA? The idea of base pairs as Josephson junctions need not be realistic but deserves to be shown wrong, if not anything else.

(a) The sensory communication from DNA using a series of base pair Josephson junctions should utilize dark genetic code based on 3N-photons fused by Galois confinement to longer units like genes. The frequency triplet, 3-chord, must be different for codons, which differ only by the order of letters. This is impossible if one assumes that the letters are independent. The process of adding letters to codon and codons to DNA sequence must be non-commutative and one can speak of a well-defined order. This order naturally corresponds to the orientation of DNA strands.

(b) In the number theoretic vision, many particle systems correspond to space-time sheets, which are obtained by M^8-H duality from a 4-surface of M^8 obtained by holography from the roots of an octonionic continuation of a real polynomial P with rational coefficients. P is obtained as a non-commutative functional composition of real polynomials.
The spectrum of the roots has an interpretation as quantized virtual mass squared values specifying the mass shells $H^3 \subset M^4 \subset M^8$, which define holographic data. The root spectrum of a composite depends on the order of polynomials in the composite.
The letters A,T,C,G of codon could correspond to 4 different polynomials P_i, $i = 1, ..., 4$ and codons would be composites of form $P_i \circ P_j \circ P_k$. If the order of functional composition corresponds to the orientation of the strand, it would be opposite for strand and conjugate strand and the 4-surfaces corresponding to strand and conjugate strand would not be simply the same surface but with opposite direction. Only for palindromes, the base pairs A-T and T-A (C-G and G-C) at the opposite ends of the double strand are equivalent if the picture based on polynomial composition is correct. This could explain the different biological roles of strands. Also the halves of many binary structures of biology, such as brain hemispheres could have a similar relationship.

(c) Base pair would give rise to a basic Josephson junction between aromatic rings acting as superconductors. These elementary Josephson currents would integrate to to 3N-Josephson junction as a quantum coherent unit. The emitted Josephson photons would be dark 3N-photons analogous to BE condensates.

(d) The delocalization of protons in the hydrogen bonds of base pairs A-T and C-G would take place. In the delocalization the proton tends to shift to the direction of the atom to which hydrogen bonding takes place. Protons generate a polarization creating an electric field in which electron Cooper pairs move but at different space-time sheets than protons. This would produce oscillatory Josephson current emitting Josephson photons [K85]. The dark electron Cooper pair currents would originate from the aromatic rings. Note that the Josephson voltage would be the same along all space-time sheets.

(e) The pairing of aromatic rings by hydrogen bonds need not be the only way to create dark Josephson junctions. Also Josephson junctions between hydrogen bonded molecules without any aromatic rings can be considered. Pollack effect creates negatively charged exclusion zones (EZs) in water. The protons would be transferred to dark proton sequences at the flux tubes whereas the electrons of EZ would form dark electron Cooper pair condensates generating Josephson currents and Josephson radiation perhaps making possible communications between these systems.

(f) An estimate for the Josephson voltage is obtained by assuming that the Josephson voltage scales as the inverse of the size scale of the basic object. For neuron membrane of thickness D=10 nm (for cell membrane the thickness is nearer to 5 nm) is replaced with A-T or C-G pair with thickness of d=.34 nm. This gives an estimate for the energy $E_J = 2eV$ of Cooper the estimate $E_J = (D/d) \times .01$ eV = 3.3 eV (1.75 nm). This energy looks rather reasonable. Interestingly, this is not too far from the energy 2.27 eV associated with the

laser photons inducing the Comorosan effect already discussed.
In Comorosan effect [I105, I29], the irradiation with a laser beam with a photon energy $E_J = 2.27$ eV would generate the BE condensate of dark Cooper pairs . This might be true also for the base pairs. This should be testable.

Biosystem as a spin glass like system

Spin glasses represent an exotic phenomenon, which remains poorly understood in the standard theoretical framework of condensed matter physics. Actually, spin glasses provide a prototype of complex systems and methods used for spin glasses can be applied in widely different complex systems. Biology is certainly one the most interesting applications.

In [L133] a TGD inspired view about spin glasses is discussed.

(a) TGD view about space-time leads to the notion of magnetic flux tubes and magnetic body. Besides spins also long closed magnetic flux tubes would contribute to magnetization. The basic support for this assumption is the observation that the sum of the NFC magnetization and the FC remanence is equal to the NFC magnetization. Magnetic field assignable to spin glass would correspond to a kind of flux tube spaghetti and the couplings J_{ij} between spins would relate to magnetic flux tubes connecting them.

(b) Quantum TGD leads to the notion of "world of classical worlds" (WCW) and to the view about quantum theory as a "complex square root" of thermodynamics (of partition function). The probability distribution for $\{J_{ij}\}$ would correspond to ground state functional in the space of space-time surfaces analogous to Bohr orbits.

(c) Spin glass is a prototype of a complex system. In the TGD framework, the complexity reduces to adelic physics fusing real physics with various p-adic physics serving as correlates of cognition. Space-time surfaces in $H = M^4 \times CP_2$ correspond to images of 4-surfaces $X^4 \subset M^8_c$ mapped to H by $M^8 - H$ duality. X^4 is identified as 4-surface having as holographic boundaries 3-D mass shells for which the mass squared values are roots of an octonionic polynomial P obtained as an algebraic continuation of a real polynomial with rational coefficients. The higher the degree of P, the larger the dimension of the extension of rationals induced by its roots, and the higher the complexity: this gives rise to an evolutionary hierarchy. The dimension of the extension is identifiable as an effective Planck constant so that high complexity involves a long quantum coherence scale.
The TGD Universe can be quantum critical in all scales, and the assumption that the spin glass transition is quantum critical, explains the temperature dependence of NFC magnetization in terms of long range large h_{eff} quantum fluctuations and quantum coherence at critical temperature.

(d) Zero energy ontology predicts that there are two kinds of state function reductions (SFRs). "Small" SFR would be preceded by a unitary time evolution which is scaling and generated by the scaling generator L_0. This conforms with the fact that relaxation rates for magnetization obey power law rather than exponent law. "Big" SFRs would correspond to ordinary SFRs and would change the arrow of time. This could explain aging, rejuvenation and memory effects.

(e) Adelic physics leads to a proposal that makes it possible to get rid of the replica trick by replacing thermodynamics with p-adic thermodynamics for the scaling operator L_0 representing energy. What makes p-adic thermodynamics so powerful is the extremely rapid convergence of Z in powers of p-adic prime p.

Is there an analogy between dark information molecules and spin glasses?

(a) The TGD based model for spin glass involves dark flux tubes with a local magnetization and the state could be seen as a kind of flux tube spaghetti. Also the dark variants of basic information could be seen as this kind of flux tube structures.
Quantum criticality of TGD suggests that the flux tube configuration has a large number of energy degenerate states and that this is essential for morphogenesis controlled by counterparts of dark genes. In fact, the huge non-determinism of Kähler action due to the existence of vacuum extremals with a CP_2 projection, which is Lagrangian manifold, led to the notion of 4-D spin glass. Twistor lift removes the non-determinism and reduces

degeneracy by adding to the action a small volume term, whose coefficient is proportional to a length scale dependent cosmological constant. 4-D spin glass degeneracy is expected to reduce to 3-D spin glass degeneracy.

(b) Spin and weak isospin distinguishing between dark neutron and proton are in a key role in the proposed model for the dark nucleon realization of the genetic code [L162]. Codons correspond to closed flux tubes containing 3 dark nucleons connected by pion-like flux tube contacts. The states of this object give rise to dark information molecule DX paired with X, X=DNA, RNA, tRNA, and AA. The states correspond to tensor products of spin-isospin states in representation $4_I \times 4_s$ of 3 dark nucleons with the angular momentum state of string-like flux tube possessing orbital angular momentum L and correspond to $5 \oplus 3$ (spin 2 and spin 1) for DDNA, DRNA and DtRNA and singlet 1 for DAA as representations of rotational group. In spin and nuclear spin degrees of freedom DDNA corresponds to $(1/2, -1/2)_I \otimes 4_s$, DRNA to $(3/2, -3/2)_I \otimes 4_s$ and DtRNA to $2_I \otimes 2_s$. 32 DtRNAs are predicted and this is the minimal number. The pairing of DtRNAs with tRNAs need not be unique.
Remark: Genetic code has a complete (U-C) symmetry and almost complete A-G symmetry with respect to the third nucleotide of RNA codon. These symmetries have an interpretation in terms of rotational symmetry [L162]. What could be the interpretation of purine sequences (A and G) paired with pyrimidine sequences (T and C) in this picture?

Could one understand how the dark information molecules DX (X refers now to DNA, RNA, and proteins P rather than codons and AAs) could control the conformations of X?

(a) The spin state of the dark codon varies along the flux tube so that dark information molecules as flux tubes carrying various spin states differ from the simple ferromagnetic or antiferromagnetic system locally. In spin glasses, ferromagnetism and antiferromagnetism compete and the notion of frustration meaning that there is a large number of states with the same free energy implies complexity. Still DX is much more complex that spin glasses. One can however ask, whether the variation of the spin state of DX along the flux tube is analogous to the frustration of spin glasses? Could the total (free) energy of the dark nucleon triplet depend only very weakly on the codon content so that the frustration would be maximal and give rise to a maximal representative power.

(b) The nuclear spin of the dark nucleon triplet couples with the stringy angular momentum of the closed flux tube of the codon. One can expect similar coupling in longer scales between the total angular momentum of subsequent codons along the flux tube and also with the stringy angular momenta assignable to larger units of DX such as gene, promoter region, or a control region like Alu in the case of DNA. One would have a tensor product of representations of the rotation group for codons and longer basic units. These tensor products decompose to irreps.
Could various irreps in these decompositions correspond to various flux tube configurations for the units of DX, X= DNA, RNA. DAAs have stringy angular momentum at the level of codons as closed flux tubes. Dark protein (DP) flux tube has angular momentum and it can couple to the angular momenta of DAAs?
Could this coupling make it possible for the units of DX to control the dynamical geometry of the flux tube as phase transitions between different irreps of the rotation group? Could these transitions occur at quantum criticality?

(c) If this picture is correct, the degeneracy of the angular momentum states of the dark information molecules DX (genes, RNA, proteins) would correspond to a degeneracy of the geometric configurations of information molecules X. DX would serve as a control knob. This is just what a morphogenetic field should achieve. The feed of metabolic energy would induce transitions in the quantum spin glass energy landscape. Also protein/DNA/RNA folding and unfolding induced by energy feed could be understood in this manner.

7.3.3 Communications to and control by MB

Communication from the biological body (BB) to MB and its control by MB would rely on dark photons, which can transform to ordinary photons with a large h_{eff} and vice versa. Molecular transitions would represent one form of control.

(a) Cell membranes could act as generalized Josephson junctions generating dark Josephson radiation with energies given by the sum $E_J + \Delta E_c$ of ordinary Josephson energy E_J and the difference ΔE_c of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential modulates the Josephson frequency and codes the sensory information at the cell membrane to a dark photon signal sent to MB.

(b) The large effects of radiation at ELF frequencies observed by Blackman and others [J8] could be understood in terms of the cyclotron transitions in $B_{end} = .2$ Gauss if "h" in $E = hf$ is replaced with h_{eff}. h_{eff} should be rather large and possibly assignable to the gravitational flux tubes with $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. For the simplest model, M represents the Earth's mass coupling to the small mass m, and v_0 is a parameter with dimensions of velocity expected to have discrete spectrum. The energies $E = h_{eff}f$ of dark photons should be in the biophoton energy range (visible and UV) characterizing molecular transitions [K19, K28].

(c) For the value $v_0/c \simeq 2^{-11}$, suggested by the Nottale's model for planetary orbits [E1], the predicted cyclotron energy scale is 3 orders of magnitude higher than the energy scale of visible photons. Several solutions of this problem were considered [L138]. The most plausible solution [L138, L125] is $\beta_0 = v_0/c = 1/2$ for living matter so that gravitational Compton length $\Lambda_{gr} = GM/\beta_0$ equals to Schwartschild radius at the surface of Earth and brings nothing new to the original Nottale hypothesis.

Cyclotron photons and Josephson photons as basic tools of control and communication

By its higher level of "IQ", MB would naturally be the master controlling BB by cyclotron radiation - possibly via a genome accompanied by dark genome at flux tubes parallel to the DNA strands.

(a) Cyclotron BE condensates (BECs) of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear as dark matter in living systems and the $h_{eff} = h_{gr}$ hypothesis predicts a universal cyclotron energy spectrum in the range of bio-photon energies. Dark matter and MB would use the biological body, defined in very general sense since life is a universal phenomenon in TGD, as a sensory receptor and motor instrument. MB would receive sensory input most naturally as generalized dark Josephson radiation and control it by dark cyclotron radiation.

(b) All charged elementary particles and basic biological ions would have dark variants and could define Josephson currents. Dark photons and BE condensate-like states formed from them would give rise to the analogs of morphogenetic fields. Dark Josephson radiation associated with electrets, which are indeed electric dipolar structures, replaces Fröhlich condensates in the TGD framework.

(c) The key equation is $f = ZeV/h_{eff}$ which allows to associate low Josephson frequencies with large energies, say the Josephson energy associated with cell membrane to ELF frequency. Second key equation $E_c = \hbar_{eff}f_c = \hbar_{eff}ZeB/m$ assigns to a low frequency, such as EEG frequency, a large cyclotron energy.

(d) There is a connection with biophotons [I96, I54, I124, I28, I73, I79], which is a phenomenon having no feasible biochemical explanation. In the TGD Universe, biophotons can be regarded as ordinary photons resulting from the transformation of dark photons to ordinary photons in an energy conserving manner [K19, K28]. This dramatically reduces the wavelength and in this manner couples long and short length scales dynamically.

In ZEO, the field body (FB) and MB correspond to 4-D rather than 3-D field patterns and quantum states correspond to quantum counterparts of behaviors and biological functions. Conscious holograms could be generated as a result of interference of a dark photon reference

beam from MB and a dark photon beam carrying the sensory information. This hologram would be read by MB using the conjugate of the reference beam. In ZEO time reversals of these processes also take place. This makes it possible to understand memory as a result of communications with memory mental images.

If one accepts the view that dark Josephson radiation is a universal communication tool in communications between biological body and MB, one can as whether DNA could utilize it. Consider first the situation at the level of the cell membrane.

(a) Dark generalized Josephson radiation associated with the generalized Josephson junctions defined by membrane proteins would make possible communication of local sensory data to MB [K85, K86, K40]. These Josephson junctions are idealizable as continuous Josephson junctions with a geometry of a cylindrical shell. Ground state would correspond to a soliton sequence and the dark variant of nerve pulse would correspond to a perturbation of the soliton sequence propagating like a nerve pulse.

(b) The feedback as control actions could take place via genome as transcription of genes or more general gene expression. This would require communications from genome to nuclear membrane to cell membrane perhaps made possible by magnetic flux tubes connecting them. Their braiding would also make possible topological quantum computation type processes [K5, K110, **?**].

(c) This model generalizes to a model for the communications of "sensory" data from nuclear membrane to MB.

One can consider several analogs of Josephson junctions at the level of DNA double strand and even at the level of DDNA.

(a) One can of ask whether the linear structures formed by the electron chains [I112, I110, I111] assigned with the stack of aromatic rings and proton chains defined by longitudinal hydrogen bonds inside the DNA double strand form Josephson junctions so that Josephson currents would consist of protons and electrons.

(b) Could Josephson junctions between base pairs make sense? What is missing is the membrane-like structure and nanoscopic Josephson junctions as analogs of membrane proteins. Base pairs could in principle give rise to Josephson junctions if there is voltage between them. In this case, even the analogs of soliton sequences and nerve pulse could make sense.

(c) There exists a longitudinal electric field along DNA [L190, L192]. It could be that nucleotides define analogs of Josephson junctions and they might generate collectively dark 3N-photons as generalized Josephson radiation. In this case, the analog of nerve pulse would not make sense.

Control of DNA and other biomolecules by MB

How MB could control the DNA and other biomolecules?

(a) Suppose that the monopole fluxes of dark DNA strands generate currents flowing in aromatic rings of strands. Also spin magnetization could be induced and this in turn would genrate currents in aromatic rings. This could give rise to an analog of magnetized state. Also a diamagnet with vanishing total magnetic field perhaps giving rise to superconductivity is generated.

(b) The control of the network of formed by the typically linear structures and membranes is an essential part of biosystems in supramolecular scales. Here an analogy with spin glasses is highly suggestive. Spin glass has become a prototype of complex system. They characterized by a local magnetization with a varying direction. Spin glass landscape has fractal energy landscape having valleys inside valleys and p-adic physics suggests an elegant description of it [L133]. This kind of phase would be ideal control tool used by MB.

(c) In the TGD framework, spin glass could correspond to a dark magnetized flux tube network. Spin glass phase could couple to biophotons produced from dark cyclotron photons with large h_{eff} transforming to ordinary biophotons of dark photons with a smaller value

of h_{eff} and induce transitions between valleys of the energy landscape corresponds to different geometric and topological configurations of flux tubes. Reconnections and changes of flux tube lengths induced by the change of h_{eff} would be basic processes.

(d) Braiding would make possible topological quantum computation using magnetizations associated with flux tubes as analogs of qubits. These qubits would be highly stable as magnetized multi-spin systems. Entanglement would be between magnetizations instead of spins. The first version of topological quantum computation discussed in [K5, K6, K110] did not yet involve spin glass hypothesis.

7.3.4 Dark counterparts of information molecules and dark realizations of genetic code

There are good reasons to expect that genetic code is something very fundamental and realized at the level of fundamental physics. Genetic code relates to information processing and dark matter at MB has higher "IQ" as the dimension of extension of rationals identifiable in terms of h_{eff}. This leads to two realizations of the genetic code in terms of dark photons and dark nucleons and also strongly suggests that the genetic code is a universal phenomenon having many other realizations besides the biological ones.

Dark analogs of the basic information molecules

The basic information molecules DNA, RNA, tRNA and aminoacids (AA) would have dark counterparts in TGD Universe. DDNA, DRNA,DtRNA, and DAAs would serve as sources of dark 3N-photons representing genes and in special case codons. There would be resonance couplings between DDNA and DRNA, DRNA and DtRNA, DtRNA and DAA. Also resonant coupling change the value of h_{eff} and the frequency by energy conservation $E = h_{eff_1} f_1 = h_{eff_2} f_2$. If h_{eff} changes there is only energy resonance.

During the interaction, these systems should be quantum critical in order to make control, communication and sensory sensitivity optimal which suggests that temporary transitions to quantum criticality is basic aspect. Since the increase of h_{eff} requires energy, metabolic energy would be needed to achieve these transitions. The layers of MB with different values of h_{eff} forming a slaving hierarchy would couple by energy resonance.

Also the communications and control of the ordinary biomatter by dark biomatter is needed. There must exist couplings between DX and X. DX-X pairing would represent permanent interaction of this kind of interaction. Since $h_{eff} = h$ does not actually correspond to the minimum value h_0 of h_{eff}, it would seem that resonant interaction must be involved. Energy resonce gives strong conditions on cyclotron transition energies of DX and transition energies of X. The transition energies for X should be chemical transition energies.

That biophotons, which could result from dark N-photons, have energies in visible and UV range, conforms with this picture. This would make possible direct control of chemistry. Also transitions changing molecular conformations could be activated: the energies for them are in THz range and analogs of biophotons in microwave range are highly suggestive. Dark N-photon could consist of dark photons with energy corresponding to Thz range. Vibrational and rotational transitions could be also activated.

Two realizations of genetic code

TGD inspires the proposal of two dark realizations of genetic code whose most recent forms are discussed in [L162].

(a) The first realization represents codons as dark nucleon triplets [L65, L82] and the second realization as dark photon triplets that is 3-chords [L24] [L111, L128, L162].

(b) The models for dark codons generalize to models of genes. Galois confinement predicts that dark N-particles states are possible. In particular, genes could correspond to dark 3N-nucleon states as a bound state of dark 3-nucleons associated with flux tubes parallel to DNA strands and to dark 3N-photon states as analogs of BE condensate.

The communications and control would be based on 3N-resonance in which frequency modulated Josephson radiation would produce a sequence of resonance pulses at MB possibly related to nerve pulses. The genetic codon would determine the address of the receiver as in LISP and modulation would encode for the information transmitted.

(c) The icosa tetrahedral model of the genetic code introduced as a model of music harmony has justification in terms of icosa tetrahedral tessellation of the hyperbolic space H^3 defining mass shell [L128]. These mass shells define holography and allow explosion of cognitive representations since all algebraic integers are allowed as points. Genetic code would be therefore universal and could also have 2- and 3-D representations. Even cell membranes could define such a representation.

(d) One can say that dark matter at MB and Josephson junctions involving the flow of dark ions define morphogenetic fields in the TGD framework and their interactions are based on signals propagating along topological light rays parallel to the flux tubes. N-resonance making possible precise selective receival of the signals and frequency and amplitude modulation codes for the message.

(e) The new view about genetic code leads also to a vision about the evolution of language known to be initiated by mutations of only few genes [L194, L195]. The ideas is that the value of h_{eff} increases for the highest layers of MBs associated with these genes and led to the cultural evolution which quite generally corresponds to evolution at the level of MB.

To sum up, dark Josephson and cyclotron $3N$-photons could define the TGD analogs of morphogenetic fields. The communication would be based on $3N$-resonance and information would be coded using frequency and amplitude modulation and would generate a sequence of resonance pulses.

7.4 Water memory

Water memory, or homeopathy, is still not taken seriously by mainstream biologists although the empirical support is unquestionable. In this section I will discuss the findings of Benveniste's group and Montagnier's group from the TGD point of view.

7.4.1 Biological signaling by EM means

Yolene Thomas discusses the history of the notion of water memory in the articles "*The history of the Memory of Water*" [I126] in particular the basic findings of Benveniste's group. In [I127] further findings are discussed. These findings serve as bench tests for the TGD view.

Basic findings of Benveniste's group

Yolene Thomas worked in the group of Benveniste. Among other things Benveniste had discovered an allergy test using blood cells known as basophils. At 1980's Jacques Benveniste and Bernhard Poitevin started to study homeopathy. Antibodies causing basophil degranulation were added to water. A repeated dilution together with agitation led to a situation in which the concentration of the molecule was extremely low and should have caused any effects. The solution however induced a degranulation of the biomolecule itself. The finding was in conflict with the standard lock-and-key mechanism. The conclusion was that the information about antibodies might have been transferred to solution during dilution/agitation process by some unknown molecular organization.

The results were checked in other laboratories and eventually an article by Benveniste and Poitevin was published in Nature but induced violent reactions of skeptics. Instead of a scientific committee, Nature sent Magician James Randi and Walter Stewart, a fraud investigator, to the laboratory of Benveniste. They did not find any evidence for fraud. Nevertheless, they concluded that Benveniste had failed to replicate the claimed results.

Although Benveniste becamed isolated from the community, the research continued.

(a) It was found that the vigorous agitation involving vortexing was essential for the effect. Pipetting up-and-down did not have the effect.

(b) The effect was found to occur also for the dilutions of ethanol and propanol but not for dilutions of dimethyl sulphoxide.

(c) Heating, freeze-thawing or ultrasonication suppressed the activity of highly diluted solutions, but not the activity of several active compounds at high concentrations.
Molecules reacted to heat according to their distinctive heat sensitivity, whereas all highly diluted solutions ceased to be active between 70 and 80 C. This suggests that the mechanism is independent of the nature of the original molecule.

(d) It was found that the activity of highly diluted agonists was abolished by the application of 50 Hz magnetic field of strength 150 Gauss for 15 minutes (Earth's magnetic field has strength .5 Gauss and the endogenous magnetic field explaining the findings of Blackman has strength .2 Gauss). There was no comparable effect on original molecules.

What can one conclude from these findings in the TGD framework?

(a) Vortex formation could correspond to the formation of magnetic monopole flux tubes which provide a representation for the MB of antigen. Also Z^0 magnetic flux tubes could be involved in TGD based hydrodynamics and accompany hydrodynamic vortices [L135]. The agitation could feed kinetic energy as a metabolic energy feed for primitive non-chemical lifeforms generated at the flux tubes.
The different effects of freeze-thawing or ultrasonication effects on the antibody and on the diluted solution supports the view that something representing the antigen in some respects was formed at the flux tubes.
Pollack effect [I63, I64, L27, I99, I128] generating in the presence of say IR radiation negatively charged region as exclusion zones (EZs) suggests that part of protons of water molecules were transferred somewhere.
The TGD based explanation [L27] is the formation of dark proton sequences at the flux tubes as analogs of nuclei at the flux tubes defining a primitive lifeform utilizing IR radiation as metabolic energy source: metabolic energy feed would increase the value of h_{eff}. These life forms would correspond to MBs assignable to water clusters.
The flux tubes of MBs would reconnect with the molecules of the MB of antigen and change their thickness to tune into resonance. In this way they would form representations of antigen by mimicking the cyclotron frequency spectrum of the antigen. They could induce the same effects as antigen if the cyclotron frequencies are a basic control tool of biochemistry. Water clusters would catch the invader molecules. This mechanism would underlie the biochemical immune system and biocatalysis.
One can even ask whether genetic code is realized for these life forms: the restriction of dark nucleon sequences to those consisting of protons gives as outcome 32 codons, the minimum number of tRNA codons.

(b) The effect occurs for ethanol and propanol but not for dimethyl sulphoxide. Hydrogen bonding requires OH-groups. Ethanol and propanol have OH groups but not dimethyl sulphoxide so that the hydrogen bonding could explain the difference. The proposal indeed is that water allows long hydrogen bonds with non-standard value of h_{eff} containing delocalized proton or even several protons. This can explain the numerous anomalies associated with the thermodynamics of water.

(c) The 50 Hz oscillatory magnetic field abolished the effect. Note that 50 Hz is a cyclotron frequency of ^{7}Li in the "endogenous" magnetic field $B_{end} = .2$ Gauss explaining Blackman's findings and interpreted in the TGD framework as magnetic field assignable to monopole flux tubes. Could it be that the reconnection with flux tubes of MB of the antibody catches parts of its MB and also ^{7}Li ions at it?
Was the mere oscillatory character of the magnetic field essential or does 50 Hz correspond to a cyclotron or Larmor frequency associated with the magnetic flux tubes so that resonance was involved?
For instance, could the resonance have abolished dark proton condensates at the monopole flux tubes as life forms mimicking the cyclotron spectrum of the antigen to flux tubes of external nono-monopole magnetic field? Does 50 Hz frequency belong to the ELF spectrum of the antigen?

Between 1992 and 1996, the group of Benveniste learned to transfer molecules signals, in real time, molecular signals indirectly to water or directly to cells. Cells were placed in a 37 C humidified incubator on one coil attached to the oscillator, while an agonist (or vehicle as control) was placed on another coil at room temperature. In one such exploration, it was found that molecular signals associated with a common phorbol ester could be transmitted by physical means directly to human neutrophils to modulate reactive oxygen metabolite production.

Since 1995 it has been possible to record, digitize, and replay water memory.

Some further findings of Benveniste's group

In the second article "*Biological signaling by EM means* [I127] (`https://cutt.ly/EAe67sy`) Yolene Thomas summarizes some findings of Benventiste's group represented by Benvenist in 1994. The findings were related to cell lines, isolated guinea-pig heart and in vivo in a mouse model.

(a) Heavy metal poisoning causes serious disorders, either inflammatory or strinctly immunological. For the isolated cell lines the effects of Cd at very low doses were studied. For 5-10 μM Cd a high mortality was observed. The pre-treatment with non-toxic doses of HD of Cd with dilution log 16-25 or 26-35 for several days, a significant modulation of cellular activation and growth was observed either directly, both before and after the otherwise lethal concentrations.

(b) Isolated guinea-pig or rat hearts were perfused at constant pressure in the so called Langendorff system with highly diluted vasoactive amines. ACh, histamine and water above the aorta. Variation in the coronary flow (CF) was observed. Significant effect on CF was observed. Also now the application of 50 Hz magnetic field abolished the effect.

(c) HD of silica (cytoxic for macrophages) was applied to mice in vivo. The effect on macrophages was compared for the treated and control mice. The impact on synthesis of paf-aceter, mediator of inflammation and its precursor lyspaf-aceter was studied. Significant differences were observed. Increase in synthesis of paf-aceeter was found. No effect on the synthesis of the precursor in the HD sample was detected.

All these findings conform with the water memory interpretation and TGD based model for it.

Results of other groups

Thomas describes also some findings of other groups.

(a) During the period 1990-1994 Endler studied thyroxine controlled morphogenetic regulation of amphibian Rana temperaria in the transition from 2- to 4-legged stage. Animals that were pretreated with HD of thyroxine metamorphosed more slowly. One could interpret this as immunity against the effect of actual thyroxine produced by the organism produced by false thyroxine. Same effect was achieved with electronic circuitry using recorded frequency spectrum with frequences below kHz.

(b) Luc Montagnier has studied since 2005 the effect on mycoplasma, HIV and bacteria. Certain bacteria and DNA extracted from bacterial suspension are filtered and diluted, and the HD is found do emit low frequency em waves.

(c) What is interesting is that emission stops when the medium gets in close contact with an infected individual. What could this mean?
In the TGD framework, this question can be reformulated. Suppose that the emission is analogous to biophoton emission and consists of dark (N-)photons, which have transformed to ordinary photons. Could the flux tubes of the representation of the microorganism or of its DNA in HD reconnect with the infectant flux tubes of infected invidual so that the radiation does cannot leak out anymore as ordinary photons?

(d) It is possible to detect the em radiation of HIV DNA even when the RNA of virus has disappeared from blood. Could this mean that HIV DRNA remains in the organism?

(e) Montagnier's group has also reporpted that it is possible to reconstruct DNA sequences from the EM signal produced by HD [I51, I50]. I have already discussed the findings these findings from the TGD view point in [L13, L16].

7.4.2 Water bridging dynamics of PCR chain reaction

This section discusses the article: "*Water Bridging Dynamics of Polymerase Chain Reaction in the Gauge Theory Paradigm of Quantum Fields*" of Montagnier *et al* [I52](`https://cutt.ly/yArqeJz`) from the TGD view point.

The basic goal is to understand the DNA-enzyme coupling in DNA polymerization. The polymerization process is a highly organized time-ordered sequence of steps with a precise spatial organization. Computer program is the first analog that pops up into mind. DNA polymerization and biocatalysis in general are extremely difficult to understand in a nothing-but-chemistry approach, which suggests a stochastic process in a sharp conflict with these features.

The proposal of authors in accordance with the vision of Fröhlich that quantized dipole electric fields make possible states which are known as Fröhlich condensates but can one argue bringing in quantum field theory is not enough. The coherence of living matter would naturally follow from quantum coherence in long scales but standard quantum theory fails to produce this: the value of Planck constant is simply too small.

The characteristics of the process fits nicely with the basic predictions of ZEO that quantum states are superpositions of space-time surfaces obeying not only determinism dynamics but being analogous to Bohr orbits. This together with hierarchy of Planck constants would also explain the long scale coherence and precise spatial organization.

The findings

Polymerize chain reaction (PCR) is a method of detecting the presence of DNA in a solution. The article reports findings about highly diluted viral or bacterial DNA in water. The solution contains also DNA polymerase (DNAP), which is thermostable up to 80 C and even above it albeit non-functional, This DNAP, briefly Taq, is associated with a heat tolerant strain *T. aquaticus*. *Taq* is used in PCR quite generally. The properties of *Taq* do not seem to be relevant for the findings.

(a) Some viral or bacterial DNAs in a very highly diluted agitated solution (HD) ($10^{-6} - 10^{-10}$) emit electromagnetic radiation (EMS). In the ELF range 40-2000 Hz EMS is several orders of magnitudes more intense than elsewhere. The log-log plot of power is in this range linear and there are self-similar fluctuations regarded as a signature of coherent dynamics at microscopic level.

(b) This radiation is recorded and the first dilutions show no signal. The recorded radiation pattern generates electric current creating a time dependent magnetic field in a sample containing only water and *Taq* and oligonucleotide primers.
IT is assumed that coherent nano domains representing DNA are formed in water or cellular water. The signal would be read by *Taq* polymerase in presence of primers and XTPs, X= A,T,C,G. A polymerization of the viral or bacterial DNA is observed by PCR. In the TGD based model [K119] the term "remote replication of DNA" is used. It would seem that *Taq* pairs with coherent nanoscale domains representing DNA and induce a polymerization of ordinary DNA around it.

(c) In the second experiment water is replaced with a flask of living cultured tumor cells or in vitro cell lines. DNA polymerization is observed by PCR also now. Cell growth is inhibited and cells die.

How do *Taq* and oligonucleotide primers find each other to make DNA amplification possible?

The proposal is that dipole electric fields define morphogenetic fields somehow representing DNA. These fields are treated in the gauge theory paradigm involving symmetry breaking and generation of Goldstone bosons generating long range correlations as collective modes. But can collective modes really represent detailed information about genetic codons? This

is local information in nanometer scale requiring wavelengths of order nm meaning energy of order 10^3 eV for photons and considerably above the natural energy scale of few eV for molecular transitions.

TGD based model for the findings

The TGD explanation for the findings would go as follows.

(a) The mechanism to be discussed works in both experiments. The relevant system would be the dark counterpart of DNAP (DDNAP), which would be modified so that it coules only with the DDNA transmitted to the system electromagnetically. In the first experiment DNAP would *Taq* and in the second experiment the DNAP associated with the cells of the sample.

(b) The nanoscale domains would correspond to the remotely generated DDNA as flux tubes at which codons are realized as dark nucleon triplets [L162, L111, L128]. The resonance mechanism for the pairing of DDNA and dark DNA polymerase proteins (NDNAP) paired with DNAP proteins applied to DDNA-DDNAP pair could explain the findings in both cases. Dark 3N-nucleons as a representation of dark genes/proteins accompanying ordinary genes/proteins pair via dark 3N-resonance.

(c) DDNAP would tune to the cyclotron energies and frequencies of electromagnetically transmitted DDNA by changing the radii of the dark magnetic flux tubes of DDNAP paired with DNAP. Dark 3N-resonance coupling would lead to the polymerization.
The general mechanism would be the same as in homeopathy and water memory [K50] in which MBs of water clusters tune their flux tubes to the cyclotron energy (and possibly also frequency -) spectrum of the invader molecules and in this manner form its low frequency representation.

(d) This mechanism would be the fundamental mechanism of the immune system and of bio-catalysis.

   i. U-shaped flux tubes would act as tentacles inspecting the environment for invader molecules and eliminate them by reconnection. Flux tubes would continually vary their thickness to vary the frequency scale of their siren's song and the invader molecule would be caught when a reconnection at resonance is formed.

   ii. In bio-catalysis in which reconnections between U-shaped flux tubes to a pair of flux tubes in resonance would form bridges between reactants and catalyst and the reduction of h_{eff} would shorten the flux tubes and bring them close to each other. The energy liberated would help to get over the potential energy wall so that the reaction would proceed swiftly.

(e) The magnetic flux tubes of the DNAP would change their thickness so that the cyclotron frequency spectrum of DNAP tunes to that of the DNAP of the EMS emitting system. There would be tuning of the frequency scale and perhaps also frequency ratios to some extent. DNAP would retune within few days and start to resonanate with the frequency the spectrum of the DDNA representing the electromagnetic invader.

(f) The tumor cells and in vitro cells would die because their DDNAP tunes to the DDNA of the invader and loses its tuning with the DDNA of the tumor/in vitro cells. What happens if non-tumor cells are used? If the healthy cells do not die, they could have an electromagnetic immune system preventing the modification of the cyclotron frequencies of the flux tubes of their DDNA. This immune system could explain why remote mental interactions between different organisms are very rare [K103].

7.5 DNA resonance code

The experimental findings represented in three articles by Savelev *et al* motivated this section. The articles are

- Savelev *et al*: "*On The Existence of The DNA Resonance Code and Its Possible Mechanistic Connection to The Neural Code*" [I112] (`https://cutt.ly/KAe6BOd`).

- Savelev and Myakishev-Rempel "*Possible traces of resonance signaling in the genome*" [I110] `https://cutt.ly/rArqdlA`
- Savelev *et al* How the biofield is created by DNA resonance [I111] (`https://cutt.ly/EArqzSL`).

The motivating observation is that molecular gradients and neuronal signals are too imprecise if one wants to understand processes like DNA polymerization.

Gurwitch, Miller and Webb, Burlakov, Montagnier, Meyl, etc... introduced the notion of morphogenetic field, Miller and and Webb assumed that the morphogenetic field is holographic and is generated by DNA.

Th finding of Meyl that there is no dissipation involved with the morphogenetic field, suggests that quantum coherence in long scales is involved and that this coherence might induce the coherence of biomatter.

It is argued that if the morphogenetic field is generated as a dipole field by moving charge carriers, they should have a low mass and be isolated from the cellular water. Base pairs are hydrophobic and this forces the distances of the bases to be minimal whereas the charges of the phosphate tend to make DNA as straight as possible. This leads to a proposal that DNA strands or at least parts of them act as resonators producing the morphogenetic field, which could represent the genetic code as the findings of Montangier *et al* suggest. It is proposed that the repeating parts of DNA which do not code for proteins and are usually identified as junk DNA could act as kind of quantum antennas.

7.5.1 Some findings of Burkalov and their TGD based explanation

There are several experimental findings supporting the presence of morphogenetic fields. Gurwitch and Benveniste who studied water memory belong to the pioneers of the field. Also biophotons, which are not discussed in the articles commented in this article, could closely relate to the morphogenetic field.

Burkalov studied fish embryos inside two quartz cuvettes above each other, 50 fish embryos in each cuvete in sealed quartz cuvettes. They are incubated for several days in a metal box lasting for several days. It was found that older embryos inhibit the development of younger embryos.

It was also found that a germanium mirror accelerates the development if a single cuvette is placed on it. Quartz retroreflector prism in turn represses the development and causes abnormalities. Retroreflector has the basic property that it reflects back by 180 degrees independently of the angle of incidence. Reflector reflects in this manner only if the incidence is normal.

Consider now a possible TGD based explanation for the findings of Burkalov.

(a) MB has an onion-like hierarchy of layers and would take the role of a morphogenetic field as a controller. Magnetic flux tubes would determine the morphology. Some higher layer of MB could send control commands through the genomic repeats which in turn would control the transcription and other basic processes. Alu repeats involve promoters.
The lowest level in MB hierarchy would correspond to DDNAs paired with DNAs? Same for other linear information molecules. Higher layers of MB could use genomic repeats as control knobs.

(b) The frequency scale for bioharmony changes with aging, and the first guess is that it slows down. Younger embryos have very sensitive MBs able to rapidly modify the flux tube thickness and tune to the external source. Older embryos therefore induce a modification of the frequency scale of the dark flux tubes of younger embryos. Development slows down or stops because the resonance between DDNA and DNA is lost or does not conform with the biological evolutionary age for proteins.

(c) In the experiments involving reflector, the dark photons leaking out as ordinary radiation are reflected and leave the system. In retroreflector the ordinary radiation returns back and causes the decoherence of dark N-photons: instead of dark N-photon ordinary photo is absorbed. Could retroreflection slow down the gradual scaling of frequency scale?

7.5.2 Electron and proton chains along DNA as sources of morphogenetic field?

The proposal is that electron and proton chains along the stack formed by base pairs serve as the source of the morphogenetic field. The proposed electron and proton chains are called HIDERs (Homologous If Decoded Elements, Repetitive).

(a) Morphogenetic field is identified as electromagnetic dipole field assigned to DNA. Resonant oscillations of delocalized electron and proton chains in the base stack of DNA are proposed to serve as the source of the field.

(b) Hydrophoby pushes bases together and phosphate charges make DNA maximally linear. This volume is insulated.

(c) Base pairs of the double DNA strand (A-T, C-G) oscillate between tautomeric states with frequency in the MHz-THz range. G-C base pairs have three tautomeric states whereas A-T has 2 tautomeric states. There are also aromatic rings oscillating between aromatic and non-aromatic states. They are predominantly in non-aromatic states and one can ask whether the switching forth and back between these states has some role in biocontrol.

(d) Aromatic rings are suggested to unite into a stack such that electrons are delocalized along this stack. There is evidence for pi electron chains along hydrophobic base stack associated with purine (A,G) stretches. There is also evidence that these stretches get longer during evolution and that they are conserved.
DNA charge transfer provides support for the electron chain concept. DNA acts as 1-D conductor and semiconductor and both electrons and holes act as charge carriers.

(e) The proposal is that proton chains associated with the longitudinal hydrogen bonds, which is introduced as a new notion, exist. Both electron and proton chains would reside inside a linear double-helical crystal with insulation caused by hydrophoby. This suggests that the dissipation of energy for the chains is very low as the experimental findings about the morphogenetic field require.

Genomic repeats as a source of morphogenetic field?

Genomic repeats are introduced as a further key concept.

(a) The starting point is the observation that only 1 % of the human genome corresponds to a coding genome. The non-coding is called junk DNA. 2 % of the genome is conserved and non-coding and must have some important function. The function of the rest 97 % is unknown. Introns, which are spliced from mRNA in the maturation of the final mRNA product belong to the non-coding part.

(b) Genomic repeats associated with the intronic portions of the genome must have some important function. There are many kinds of repeats. The smallest repeating structure is a single nucleotide. Also 2-,3-,4-, and 5-nucleotide repeats called microsatellites are frequent. Telomeric and centromeric repeats. Telomeric and centromeric repeaters belong to the simplest repeaters. Typical telomeric repeat is 6 bases long GGGTTA. Human telomeres are around 2500 repeats long. The proposal is that they define fundamental resonators.
Purine (A,G) repeats are identified as the most important repeats. There is evidence that the lengths of purine chains increase during evolution and that they are conserved.

(c) Alu repeats are about 300 bp long, appears in primates only, and has the highest number in the human genome. There are about 1.1 million copies of Alu. Alu is an interspersed repeater meaning that it does not repeat periodically but in a random manner. Alus are near genes and strongly bind to nucleosomes and often serve as a crystallization point for chromatin condensation. Alus coil around almost two nucleosomes. Alus are frequent and conserved in gene promoters, which suggests a possible regulatory role.
Alus code for an untranslated RNA so that they decompose to codons. The variations with an Alu sequence in a gene promoter correlate with the transcriptional activity of the gene. Alus are normally silent but are activated during cellular stress. The methylation pattern for Alus vary and this affects the RNA expression. It is not clear whether methylation affects the possible control role otherwise.

Alus are possessed only by primates and the proposal is that Alu makes us humans. Alus would receive the wave information of the morphogenetic field and convert it to bioinformation by controlling gene expression.

Some objections as a way to end up with the TGD based view

The work of Fröhlich [J24, I60, I71] [J24] has inspired the idea about the fundamental role of electric dipoles in biology (`https://cutt.ly/3AmIKQi`). Electric dipoles would give rise to Fröhlic condensates explain the coherence of biosystems which remains a mystery in standard quantum physics. No direct evidence for them have been found.

There are some objections against the fundamental role of electric dipoles and dipole radiation.

(a) In contrast to magnetic moments, the electric dipole moments of elementary particles vanish to extreme accuracy so that electric dipoles should be associated with composite states such as atoms and molecules which are however heavy so that morphogenetic field would be generated by mass motion of DNA and require considerable metabolic energy feed.

(b) The time scale of control dynamics should be slow as compared to the time scale of electric dipoles. For instance, DNA transcription involves time scale of order .1 second assignable to alpha rhythm. Cyclotron frequencies in the magnetic field of order Earth's magnetic field correspond to this time scale. It would seem that cyclotron radiation relates more naturally to the notion of a morphogenetic field. Here however the extremely small energy is the problem and led to the $h_{eff} = n \times h_0$, which later emerged from the number theoretic vision of TGD.

(c) One can however consider a different realization of the electric dipole idea. Electrets populate biology, which suggests that nano-scopic and microscopic structures formed from dipole-like entities are crucial. Electret property implies a coupling between acoustic and electromagnetic degrees of freedom and is very probably crucial for hearing. Basically acoustic oscillation corresponds in TGD framework to oscillations of flux tubes connecting particles and if for charged particles forming a dipole this coupling becomes possible.
For instance, in the TGD vision cell membrane can be regarded as a (actually a generalized) Josephson junction and if dark matter hierarchy is accepted, Josephson frequency is given by ZeV/h_{eff} and is very small for large enough h_{eff}. One obtains the desired slow time scale and energy scale just above thermal energy. Also DNA and microtubules have longitudinal electric fields.
Comorosan effect [I105, I29] means that there are 5 second and 10 second periods associated with molecules. They are not understood but the interpretation in terms of Josephson frequency of a polarized molecular bond is attractive [K116].

Magnetic dipoles at elementary particle and ion level and macroscopic electric dipolar structures like cell membrane, DNA strand and microtubule would play a fundamental role in the TGD inspired biology and the hierarchy of Planck constants would make the interaction between them possible.

It is quite possible that genuine quantum coherence is realized only at the level of MB and the coherence of biomatter is induced by MB and is not genuine quantum coherence. This would solve the problem due to the fact that the standard value of Planck constant does not allow quantum coherence in long scales.

TGD view about the role of genomic repeats

The TGD view about how dark information molecules DDNA, DRNA, DtRNA, DAA couple with each other and with ordinary information molecules has been discussed. One would have a slaving hierarchy with levels labelled by h_{eff} controlling each other by energy resonance coupling using dark variants of genes as dark 3N-photons analogous to BE condensates.

They would have energies in biophoton range (visible and UV), very probably also in IR range since metabolic energy quantum around .5 eV must be included, and possibly also in microwave photon range and the energy scale of about .2 eV defined by membrane potential.

These transitions would control chemical reactions, induce conformational changes of biomolecules, etc...

The motor actions of MB would naturally induce conformational changes of molecules and also larger objects. The geometric degrees of MB would be behind morphogenesis. Biological growth could quite concretely correspond to the growth of MB meaning increase of h_{eff} of the highest level present in the hierarchy.

How does this view relate to the proposal that repeating DNA sequences serve as antennas, resonators and circuits?

(a) HIDERs could be present. Electron and proton spins could be important and DDNA could induce spin magnetization in turn generating magnetic fields inside DNA inducing currents in aromatic rings.
An interesting question is whether these currents create a magnetization summing up to zero with spin magnetization: one would have perfect diamagnet. Does this mean electronic super-conductivity inside DNA. I have indeed proposed this earlier. The idea that HIDErs serve as electric dipole oscillators does not however look attractive.

(b) Repeating DNA sequences, in particular Alus, must have an important role in communication to and control by higher layers of MB. The presence of higher layers of MB conforms with the fact that Alus are not present in non-primates. Also the connection with epigenesis is suggestive.
Could Alus serve as control knobs or could they send sensory information to MB and therefore play the same role as cell membrane? Could electric dipolar structure play quite generally the role as generators of sensory input and could MB respond by sending cyclotron radiation as a response?

Consider now in more detail the possible role of Alus in the TGD framework.

(a) DNA and also Alus carry a longitudinal electric field making it a long dipole. Also codons act as dipoles with dipole moment depending on the codon. Could the idea that the entire Alu acts as a long Josephson junction make sense? This would not allow information transfer using genetic code.

(b) Could codons act as Josephson junctions with Josephson energy $Ze\Delta V$ depending on the codon. Could these Josephson junctions form a 3N-Josephson junction generating coherently dark Josephson 3N-photons as sensory input to MB. The modulation of Josephson current would code for sensory input. This would induce a sequence of resonance pulses at the layer of NB producing a feed back sending sensory data to MB, which could induce control actions, such as DNA transcription.

(c) From the length of Alu of order $L \sim 10^{-7}$ meters (300 bps/100 codons) the estimate for the Coulomb energy of electro associated with the entire length is about Z^2e^2/L, for opposite charges at the ends of Alu if it has charges $\pm Z$ at its ends. This corresponds to energy of order few eV and is in the biophoton energy range. This would conform with the energy scale of dark cyclotron photons.
DDNA could serve as the nearest boss of DNA. Also higher levels in the hierarchy of MB layers would realize dark genetic code if the icosa tetrahedral tessellation at H^3 defines a universal realization of genetic code.
Since genetic code would be used in the communications, the sensory signal would go to MB with dark codons similar to Alu.

(d) Somehow a control response should be generated as a response. Suppose that Alus, and perhaps entire DNA, is magnetized. This could be made possible by possible spin polarization of electron chains and/or rotating currents in aromatic rings. Could MB realize control commands by using dark cyclotron 3N-photons absorbed by Alu?
A universal standard control knob property Alu, or of a repeating unit in general, would allow minimal complexity of the nucleotide content. The flux tube connections would allow targeted control commands such as activation of propometers of gene transcription. Note that Alus also code for RNAs having some function but are most of the time silent and are used only in emergency situations (cellular stress).

There is an interesting experimental finding, which could be seen as a support for the presence of dark UV photons at magnetic flux tubes.

(a) The irradiation of cultured mouse fibroblasts at low power millimeter waves at certain wavelengths protects DNA against damaging effects of UV radiations. What comes to mind is the shielding of the biosphere by the magnetic field of Earth: the cosmic radiation sticks to the flux tubes.

(b) Could UV radiation be caught by MB flux tubes with large h_{eff} and transform to dark radiation with much longer wavelength? Could some fraction of the millimeter irradiation transform to dark photons with UV energies? Could the flux tubes of MB tune to millimeter radiation so that they become sensitive to it? Could a BE condensate of photons with energy in UV range emerge and serve as induce the BE condensation of ordinary UV photons so that they would be defused?

7.5.3 Is DNA magnetic?

The article also discusses the possible magnetism associated with DNA. DNA strands seem to behave like pairs of magnets. Ring currents could cause the magnetization but their presence requires an external magnetic field inducing magnetization.

The problem is that in an external magnetic field DNA becomes orthogonal to it and no magnetization is generated. The source of the external magnetic field must stay parallel to DNA which is impossible in standard view about DNA.

The proposal is that the ring currents are induced by some enzyme in the presence of ATP. There is also the question whether the magnetization is static or oscillatory.

The TGD view of DNA as a magnetic system would be following.

(a) DNA strands seem to behave like pairs of magnets. Ring currents could generate magnetization. A strong enough magnetic field parallel to strands is needed to induce the magnetization. The DDNA associated with dark monopole flux tubes (no current needed to create the magnetic field), necessarily parallel to DNA, would induce the magnetization of DNA. Connection with DDNA in icosa tetrahedral picture emerges.

(b) How DDNA could couple with the DNA magnetization? The magnetic field is strong and from flux quantization it would be of order 100 Teslas. Cyclotron frequency scales are totally different. $f_c(e) \sim 3 \times 10^{11}$ Hz. For $h_{eff} = h$, the cyclotron energy is of order 3 meV and below thermal energy. Could DNA interior be thermally insulated from the environment. $h_{eff} = nh$, $n \sim 10^3$ would give a few eV scale for the cyclotron frequencies.

(c) Large h_{eff} cyclotron 3N-photon transforms to a single ordinary photon with much larger energy and is absorbed in ordinary cyclotron transition by DNA magnet and induces motor action of DNA.

(d) Control communication from higher layers of MB could take place via repeats whereas for coding regions only the lowest layers of MB, such as DDNA would be involved. Alu regions as control knobs in gene expression controlled by MB. All layers of MB could realize dark genetic code but in a different scale proportional to h_{eff}.

7.5.4 Dark $3N$-resonances and quantum teleportation

Could the communication by $3N$-resonances relate to quantum teleportation? This is possible but requires modifying the previous assumption that the states of dark proton sequences are fixed and correspond to those of ordinary genes with which they are in energy resonance when communicating. One must loosen this assumption.

(a) Give up the assumption that cyclotron states of the dark $3N$-proton are always the same and correspond to a gene. Assume that in some time scale, perhaps of order cyclotron time, dark proton sequences representing genes decay to the ground state configuration defining an analog of ferromagnet.

(b) Assume that some excited dark $3N$-photon states, dark geme states, can be in energy resonance with ordinary genes, most naturally the nearest one if dark DNA strands are parallel to an ordinary DNA strand. Even this assumption might be unnecessarily strong. Dark $3N$-proton would interact with its ordinary counterpart by energy resonance only when it corresponds to the dark variant of the gene.

Same applies to dark genes in general. Only identical dark genes can have resonance interaction. This applies also to the level of other fundamental biomolecules RNA,tRNA and amino acids.

(c) What is this interaction in its simplest form? Suppose dark $3N$- proton is in an excited state and thus defines a dark gene. Suppose that it decays by SFR to the ground state (magnetization) by emitting dark $3N$-photon. If this $3N$ photon is absorbed in SFR by a dark proton sequence originally in ferromagnetic state, it excites by resonance the same gene. The transfer of entanglement takes place.
This is nothing but quantum teleportation but without Alice, doing Bell measurements and sending the resulting bit sequences to Bob , performing the reversals of Bell measurements to rebuild the entanglement.

This suggests a modification of the earlier picture of the relation between dark and chemical genetic code and the function of dark genetic code.

(a) Dark DNA (DDNA) strand is dynamical and has the ordinary DNA strand associated with it and dark gene state can be in resonant interaction with ordinary gene only when it corresponds to the ordinary gene. This applies also to DRNA, DtRNA and DAA (AA is for amino acids).
This would allow DDNA, DRNA, DtRNA and DAA to perform all kinds of information processing such as TQC by applying dark-dark resonance in quantum communications. The control of fundamental biomolecules by their dark counterparts by energy resonance would be only one particular function.

(b) One can also allow superpositions of the dark genes representing 6-qubit units. A generalization of quantum computation so that it would use 6-qubits units instead of a single qubit as a unit, is highly suggestive.

(c) Genetic code code could be interpreted as an error code in which dark proteins correspond to logical 6-qubits and the DNA codons coding for the protein correspond to the physical qubits associated with the logical qubit.

(d) The teleportation mechanism could make possible remote replication and remote transcription of DNA by sending the information about ordinary DNA strand to corresponding dark DNA strand by energy resonance. After that, the information would be teleported to a DNA strand in a ferromagnetic ground state at the receiver. After this, ordinary replication or transcription, which would also use the resonance mechanism, would take place.

Could there be a connection with bioharmony as a model of harmony providing also a model of genetic code [L24, **?**, L128]?

(a) In the icosa-tetrahedral model, the orbit of the face of icosahedron under the group Z_6, Z_4, $Z_{2,rot}$ or $Z_{2,refl}$ would correspond to single physical 6-qubit represented as dark protein. This representation of the logical qubit would be geometric: orbit rather than sub-space of a state space. One could however assign to this kind of orbit a state space as wave functions defined at the orbit. This representation of Z_6, Z_4, $Z_{2,rot}$ or $Z_{2,refl}$ would correspond to a set of 6-qubits, which replaces a single 6-qubit.

(b) The TGD proposal for TQC [L155, L161] is that the irreps of Galois groups could replace qubits as analogs of anyons. Could these orbits correspond to irreps of Galois groups or their subgroups, say isotropy groups of roots?
Another option is the finite subgroups G of quaternionic automorphisms, whose MacKay graphs, characterizing the tensor products of irreps of G with the canonical 2-D irrep, give rise to extended Dynkin diagrams [L153]. What puts bells ringing is that Z_6, Z_4, $Z_{2,rot}$ or $Z_{2,refl}$ are subgroups of the icosahedral group, which corresponds to the Dynkin diagram of E_8.
These alternatives need not be mutually exclusive. I have proposed that Galois groups could act as the Weyl groups of extended ADE Dynkin diagrams given by McKay graphs of finite subgroups of $SU(2)$ interpreted as the covering group for the automorphism group of octonions. The Galois group and its subgroup would define a cognitive representation for the subgroup of the covering group of quaternion automorphisms.

The communications by the modulation of frequency scale 3N-Josephson frequency scale are still possible.

(a) The 3N-resonance occurs when the receiver 3N-proton is in ferromagnetic ground state and the 3N-Josephson frequency corresponds to 3N-cyclotron frequency. If the time scale for the return to the ferromagnetic state is considerably shorter than the time scale of modulations, a sequence of resonance pulses results and codes for the frequency modulation as an analog of nerve pulse pattern. This communication can lead to communication if the ordinary gene accompanying the excited dark gene is in energy resonance with it.

(b) It must be noticed that the communications by dark $3N$-resonances are not possible in standard physics and are made possible only by Galois confinement and h_{eff} hierarchy. In standard physics only single photon fermion interactions would be present and would be relatively weak. In quantum computation, this suggests the possibility of quantum coherent manipulation of N-qubit states by dark N-photons instead of qubit-wise manipulations prone to errors and destroying the coherence. There is evidence for N-photon states with these properties [D2, D2]: for the TGD inspired comments see [L134].

Chapter 8

The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?

8.1 Introduction

During almost two decades I have returned repeatedly to the fascinating but unfortunately unrecognized work of Roschin and Godin about rotating magnetic systems [H15]. The motivation has been that the strange effects such as change of weight proportional to the rotation velocity of rollers taking place above 3.3 Hz rotation frequency and rapid acceleration above 9.2 Hz up to frequency 10 Hz could provide the clues for developing a general vision about morphogenesis of magnetic body, whose flux quanta carry Bose-Einstein condensates of dark charged ions with given mass and charge if the hypothesis $h_{eff} = h_{gr}$ holds true.

At this time my friend Samuli Pentikäinen re-stimulated my interest by sending some links to the files describing the patent of Godin and Roschin. We had a nice brain storming about the system, which eventually inspired the preparation of this article to clarify my recent views about the system. One can find from web a brief description of the rotating magnetic system (see `http://tinyurl.com/jceswe4`) and the english translation of the patent (see `http://tinyurl.com/hb6bfla`). I am grateful for Samuli for these links and interesting discussions. In the sequel I summarize the most recent views. It is earlier view but with some important new ideas added.

The best way to proceed is to identify the crucial questions. In the following I list these questions. I have proposed several alternative answers to these questions and the goal in the following is to fix the answers as uniquely as possible.

Consider first questions related to the formation of magnetic walls.

(a) How could the observed magnetic walls be formed? So called Chladni mechanism making visible the nodal lines of oscillations of a vibrating square plate by putting thin powder on the plate so that the powder ends up to the nodal lines is neatly described in the article of Geesink [I76] (see `http://tinyurl.com/j9rsyqd`).
Could a generalization of Chladni mechanism [L48] explain the formation of magnetic walls as an analog of morphogenesis at the level of dark matter?
Neither standing waves nor circularly polarized waves are possible as single sheeted structures. Propagating circularly polarized waves with net spin assignable to pairs of "topological light rays" ("massless extremals", MEs) and standing waves assignable to the pairs of these pairs would have cylindrical nodal surfaces, which in the simplest situation would be stationary.

Charged flux tubes would drift to these stationary 2-D magnetic walls where electric field vanishes. Ordinary matter would in turn condense around magnetic body as assumed in TGD inspired quantum biology so that dark morphogenesis would induced ordinary morphogenesis.

(b) Could the generation of magnetic walls be a quantum phase transition taking place at quantum criticality? Could generalized Chladni effect lead to the drift of the charged flux tubes to the nodal surfaces defining the magnetic walls? What could serve as the seed of this phase transition? Since the signs of the momentum gain and acceleration at the roller correlate with the rotation direction, the rotation of roller and its magnetic body could serve as the seed.

What can one say about magnetic flux tubes and walls?

(a) Could the flux tubes from rollers go through wormhole contacts to a larger space-time sheet containing return flux tubes from rollers drifting to the magnetic walls?

(b) The magnetic walls have magnetic field in the same direction as the magnetic field of rollers in the same region so that the interpretation as return flux makes sense. The patent does not tell whether the magnetizations are parallel or not. If the magnetizations are opposite as stability considerations would suggest, the return flux for the magnetic flux from stator would not form magnetic walls. If so, the rotation of the rollers should be essential for the formation of the magnetic walls and would serve as a seed of this phase transition.

Where does the dark matter at magnetic walls come from?

(a) The charge density $n = \omega B/e$ ($c = 1$) at roller changing sign with the direction of rotation would be naturally due to the transfer of electrons between rollers and magnetic body and one can interpreted the distance between magnetic walls as cyclotron frequency associated with electrons in the magnetic field $B = .3$ Tesla. The density of electrons (holes) is extremely small and cannot explain weight change and spontaneous acceleration. Neither can the electrons from rollers correspond to the dark matter at the flux tubes and magnetic walls.

(b) Could the charged particles already exist at the flux tubes leaving the roller and at the return flux tubes and drift to the flux walls? Does $h_{gr} = h_{eff} = n \times h$ hypothesis [L39] [K77, **?**] guaranteeing that given flux quantum contains only charged particles of given mass hold true? This allows in principle many kinds of charged particles. In TGD inspired quantum biology many ions indeed appear and dark phases.
Note: The notion of gravitational Planck constant h_{gr} introduced originally by Nottale deserves a comment. It is defined as $\hbar_{gr} = GMm/v_0$, where M could in the recent case be $M_D \sim 10^{-4}M_E$ for flux tubes of $B_{end} = 2B_E/5$ and Earth's mass M_E for the flux tubes of galactic magnetic field $B_{gal} \sim 1$ nT mediating the gravitational interaction of Earth. By assuming that the parameter $r = v_0/v_{rot,M}$ for Earth has the same value as for Sun. The value of r is fixed by $v_0 \simeq 2^{-11}$ for Sun from the Bohr orbit model for the orbits of inner planets originally proposed by Nottale [E1] [K94] and v_{rot} is the rotational velocity of Sun.

(c) Is there a connection with biology? The spontaneous acceleration occurs in the range 9.2-10 Hz. This range corresponds to alpha band in EEG. In TGD inspired biology the endogenous magnetic field $B_{end} = .2$ Gauss (maybe Earth's magnetic field inside organism or at some distance from the surface of Earth) and magnetic field with strength range around the average value $B_{gal} \simeq 1$ nT of galactic magnetic field are important.
Are these magnetic fields involved and could they serve as sources of dark charged particles? The flux tubes mediating the gravitational interaction of Earth could be at the flux tubes which are originally those of galactic magnetic field and would satisfy the condition $h_{eff} = h_{gr}$ guaranteeing that dark cyclotron photons have the energy spectrum of bio-photons as a universal energy spectrum in visible-UV range in which also the transition energies of bio-molecules are.
Could the rotation of the rollers inducing the rotation of flux tubes increase the probability of reconnections with the flux tubes of $B_{end} = .2$ Gauss and $G_{gal} \sim 1$ nT mediating Earth's gravitational interaction? Could the charged particle condensates from these

flux tubes flow to the flux tubes of rollers or to the magnetic walls? The values of critical frequencies indeed suggests that $B_{end} = .2$ Gauss and $G_{gal} \sim 1$ nT could have an important role.

A further group of questions relates to the mechanism of effective weight change and spontaneous acceleration.

(a) Where do the momentum and angular momentum causing effective weight change and spontaneous acceleration come from? At the magnetic walls Bose-Einstein condensates could be generated and give rise to either super-conductivity or cyclotron Bose-Einstein condensates as generalized spontaneous magnetization or both. This demands that the charged particles at the flux quanta form Bose-Einstein condensates so that they have parallel longitudinal momenta p_L and/or spin and cyclotron quantum numbers n, m. This requires that the spins or momenta of charged particle have same value. Conservation laws require that the increments of quantum numbers in the phase transition go to the roller and would cause weight change in the case of super-conductivity and spontaneous acceleration in the case of cyclotron Bose-Einstein condensate associated with angular momentum.

(b) How can one understand the correlation between the sign of the weight change and direction of rotation? Could parity breaking - perhaps made possible by large h_{eff} variants of weak gauge bosons - make this possible? What comes in mind is the winding of DNA and twisting of magnetic flux tubes in Sun. Are the flux tubes leaving from rollers transferred to space-time sheets carrying magnetic walls at fixed positions of wormhole contacts? If so the flux tubes emanating from rotating rollers would twist so that they would become chiral. Could this chirality force the dark photons to propagate with higher probability to another direction of the flux tube and induce the apparent weight change by momentum feed due to the transformation of dark photons to ordinary ones followed by absorpion?

The observation of visible and yellow light could be interpreted as a transformation of dark photons to ordinary photons with energies in visible and UV range.

(c) Where comes the rotational energy of the roller during spontaneous acceleration and the energy associated with the dark photons inducing weight change?

The simplest explanation is that the formation of magnetic walls liberates energy and this energy goes to the magnetic system in the way described.

Charged particles could also form kind of dark nuclei at the flux tubes and the dark nuclear energy which is assumed to scale down by $1/n$ in TGD based model of cold fusion, liberates energy. These dark nuclei could transform to ordinary nuclei when interacting with charged systems and would liberate practically all ordinary nuclear binding energy. Could the observed corrosion of copper foils around the rotor and stator could be due to this transformation?

An further possibility could be remote metabolism in which system sends negative energy signal to a system able to receive it. This mechanism might be central mechanism in quantum biology based on ZEO associated with metabolism, motor actions involving signals to geometric past (explaining Libet's classical finding that neural activity precedes conscious decision), and with memory as communications with geometric past.

What is the proper quantum description for the change of weight and acceleration?

(a) Could the most elegant option rely on a discrete state function reduction sequence for macroscopic quantum states of the tensor product system formed by rollers and the flux tubes leaving them and the return flux tubes at magnetic walls (possibly fused to form magnetic walls)? The states of this system would be entangled pair with vanishing total angular momentum and momentum and thee quantum numbers would be opposite for every state in the superposition. Could these reductions could be regarded as quantum phase transitions? The quantum numbers increments would go to the dark photon many-particle states and dark photons would be absorbed by the rotor and give rise to apparent weight change or spontaneous acceleration. Rollers could be treated as quantal rigid bodies with cylindrical symmetry in the simplest model.

(b) Could one treat the entire flux tubes coming from the rollers going to larger space-time sheets containing the magnetic walls via wormhole contacts as particle like quantum

system and treat the transitions as phase transition between the states of these systems rather than at single particle level?

There is also evidence that the presence of light source below massive object affects its weight by about .1 per cent. This effect could be explained along the same lines. Zero Energy Ontology and the proposed mechanism remote metabolism at the level of dark matter is however needed and this would force to modify dramatically the views about basic interactions at the level of dark matter.

An increase of weight $\Delta g/g \simeq 2 \times 10^{-4}$ is observed for electrets [E11]: this number has appeared in TGD already earlier [**?**, K77] and in TGD framework could have interpretatation in terms of dark matter layer with mass $M^D \simeq 2 \times 10^{-4} M_E$ at distance of Moon. Amusingly, this change of weight happens to consistent with the "weight of soul" claimed to be 21 g.

8.2 The construction of the magnetic system and findings

The rotating magnetic system is a modification of the homopolar generator (see `http://tinyurl.com/cn94kbk`) invented by Faraday. Homopolar generator is a metal disk rotating in magnetic field orthogonal to it. A radial electric field $E = -v \times B$ is generated in equilibrium and implies that current follows in the wire, whose end is attached to the boundary of rotating disk. The current can run through a load and the system provides electric power. One must of course feed power to the system to keep disk in rotation.

The system replaces the rotating disk with rollers, which are cylinders rolling along the surface of stator without slipping so that the rotation is transformed to rolling motion: car is familiar example of this. The slipping is prevented by a magnetic cog wheel obtained by inserting orthogonal linear magnets to the stator and rollers.

The patent application represents the role as electric generator as basic function of the system but the reported effects suggest that it can indeed transform to a generator in the sense that the system begins to accelerate at rotation frequency near 10 Hz and produces power. Also a change of weight is observed. These effects make the system a possible example of new physics effects.

8.2.1 Construction

The rotating part consists of rollers, which are cylinders rotating along the stator ring. The radius of the whole system called converter was about .5 m. Stator and rollers were made of the same magnetic material consisting of rare earth metals. The value of the residual induction was $B = .85$ Tesla with coercive force $H_c \sim 600$ kA/m and with density of magnetic energy $W \sim 150$ kJ/m^3. Magnets were constructed using electric induction. Inserts with radial magnetization were added to both stators and rollers (see Fig. 1 at `http://tinyurl.com/hb6bfla`) in order to build magnetic cog wheel. Inserts had $B = 1.2$ Tesla, $H_c \sim 1000$ kA/m, and $W \sim 360$ kJ/m^3).

Stator and rollers were wrapped with copper foild of thickness .8 mm having direct contact eith magnets at stator and rollers. Between the surfaces of the stator and roller there was an air gap of thickness $\delta \sim 1$ mm.

The magnetizations of both stator and rollers were along the axis of the cylinder but it remained unclear to me whether they were parallel or antiparallel. Antiparallel magnetization would be favoured by the minimization of magnetic interaction energy $E = -\mu \cdot B$ in dipole magnetic field with return flux in direction opposite to magnetization.

The diameter of the stator 1 and the rotor 2 (see Fig. 2 at `http://tinyurl.com/hb6bfla`) was selected so that the ratio of the stator diameter D and the roller diameter d was integer multiple of 4: $D/d = 4 \times n$. This is reported to be a condition for spatial quantization and achieve resonant mode between the working elements of the device body. If no slippage occurs in the rotation, the velocity v of the roller rotation at its surface is same as the rotation velocity V of roller along stator surface: $v = V$ implies $\omega d = \Omega D$ giving $\omega/\Omega = D/d$. The condition

$D/d = m$ guarantees that single full rotation along stator corresponds to m full rotations for roller and this is very natural condition if one considers em waves possibly associated with the motion. Why one must have $m = 4 \times n$ fullrotations per one full rotation along stator is not quite clear. For $n = 1$ this would mean that a rotation of $\pi/2$ along stator means 2π rotation for roller.

The total weight of the system was about 350 kg.

Ring electrode was attached to the periphery of the device (along the ring just outside the roles) connected to high voltage source with stator as positive pole and the outer boundary of roller ring as negative pole. The voltage had typically a limiting value of 20 kV. The use of the radial electric field was reported to stabilize the mode in which the system produces energy.

8.2.2 Observations

Several strange findings are reported. The system was set in motion by using an electric motor and the rotation frequency was gradually increased by increasing the power feed to the system.

The sign of the weight change depends on the direction of rotation. The following describes the situation for which weight change occurs.

(a) At rotation frequency of 3.3 Hz the weight of the system started to change with the sign of the change depending on the direction of rotation. Fig. 4 at `http://tinyurl.com/hb6bfla` shows the relationship between rotation frequency f (rpm as unit) and the weight loss $|\Delta G|$ in per cents.

(b) At rotation frequency 9.2 Hz and the system started to spontaneously accelerate. At this moment the system was coupled to a fist load of 1 kW. At the same time weight loss slowed down to and increased from 30 per cent to 35 per cent during in the range 9.2 Hz-10 Hz. An unpleasant whistling sound was heard. Fig. 5 at `http://tinyurl.com/hb6bfla` shows also the time development during the period $9.2 - 10$ Hz

(c) At $f = 10$ Hz frequency the total load was $P = 7$ kW. I am not sure whether it was kept in that value during the next period when the rotating frequency was reduced or whether it was reduced gradually. At these values of f and P a high voltage of 20 kV was applied with positive pole at stator. The rotation frequency dropped to 3.3 Hz without any change in weight change ΔG. After than also weight change went to zero. The load of 7 kW caused the fall down of the system. Did the magnetic cogwheel start to slip or what happened?

The behavior of weight change suggests that there was a feed of both momentum (and energy) to the system in the interval 3.3 Hz-9.2 Hz during which $|\Delta G|$ increased. In the interval 9.2 Hz-10 Hz there was energy feed but no momentum feed. For the load of 7 kW the feed of energy was reduced and the rotation frequency started to reduce but $|\Delta G|$ remained the same. At $f = 3.3$ Hz the momentum feed began to reduce and weight change reduced gradually to zero.

This suggests that three critical frequencies were present. 3.3 Hz, 9.2 Hz and 10 Hz. Above 3.3 Hz the presence of momentum feed is suggestive. Perhaps by a beam of massless particles with downwards direction to cause weight change. In 9.2 Hz-10 Hz range also the presence of beams of massless particles in both directions parallel to rotors was present causing energy feed but no momentum feed. Above 10 Hz and with load of 7 kW the standing wave energy feed stopped and only the momentum feed remained. It did not go to zero at 3.3 Hz but went to zero smoothly so that the effect was not reversible. This might be due to the presence of load.

Also other effects were observed.

(a) In dark room a coronal discharge was observed around the convertor in form of blue-pink glow and characteristic smell of ozone. Cloud ionization region covering stator and rotor respectively and a toroidal shape. Visible wave pattern - increased luminescence intensity zones of white and yellow light located along the height of the roller was observed. The sound characterizing corona arc was not audible.

(b) There was also a visible erosion damage to the copper surfaces of the stator and rollers.

(c) Also vertical magnetic walls with field strength of .05 Tesla and with layer thickness of 5-8 cm and distance of .5-0.6 m were observed around the unit. If I understood the english translation correctly, the direction of magnetic field co-incided with that for the magnetic field created by rollers so that the flux can be interpreted as a return flux from rollers. The pattern was observed also outside the laboratory.
Magnetic walls begin to appear at rotation frequency 3.3 Hz with the intensity of the magnetic field and temperature drop increasing linearly with the rotation frequency. Maximal temperature drop from 22 °C to 6-8 °C inside the magnetic walls is reported.

8.3 Quantum model

The classical model summarized in Appendix does not work. Dark matter realized as a hierarchy of $h_{eff}/h = n$ phases assignable to magnetic body of the system at quantum criticality is the basic idea. The general explanation for the spontaneous acceleration and weight change is transfer of momentum and energy between the magnetic system and its magnetic body.

8.3.1 Some guidelines

What can one learn from homopolar generator?

The patent talks about a modification of homopolar generator (see `http://tinyurl.com/cn94kbk`), which is basically a rotating metal disk in magnetic field orthogonal to the disk. The modification is that the rotating metal disk is replaced by magnetic cylinders rolling along the boundary of the stator ring.

(a) As already Faraday observed, a direct current is generated to the wire attached to the boundary of the disk. This suggests that a radial electric field is generated to the disk and in equilibrium the force to rotating charge vanishes so that one has $F = q(E + v \times B) = 0$: this gives $E = -v \times B$. This effect does *not* follow from Faradays law stating that a system moving linearly in magnetic field observes also electric field $E = v \times B$.

(b) What is strange that the electric field has source: a constant charge density whose sign depends on the direction of rotation. Charge separation would occur: depending on the direction of rotation some amount of positive or negative charge leaves the system and goes somewhere. Also charge of opposite sign could enter from outside.
What is important to notice is that parity breaking in macroscopic length scale takes place. Standard model predicts large parity breaking effects only in intermediate boson length scales. Could large $h_{eff}/h = n$ phases for which weak bosons have Compton length scaled up by n proposed in the model of cold fusion [L31] be involved. The situation would be same as in biology, where chirality selection having no generally accepted explanation in standard model framework takes place.

(c) An analogous charge separation occurs in the Pollack effect [L27] occurring when water bounded by gel phase is irradiated with IR light [L27]. Charge separation occurs and so called exclusion zone of thickness up to 100 micrometers becomes negatively charged: the negatively charged region has strange properties and Pollack calls it exclusion zone. The effective stoichiometry of water changes 0 to $H_{1.5}O$ as one proton per probably hydrogen bonded pair of water molecule goes somewhere. In the case of Pollack effect TGD explanation is that positively charged protons go to magnetic flux tubes as dark protons making possible macroscopic quantum effects crucial for life.
Charge separation is central in biology. Cell is negatively charged and also DNA has negative charge of one unit per nucleotide and the proposal is that dark protons are located along flux tube parallel to DNA and provide a realization of genetic code. The chemical realization would be only a shadow of this realization at the level of dark nuclear physics: dark protons would indeed form analogs of nuclei and dark weak interactions would transform part of dark protons to dark neutrons [L37] (`http://tinyurl.com/jgfjlbe`).

(d) What is interesting is that the so called Tewari generator, which is essentially homopolar generator is claimed to produce also over unity effects and in India there is a large scale trial using Tewari space-energy generators as new power source. I have discussed already earlier a model for Tewari generator [L33] (see `http://tinyurl.com/z5zm8aa`).

A possible connection with biology

The range $9.2-10$ Hz for the rotation frequency f_0 corresponds to alpha band in EEG and to the fundamental bio-rhythm. 10 Hz frequency corresponds also to the secondary p-adic time scale assignable to electron.

The condition $f = 4n \times f_0$ for the rotation frequency of roller implied by $D/d = 4 \times n$ found to give rise to a resonance corresponds to harmonics of this frequency. For $n = 1$ (only 4 rollers) one has frequencies $40, 80, ..$ Hz. 40 Hz is the thalamocortical resonance frequency believe to be crucial correlate of conscious experience. 80 Hz corresponds to a resonance frequency in REG, the EEG counterpart for retina. Fig 1. at `http://tinyurl.com/hb6bfla` would suggest $D/d = 8$ or $D/d = 12$ so that the roller frequency would be 80 Hz or 120 Hz for $f_0 = 10$ Hz.

Maybe also the frequency 3.3 Hz at which the weight change begins could be also seen as an analog of EEG frequency. EEG indeed has a resonance frequency around 3 Hz.

In TGD inspired model of quantum biology the cyclotron frequencies of various biologically important ion in an endogenous magnetic field field $B_{end} = .2$ Gauss (2/5 of the Earth's magnetic field (possibly identifiable as the value of Earth's magnetic field inside organism or farther away from the surface of Earth) are in EEG range and crucial in explaining the effects of ELF em fields on vertebrate brain [J8] [K40] are crucial. Interestingly, for iron ion the cyclotron frequency is near 10 Hz (as also for phosphate ion which might have fundamental implications in living matter [L38]). Could it be that iron ions Fe^{-2}, which are bosons, end up to the magnetic body of the system and form a Bose-Einstein condensate?

This supports the idea about primitive plasmoid like living system having magnetic body and the analog of EEG realized in terms of dark photons. Magnetic body would used "biological body" as sensory receptor and motor instrument and the generation of rotation might be interpreted as a kind of motor action.

What could quantum criticality correspond to?

Quantum criticality is the prerequisite for generation of dark $h_{eff} = n \times h$ phases possibly satisfying also the condition $h_{eff} = h_{gr}$. Quantum criticality corresponds to some kind of instability. The motivation for the hypothesis is that at quantum criticality long range correlations and fluctuations are present and large h_{eff} would give rise to them. How could quantum criticality be realized in the system considered?

Quantum criticality certainly corresponds to the frequency intervals beginning at values 3.3 Hz and 9.2 Hz and continuing to about 10 Hz. At 3.3 Hz the formation of magnetic walls would begin and magnetic field would increase linearly as the function of frequency also the effective weigh change would start to develop. The interpretation would be that B-E condensates analogous of super-conducting phases start to form at flux tubes drifting to the magnetic walls and the momentum liberated in the process goes to the magnetic flux tubes as dark photons transformed to ordinary photons. Actually one would have sequence of quantum phase transitions feeding momentum at discrete steps to the magnetic body and inducing effective change of weight. At 9.2 Hz also Bose-Einstein condensation in angular momentum degrees would occur and also a feed of angular momentum would start to occur in the same manner and lead to acceleration.

Formation of magnetic walls as a quantum phase transition

How the observed magnetic walls could be formed? Could a generalization of Chladni mechanism explain this as an analog of morphogenesis at the level of dark matter?

(a) Propagating circularly polarized waves with net spin assignable to pairs of MEs and standing waves assignable pairs of these pairs would have cylindrical nodal surfaces, which in the simplest situation would be stationary. Charged flux tubes would drift to these stationary 2-D magnetic walls.

(b) At the magnetic walls Bose-Einstein condensates would be generated and give rise to either super-conductivity or cyclotron Bose-Einstein condensates as generalized spontaneous magnetization or both. This requires that the charged particles at flux tubes are organized so that they have parallel longitudinal momenta and/or spin and cyclotron quantum numbers n, m. This require that the spins or momenta of charged particle turn to the same direction. Conservation laws require that the increments of quantum numbers go to the roller and could cause weight change in the case of super-conductivity and spontaneous acceleration in the case of cyclotron Bose-Einstein condensate associated with angular momentum.

(c) Ordinary matter would in turn condense around magnetic body as assumed in TGD inspired quantum biology so that dark morphogenesis would induced ordinary morphogenesis.

(d) The mechanism would be universal. Even exo-planetary systems are found to be preceded by the formation of concentric rings, which suggests that Chladni mechanism is at work also here and drives dark matter to the rings after which ordinary matter condensed around dark matter.

8.3.2 Standing waves, magnetic walls and Chladni mechanism

In TGD inspired quantum biology morphogenesis could rely on a generalization of Chladni mechanism (for explanation (see `http://tinyurl.com/j9rsyqd`) [L48]. Chladni mechanism in its original form was a clever trick to make the nodal curves associated with standing waves visible: in the original situation one has vibrating square shaped oscillating membrane and the added particles end up to the nodal lines of the membrane.

In the generalization of Chladni mechanism charged particles would be driven to stationary nodal surfaces of standing waves where they experience no force. One can consider also a more general mechanism in which the nodal surfaces vary slowly in the time scale of the dynamics of charged particles.

One can generalize further: also the magnetic walls carrying dark charged matter could be associated with the nodal surfaces of TGD counterparts of standing waves where charged particles experience no force orthogonal to the flux tube. What is so remarkable that for $h_{eff} = h_{gr}$ given value of h_{eff} would correspond to a given value of particle mass so that various kinds of charged particles would at flux tubes like books in shelves corresponding to particular topics. Living matter would be extremely organized at the level of magnetic body and ordinary matter would organize around magnetic body.

The charged particles at magnetic walls could be bosonic ions or Cooper pairs of fermionic charged particles and form cyclotron Bose-Einstein condensate with all particles in same cyclotron state and with the same spin. The large distance from rotating system would suggest large quantized angular momenta proportional to the distance which is approximately a multiple of the wavelength $\lambda \sim .5m$.

What is interesting that the distance between magnetic walls is about .5 meters asymptotically whereas the cyclotron wavelength of electron in magnetic field of $B_r = .05$ Tesla is $\lambda = .2$ meters. The field giving rise to $\lambda = .5$ meters is by a factor 2/5 times smaller than B_r. Also the endogenous magnetic field $B_{end} = .2$ Gauss relates by the same factor 2/5 to the nominal value of the Earth's magnetic field $B_E = .5$ Gauss. Could it be that the "endogenous" variant of B_r - perhaps the dark magnetic field accompanying $B_r = .05$ Tesla - is also now by a factor 2/5 smaller? Or is the value of the field this in the region where the radiation is generated.

If the angular momentum has $\hbar_{eff} = h_{gr}$ as unit, the angular momentum would be scaled up from ordinary. It is not however clear whether this true. Since dark space-time sheets are n-fold coverings it could happen that single sheet has fractional angular momentum unit $\hbar/n$ so that n-sheeted structure would have $\hbar$ as unit of angular momentum. Nodal surfaces can

be associated also with propagating waves and they would be in the recent case same as those associated with the standing waves.

Chladni mechanism could transcend to a basic mechanism of morphogenesis.

(a) Charged magnetic flux quanta and therefore also biomolecules would end up to the nodal surfaces of say electric field since the force on them would vanish at the nodal surfaces. This would give stationary structures. MB could control morphogenesis by using this kind of standing waves forcing the formation of various structures at their nodal surfaces.

(b) The induced fields associated with the simplest "topological light rays" ("massless extremals", MEs) are of form $sin(\omega(t-z))\epsilon(\rho)$, $(c=1)$. $\epsilon(\rho)$ is polarization function and ρ is a coordinate varying in the direction of local polarization and can be chosen rather freely. Now it is taken to be the radial cylindrical coordinate. $\epsilon(\rho)$ can have zeros, which makes possible stationary nodal surfaces also in the case of propagating MEs.

(c) The objection is that TGD does not allow single-sheeted realizations of standing waves needed for instance to realize the standing waves assignable to induction coil and wires of electric circuits. This objection is not lethal. In many-sheeted space-time one can realize effective sinusoidal standing waves as 2-sheeted structures from two MEs propagating to opposite spatial directions and carrying plane waves with a fixed frequency. These two-sheeted structures would serve as basic building bricks. The test particle having necessarily wormhole contacts to both MEs would experience the force caused by the sum of the induced gauge fields assigned to the two MEs. The force would be same as that caused by a standing wave with separable temporal and spatial dependence not realizable as preferred extremal: that is a product of trigonometric functions - say product of form $sin(\omega t)sin(\omega z)\epsilon(\rho)$.

MEs have also always constant direction of polarization. Circularly polarized effective fields could be generated by pairs of MEs for which one has two linear polarizations in orthogonal directions with a phase lag of $\pi/2$.

(d) The force would vanish at nodal surfaces, which would thus define naturally the shape of a stationary structure defined by molecules. These surfaces would correspond to the vanishing of $sin(kz)$ factor and to the vanishing of $\epsilon(\rho)$ factor.

(e) One can take several primitive MEs and allow them to have different directions but common frequency. One would obtain effective standing wave with common factorized temporal and spatial dependences given by the sum of spatial parts of the sinusoidal waves. The nodal surface for this wave would correspond to the nodal surface for the sum of the spatial waves and one would obtain arbitrarily complex nodal surfaces.

The nodal surfaces for these waves would naturally associated with the nodes of a tensor network [L42], where the flux tubes of MB indeed meet. Fractal structure with tensor networks with nodes of tensor networks can be assumed in TGD framework. In the recent situation one would have effective 2-dimensionallity and the nodes would be cylinders.

(f) There is a connection with holography in which reference wave and the wave of same frequency reflected from the target interfere. Now all waves can be regarded as standing reference waves coming from different directions and generated by magnetic body and propagating along flux tubes of magnetic body. Bio-structures would be formed to the nodal surfaces of this hologram.

Consider now a more detailed description of the recent situation.

(a) Magnetic walls would naturally correspond to the nodes of $\epsilon(\rho)$, which would be strictly periodic function or only asymptotically periodic as Bessel function. These nodal surfaces are possible already for single sheeted situation. Cylindrical symmetry would suggest Bessel functions.

The distances between the magnetic walls are in the range .5 m-0.8 m. This length scale would correspond naturally to the wavelength of approximately periodic radial polarization function $\epsilon(\rho)$. The scale naturally corresponds to the radius of stator or the entire system. The frequency corresponding to $\lambda = .5$ meters would correspond to frequency $f = 6 \times 10^8$ Hz. The cyclotron frequency of electron would be 1.5×10^8 Hz in the field of .05 Tesla. Correct value would be obtained for $B = .3$ Tesla: this would correspond

to the value of the magnetic field at the flux tubes of the magnetic body emanating from rollers.

The hypothesis that the cyclotron energies of dark particles are in the range of bio-photon energies - visible and UV- suggests that the value of $n = h_{eff}/h = h_{gr}/h$ satisfies $n \geq 4 \times 10^3$ for the corresponding dark photons in the case of electrons. Note that the gravitational Compton scales $\Lambda_{gr} = h_{gr}/m$ would not depend on the mass m of the particles. This realizes Equivalence Principle.

(b) If the absorbed photons have well-defined helicity and thus spin, they have circularly polarized waves as classical correlates. MEs do not however allow a polarization changing with time. This problem is circumvented by using union of MEs, which have orthogonal linear polarizations but are in different phase so so that the direction of polarization observed by test particle rotates.

The transfer of spin is expected to be small below 9.2 Hz whereas the momentum is transferred. Hence these pairs could describe propagating waves present below 9.2 Hz. The continual absorption of these ME-doublets would serve as a correlate for the absorption of dark photons and would be a correlate for the weight change

There would be parity breaking in the sense that the rates for the generation of MEs with opposite momentum directions are not same: this would gives rise to a net momentum gain and weight change. Mechanism would be similar to that in the case of radiation pressure. The extreme situation is that there is strict correlation between the directions of rotation and momentum for MEs and dark photons.

(c) Standing waves with both polarizations are obtained by combining two pairs of MEs with net circular polarization and having opposite momentum directions to get a 4-plet of MEs representing standing waves with giving spin. These MEs could emerge above 9.2 Hz besides propagating MEs. The absorption of ME-4-plets would be a correlate for the energy and angular momentum transfer but no momentum transfer.

8.3.3 Spontaneous acceleration and weight change

Recall that the general features of the spontaneous acceleration and weight change are following.

(a) The change of weight increases gradually above $f = 3.3$ Hz. The interpretation would be that there is not momentum from the dark photons absorbed by the rollers. During rapid acceleration beginning at $f = 9.2$ Hz the weight change stays the same and after than slowly increases from 30 per cent to 35 per cent. The interaction is that the rate for the absorbtion of dark photons is constant during rapid acceleration and slowly increases after than as function of ΔG: as a function of time the rate could be slowly increasing all the time. This suggests that the momentum distribution for dark protons is not invariant under reflections so that a correlation between weight change and direction of rotations emerges.

(b) At 9.2 Hz an additional contribution to dark radiation for which net momentum gain is small would emerge: now only energy and angular momentum is fed to the system. The dark photons having both momentum directions with the same probability but same spin direction would be involved.

(c) Similar effect could be involved with the weight change of a rotating super-conductor observed by Podletnov at Tampere [H13] and later in experiments in which Podletnov and Modanese utilized electric discharges for a capacitor [H12, H6]. The other plate of the capacitor was super-conductor and an unknown radiation was identified as the reasons for the motion of test penduli observed. No exponential reduction of the effect occurred. This suggests that only a very small fraction of the radiation was absorbed or that the effect was a kind of control effect inducing leakage of small amount of ordinary matter to from the test penduli - perhaps as dark matter. A possible explanation is in terms of dark photons such that only small portion of them is absorbed by the test penduli and receives the momentum of the photons. The dark photons could be accompanied by topological light rays.

The loss of electrons cannot explain weight change and acceleration

The transfer of electrons between roller and its magnetic body is very natural explanation for the charging of the roller. Could the loss of electrons with same spin direction to the magnetic body reduce the magnetization of the roller and lead to a loss of spin angular momentum?

(a) If the loss of electrons does not affect total angular momentum of the roller, the loss of spin must be compensated by generation of orbital angular momentum so that roller wold experience a torque. Electrons going to the flux tubes of the magnetic body have also momentum. Could the roller receive a recoil momentum from electrons? Could electrons to the magnetic body or from the magnetic body give their spin and angular momentum to the roller.
The number density of negatively charged particles given by

$$n = -\nabla \cdot \frac{E}{e} = -\frac{\omega B}{e}$$

in the units used ($c = 1$) is extremely low: a fraction of order 10^{-23} of the number density of atoms: roughly 1 electron per mole. The maximal possible spin transfer rate predicted to be $\frac{d\omega}{dt}\frac{B}{e}\hbar/2$ by the above formula should be the torque $Id\omega/dt$ required by the spontaneous acceleration. Here $I = n \times MR^2/2$ is the moment of inertia and $R \sim .05$ m a rough estimate for the radius of the roller. This gives $\hbar B/2ce = \rho R^2/2$. The discrepancy is 25 orders of magnitude for B about 1 Tesla.

Momentum and angular momentum transfer by dark photons

A more plausible explanation is in terms of a momentum and/or angular momentum transfer from the magnetic walls or flux tubes condensing around them.

(a) The magnetic field of the roller has the same direction as the return flux of rollers so that the natural interpretation is that the phase transition increasing Planck constant fuses the return flux tubes to magnetic walls carrying the dark matter. They could also fuse to single flux sheet. Quantum coherence scale would increase from flux tube radius to the circumference flux tube and the flux wall radius could be proportional to $n = h_{eff}/h$.

(b) Bose-Einstein condensates of charged particles wih $h_{eff} = n \times h = h_{gr}$ would be formed at the topologically condensed flux tubes at walls or at the wall possible form by fusion of the flux tubes. The dark photons would be liberated in the phase transition turning either momentum or angular momentum or both so that the have same values. If the phase transition liberates energy, the energy liberated would form a many-photon state of dark photons at the flux tubes associated with rollers and stators and the photons would be transform to ordinary photons and absorbed generating effective weight change and spontaneous acceleration.

(c) The direction of the net dark photon momentum would correlate with the direction of rotation meaning parity breaking present also in the unipolar generator for which the direction of electric field and sign of the induced charge density depends on the direction of rotation. A more general assumption is that the difference between the photons with opposite momentum difference is non-vanishing and correlates with the direction of rotation.

What is the source of energy?

Where comes the rotational energy of the roller during spontaneous acceleration and the energy associated with the dark photons inducing weight change?

(a) The formation of magnetic walls could liberate energy and this energy could end up to the rotating magnetic system in the manner already described.

(b) Charged particles could form kind of dark nuclei at the flux tubes and the dark nuclear energy assumed to scale down by $1/n$ in TGD based model of cold fusion, would liberates energy. These dark nuclei could transform to ordinary nuclei when interacting with

charged systems and would liberate practically all nuclear energy. There are indications for the occurrence of this both in cold fusion and in the interaction of so called Brown's gas (see `http://tinyurl.com/5tyl92`) with metals [H7]. The corrosion of the copper folios around the stator and rotor could be interpreted in terms of transformation of dark nuclei to ordinary nuclei liberating nuclear binding energy.

(c) A further possibility could be remote metabolism in which system sends negative energy signal to a system able to receive it. Quantum credit card mechanism serving as a general mechanism in remote metabolic energy transfer, motor actions as processes involving signals into geometric past (Libet's findings), and mechanism of memory as communications with geometric past, is a natural proposal in Zero Energy Ontology (ZEO).
The dark matter at flux tubes could gain positive energy by emitting negative energy dark photons, which would be transformed to ordinary ones and be absorbed by the matter at magnetic flux tubes which indeed are cooled. This process could occur in time scale which is fraction of second or even time scale corresponding to the cyclotron time of dark photons. This process should generation of a pair of cyclotron photons at the flux tube of roller and at the flux wall. It is not necessary that the photons have same energy and momentum since the negative energy photon.
Here one cannot avoid few words about TGD inspired theory of consciousness. Large state function reduction meaning the "death" of conscious entity assignable to CD would occur at opposite boundary of CD and the resulting state would be time reversal of the original so that second law would hold in non-standard direction of geometric time and lead to effects apparently inconsistent with second law. The reported cooling of the magnetic flux walls suggests that also this mechanism could be involved. Also the idea about magnetic systems with charge separation as primitive life forms suggests this.

(d) One cannot completely exclude even more radical mechanism allowed by ZEO and not breaking conservation laws since the conservation laws hold true only in given scale characterizing CD. The reason is that the states have vanishing total values of conserved charges. The usual conserved charges can be assigned with either boundary of CD and are of opposite sign at the opposite boundaries. In the first state function reduction to the opposite boundary the average values of charges of states analogous to square roots of thermal partition functions can change. This could lead to the increase of the average energy associated with given CD which also increases in size. One could imagine even the possibility that CD increases so that it gives rise to sub-cosmology.
One could imagine that the changes of the arrow of geometric time taking place in the "death" of self with standard arrow of tiem has interpretation as signal sent to geometric past and increasing the energy at "dead" end as also the magnitude of the negative energy at the opposite end of CD. In this manner the energy of CD would gradually increase.

8.3.4 How the system could be scaled?

The system has rather large weight and it would be desirable to study smaller system. Therefore it is of considerable interest to see how the system might behave in the scaling.

(a) If the quantum critical frequencies 10 Hz an 3.3 Hz correspond to resonance frequencies of EEG and biorhythms, one can hope that they are independent of the scaling of the system.

(b) The frequency corresponding to the distance between the magnetic walls could be interpreted as cyclotron frequency for the magnetic flux tubes assignable to the electrons at magnetic field of .3 Tesla. This field value could be assigned with the rotor. Scaling of this frequency would scale the distance between magnetic walls.

(c) The values of the dimensionless parameters, in particular the ratio of the radius of the roller to that of stator should be kept unaffected.

If this view is correct, there should be no obvious problem in scaling down of the system.

8.4 Other examples about weight loss

There are also other experiments involving poorly understood weight change. In the following two examples are considered.

8.4.1 Could photons affect gravitational force?

I participated an intense Facebook discussion on rotating magnetic systems and some-one gave a link to a very interesting experiment in which light arrives horizontally in a box and is reflected there in forth and back in a 6-layered structure [E7] (see `http://tinyurl.com/zs9wley`). It is reported that the presence of light-box reduces the gravitational force on an object above the box and increases it for an object below the light-box.

Could TGD explanation be similar to that as for the reduction of weight of rotating system in Godin&Roschin experiment [H15]? This might be the case although the reduction of weight is fraction of order .1 per cent and much smaller than the maximal reduction of 35 per cent in G&R experiment. This could be understood if dark photons with energies scale up by a factor $h_{eff}/h = n = h_{gr}/h$ result as a small leakage from ordinary photons or vice versa. In G&R experiments the beam of photons arriving the system is dark.

After brainstorming the first serious trial to explain the effect led to a strange conclusion: the momentum direction for the dark photons exchanged between the light-box and test mass must be opposite to the momentum. This violates **Quantum Classical Correspondence** (QCC), which is basic principle of TGD. In the light-hearted brainstorming mood I was ready to accept this but soon realized that this won't go. After that it was easy to see that Zero Energy Ontology (ZEO) solves this problem. This however leads to a dramatically new manner to interpret gravitation and also other interactions. This interpretation is however not in conflict with existing physics although it would conform with the vision of Sheldrake.

Consider first how gravitational force by dark gravitons giving rise to momentum exchange along the flux tubes connecting the test mass to Earth could work.

(a) The weight gets momentum increments Δp assignable to gravitons with some rate and this gives rise to net momentum transfer rate dp/dt defining gravitational force. Reaction law holds in the sense that mass gets a momentum increment Δp when a momentum -Δp travels along flux tube to Earth getting opposite momentum increment. Note that the direction of Δp is **opposite** to the direction of travel of graviton in positive energy ontology! Also the energy of the graviton is negative.

(b) This does not conform with the classical expectation about (virtual) gravitons as a localized wave packets. Momentum increment -Δp can be said to travel in direction of Δp rather that in its own direction as one might expect!

How could one cure this problem?

(a) Should one give up QCC although it is basic principle of TGD? Could one argue that gravitation is quantum macroscopic interaction - something totally different from say entropic gravity - and one must speak of non-localized waves of momentum Δp in the scale of the entire system even in astrophysical situations so that classical intuition could fail. This is what TGD indeed predicts via $h_{eff}/h = n = h_{gr}/h$ hypothesis.

(b) Or should one replace positive energy ontology with ZEO and interpret the momentum exchange as taking place in reverse time direction. ZEO could allow to achieve this correspondence in terms of remote metabolism in which test mass sends negative energy dark gravitons travelling in reversed direction of geometric time to a system able to absorb them and gains positive energy as a recoil.
Test mass would send to the geometric negative energy dark gravitons with momentum -Δp (this momentum is directed upwards to the light box getting positive energy gain and downwards direct Δp p as a recoil. The QCC would not be lost because of time reversal. Since the virtual graviton propagates backwards in time, QCC is true: situation is PT reversal of a positive energy dark graviton with momentum Δp propagating in its own direction.

(c) Are planets then primitive conscious entities soaking up gravitational energy from Sun?! Or does this happen in dark sectors whereas at classical level gravitation would be described much as in GRT. From this there is not a long way to the idea that living organisms on Earth soak up energy from Sun also a dark photons. All physical systems would be trying to steal energy from each other! One can safely give up the belief that Nature is somehow innocent. This sounds a pre-Keplerian idea but in ZEO it need not be inconsistent with basic laws of physics. This picture conforms with the views of Sheldrake about learning and morphogenesis.

Consider now the experiment in this picture. What would happen as one adds light-box below the test mass?

(a) This picture about gravitational force as remote metabolism generalizes to the recent case by replacing negative energy dark gravitons with negative energy dark photons. Test mass would be a primitive living system and would gradually learn to utilize light-box as an energy source using remote metabolism. This would conform with the observation that it takes time for the effect to emerge.

(b) Test mass would send negative energy dark photons along gravitational flux tubes and some fraction of them would be absorbed by the light-box as they transform to negative energy bio-photons with some rate - at least if quantum criticality in some sense is realized: in what sense remains an open question. Does quantum criticality develop during the time needed for the effect to emerge. Certainly the fact that the photons in the light-box have energies in the range covered by bio-photon energies matters.

(c) If negative energy dark photons have Δp parallel to the direction of motion with reversed arrow of time, Δp is directed downwards and the effective weight increases if the box is below the test mass. If the box is above the test mass the effective weight is reduced. This is what has been reported in the article. From the size of the reduction of mass about 1 per cent one in principle could get idea about the rate for the transformation of dark photons to ordinary visible photons.

(d) A related TGD inspired suggestion is that topological light rays (MEs) parallel to the magnetic flux tubes mediating the gravitational interaction are generated and dark photons can be assigned to them. The fundamental property of MEs is that pulses can propagate only in single direction and this could relate closely to the sign of the force. Dark photon Bose-Einstein condensate propagating in single direction is generated as photons from the light-box transform to dark bosons. For given ME all dark photons must be collinear just like the classical pulses inside ME propagate only in single direction. The direction would be towards the test mass and opposite to the direction of momentum exchange involved to make the interaction attractive. Also now the TGD analogs of standing waves might be involved and would correspond to pairs of "plane wave" MEs such that the sums of their em fields are standing waves.

(e) What is interesting that this model could also explain the well-known fluctuations in the value of gravitational constant measurements (see `http://tinyurl.com/kvczx7g` and `http://tinyurl.com/jnb8mv9l`). Also Sheldrake notices the reports about the variation of G (see `http://tinyurl.com/zq7ee57`). The largest variation is about one percent from the average value, and there is evidence that the measured value varies periodically with a period of one sidereal day (galaxy as rest system).
This suggests that the test mass soaks energy from the flux tubes of galactic magnetic field: I have indeed proposed that they mediate the gravitational interaction of Earth (the local geometric entanglement of galactic flux tubes could be essential for the formation of various biological or even more general material structures). The effectiveness of soaking could depend on the angle characterizing the orientation of the gravitational flux tubes with respect to the line connecting Earth to Galactic center varying in the range $[0, \pi]$. The effectiveness could also depend on the position of Earth at its orbit around Sun giving annual variation: could the local density of the galactic flux tubes have periodic variation? There are also other interesting appearances of sidereal day and year in living matter [L40].
The long measurement times should tend to affect the measured value of the gravitational constant G. One should arrange the instruments so that the are not below or above the

test mass.

One can criticize the idea.

(a) Skeptic of course argues that the assumption about all matter having some aspects assigned to living systems is worst kind of pseudo-science that they have ever met and that now these quantum crackpots try to bring physics back to pre-Keplerian times. ZEO is however completely consistent with basic laws of classical physics and quantum physics. The fact is that TGD predicts that dark matter as a key aspect of what it is to be living. Adelization of physics means that cognition is present in all scales - already in elementary particle length scales as the success of p-adic mass calculations suggests. TGD also predicts hierarchy of conscious entities. Also skeptics explain all our activities in terms of conscious choices. Maybe also skeptics should finally accept free will as a fact and try to explain it scientifically. The consolating news for skeptics is that in ZEO one can indeed assign to consciousness causal powers without ending up with conflict with the laws of physics.

(b) Physicalist would argue that one can just assume that light-box has additional **attractive** interaction with test mass analogous to gravitational interaction. This interaction should be electromagnetic, certainly not the extremely weak gravitational interaction. Coulomb attraction is probably not in question. The interaction energy for this interaction should increase as the distance between test mass and light-box decreases to give attractive force as gradient of interaction energy - just as in the case of gravitation. If this picture is correct, one should be able to express this interaction in more familiar terms.

8.4.2 Weight change for electrets and "weight of soul"

Also the weight of electrets have been found to change as the Research Gate conference article or Schreiber and Tajmar reports [E11] (see `http://tinyurl.com/hh88frv`). They refer also to other works reporting anomalous looking weight changes. Recall that electrets are systems possessing spontaneous electric polarization and therefore analogous to magnets. Electret property allows to transform electric signals to mechanical and vice versa. Living systems are full of electrets.

Electrets were produced from organic materials (organic origin might be relevant) by a procedure described in the article beginning with melting at temperature 120 °C to a molten state followed by an application of an external high voltage (10 kV) electrostatic field forcing the microscopic electric dipoles to orient in parallel leading to complete solidification until room temperature was reached.

Fig. 3 describes the schematic model for the resulting electret containing parallel electric dipoles and free positive and negative charges. The polarization of the electret its not completely stable and can change or disappear. There are two kinds of free charges near the ends of the electret: the region near negative pole contains more positive than negative charges and the region near positive pole more negative than positive charges. There are two kinds of charges known as heterocharges and homocharges and these charges have different relaxation times. Therefore the relaxation can lead to change of the polarization voltage and even of its direction.

Two kinds of measurement were performed. Both the resulting polarization of electret and its weight were measured in the first experiment (see Fig. 7 of `http://tinyurl.com/hh88frv`). The voltage for these electrets changed after half an hour: the voltage dropped first from 3 kV to about 2.82 kV and then suddenly jumped to 3.425 kV. The weight showed after an initial fluctuation period a sharp increase to a saturation value taking place after 5.5 hour so that there was 5 hour lag. For an unpolarized electret the weight was found to increase steadily (see Figure 9 of `http://tinyurl.com/hh88frv`). The overall change of the weight during 20 hours was $\Delta g/g \sim 2 \times 10^{-4}$ in both measurements.

The change of the electric field of the polarized electret was accompanied by an increase of weight followed by a fluctuating period with vanishing average weight increase followed by a sudden increase after 5 hours followed by steady increase. The overall change in both cases was about $\Delta g/g \sim 2 \times 10^{-4}$. Maybe the behavior of polarized electret could be seen as that of

a depolarized electret perturbed by the change in the value of polarization. There was 5 hour lag before the sudden change in $\Delta g/g$: as if the steady weight increase occurring for electret with no polarization had been prevented by the change of the polarization and transformed to a fluctuation lasting for about 5 hours before returning to nearly normal value.

The challenge is to understand the cause of weight increase and why it was affected by the change in polarization. The models for the weight change of a rotating magnetic system and for the weight change induced by the presence of light-box suggests that the continual feed of dark photons transformed to ordinary photons was involved. One can consider two options in this framework: the electret sends negative energy dark photons to some system below the electret able to receive them or the source system located above the electret sends positive energy dark photons to the electret.

(a) Since the electret system consists of organic material one might think that it could still be able to regenerate a connection to its magnetic body carrying magnetic field - say the endogenous magnetic field $B_{end} = .2$ Gauss. Perhaps the transformation to electret returned the ability to regenerate this connection by generating an ordered phase of dipoles: could one say that the external field "revived" the organic material.

(b) The magnetic body located above the system send dark positive energy photons to the electret in which they are partially transformed to ordinary photons. B_{end} can have flux tubes also below the Earth's surface and the electret could get energy by remote metabolism by sending negative energy dark photons downwards constantly. This would give rise to a increase of the effective weight.

What other models can one imagine?

(a) One can also imagine that dark mass of order $\Delta m/m \sim 2 \times 10^{-4}$ flows from magnetic body to the system and transforms to ordinary matter.

(b) I have already earlier encountered the number 2×10^{-4} assigned with endogenous magnetic field $B_E = .2$ Gauss [K34, K35, K36, K37, K77]. The proposed interpretation was that the flux tubes of B_{end} correspond to gravitational flux tubes for dark mass $M_D \sim 2\times 10^{-4} M_E$. Could one think that the revived system regenerates gravitational flux tube connections to this mass and experiences the gravitational field generated by it?
The arguments used however strongly suggest that M_D must reside at the distance of Moon at a spherical layer: this conforms with the vision about how the condensation of visible matter around dark matter creates the astrophysical objects. In Newton's theory however the net gravitational force should be very small at the surface of Earth since different contributions to the force would interfere. M_D should reside considerably below the surface of Earth for this model to make sense.
Flux tube picture distinguish between TGD and Newton's theory could however save the situation: the gravitational flux would arrive along flux tubes through wormhole contacts below the surface of Earth and then spread out radially and give an additional contribution to the Earth's gravitational field and cause the weight increase. This explanation does not apply to rotating magnetic systems nor to the change of weight due to light.
The objection is that the system cannot just decouple from the flux tubes. Also the conservation of gravitational flux which could correspond basically to the conservation of Kähler magnetic monopole flux prevents this.
The most attractive solution of the problem emerged from the observation that the "inner inner" core of Earth having radius about 300 km has mass of order $M_D = 10^{-4} M_E$ if the density in this region is the average density of Earth. Probably M_D is somewhat larger meaning that actual estimate is higher, and even $M_D = 2 \times 10^{-4} M_E$ giving 4 times higher cyclotron energy scale - bio-photon energies include visible and UV range so that this might well make sense.

(c) The third option is that the mass of electret has also dark contribution coming perhaps from its own personal MB - its "soul"! MB as intentional agent indeed behaves in many respects like "soul". This is just what I have proposed many years ago: as the ageing biological body gets uninteresting, MB finds more interesting target of attention. In this case death would mean the loss of MB and also loss of weight $\Delta m/m \simeq 2 \times 10^{-4}$ if the ratio M_D/M is universal.

Also Earth could have MB and it could indeed correspond to the dark mass at distance of Moon. Could the flux tubes from Earth carrying monopole flux go at this distance to another space-time sheet through wormhole contacts carrying quantum numbers of dark matter particles at their throats and return near Earth's core, where they would return to the original space-time sheet and turn back to form a loop? Could these loops be just elementary particles with $h_{eff} = h_{gr}$?

An interesting test is to see what happens as organism dies: is it weight changed - reduced - as these experiments would suggest? For a weight of 100 kg the weight reduction would be 20 g if one can extrapolate from the above measurements. Amusingly, the "weight of soul" has been measured and - believe or not - the average result happens to be 21 g (see `http://tinyurl.com/k7d8vuy`! Of course, one can invent many explanations for the weight change and also challenge its occurrence, and skeptics of course ridiculize the idea about detecting the possible weight change because some-one has uttered the word "soul" in this context.

8.5 About the description of rotating magnetic systems in zero energy ontology (ZEO)

I have worked for decades in an attempt to understand the findings of Godin and Roschin [H16, H15] about strange effects in rotating magnetic system [K15]. The possible connections with TGD inspired quantum biology are discussed in [L47]. The developments in zero energy ontology (ZEO) and increased understanding of magnetic fields in TGD framework allow to lookat the situation again. I am not an engineer but more precise model might allow development of simpler systems catching just the essentials and also scaling down of the system of Godin and Roschin perhaps allowing easier testing of the model.

8.5.1 Summary of the updated picture

Basic new ideas

The basic new ideas brought by TGD are present already in the earlier model [K15] but in less developed form.

(a) Dark matter is assigned with the hierarchy of effective Planck constants $h_{eff} = nh_0$, $h = 6h_0$ [K34, K35, K36, K37, K77]. The strengthening of hypothesis introduces gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ introduced originally by Nottale [E1] and assigned with flux tubes mediating gravitational interactions. h_{gr} can have so large values that $E = h_{gr}f$ for cyclotron frequencies in ELF range (say 10 Hz) are in the range of bio-photon energies in visible and UV energies. One can assign the analog of gravitational Planck constant also to flux tubes mediating electromagnetic and other interactions: for instance $h_{eff} = h_{eff} = nh_0$ would be natural in the case of of the observed flux walls.

(b) Dark matter can perform macroscopic quantum jumps since various quantum scales scale up like h_{eff} (Compton lengths) or even h_{eff}^2 (atomic orbitals).

(c) Magnetic body (MB) is key notion. It has as building bricks magnetic flux quanta. Typically flux tubes and flux sheeets. It consists of two kinds of flux quanta. Flux can be vanishing, which corresponds to Maxwellian case. The flux can be also non-vanishing and quantized and corresponds to monopole flux. In this case magnetic field requires no current to create it. This option is not possible in Maxwellian world. These flux tubes play a key role in TGD Universe in all scales.
Also Earth's magnetic field with nominal value $B_E = .5$ Gauss has these two parts. Monopole part corresponds to $B_{end} = .2$ 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 magnetic field: this field should have decayed 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 do not have it. For flux walls the magnetic field

is of order $B = .05$ Tesla and much stronger than B_{end}, whose cyclotron frequencies are involved also with the rotating magnetic system so that different magnetic fields are in question.

MB would carry dark matter as $h_{eff} = n \times h_0$ phases and act as a "boss" controlling ordinary matter [L91]. Communication to and control of 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.

(d) ZEO predicts that the arrow of time changes in "big" state function reductions (BSFRs - ordinary state function reductions as opposed to the counterparts of weak measurements or "small" SFRs). This would happen at magnetic has dramatic implications. Time reverse dissipation looks like energy feed from the environment to system. Self-organization involves always energy feed and generation of structures rather than their disappearance in apparent conflict with second law. Self-organization would correspond to dissipation in reversed time direction implied by generalized second law. No specific mechanisms would be required and only metabolic energy storages- systems able to receive the energy dissipated in reversed time direction - are enough. Obviously this provides a totally new vision about energy technology.

Basic picture about rotating magnetic systems

What is observed in rotating magnetic systems is following.

(a) As the rotation velocity for the roller system around stator magnet approaches to 10 Hz frequency, which is basic biorhythm, the system starts to accelerate spontaneously around 9 Hz: the critical frequency is quite not the same for opposite rotation velocities. The rotating system must extract energy and angular momentum from some source. A good candidate for the apparent source of energy is the MB of the system. There should be an exchange of energy and angular momentum to system (call it "biological body" BB in the sequel) and MB.

Depending on the rotation direction the weight of the rotating system increases or decreases. The interpretation is as additional force due to the exchange of momentum between MB and BB. The exchanged momentum would have direction depending on the rotation direction.

(b) Cylindrical magnetic walls with magnetic field strength about $B = .05$ Tesla are observed and the temperature at their position is lowered. This behavior is in conflict with standard thermodynamics but would conform with time reversed thermodynamics. This would conform with time reversed dissipation from a system identifiable as MB of the rotating system. This mechanism would be completely general mechanism of metabolism in TGD being present in all self-organizing system. This would look like cooling of the air for the observer with standard time direction. One could interpret the situation as extraction of thermal energy from environment by walls of MB and its transfer to the BB leading to cooling. Also angular momentum and momentum would be transferred.

In ZEO this would conform with the occurrence of macroscopic BSFR - a phase transition changing the arrow of time at MB. The phase transition taking place instantaneously with respect to *subjective time* identifiable as sequence of SSFRs must be distinguished from what happens after it with reversed arrow of *geometric time*. The quantum jump would be instantaneous and completely analogous to what has been observed by Minev *et al* in atomic systems.

(c) The air in around rotating magnetic system emits visible - maybe also UV - light which can be assigned with molecular and atomic transitions. This suggests that transformation of dark cyclotron photons in B_{end} with ELF frequencies and very large $h_{eff} = h_{gr}$ to photons identified in bio-systems as time reversed bio-photons inducing transitions of molecules to higher energy states takes place. Observer would see emission of ordinary photons generated as molecules return to the ground state. Also direct transformation to bio-photons could take place and produce diffuse background. The cyclotron photons would have energies, which do not depend on the mass of charged particle since cyclotron

energies are proportional to $\hbar_{gr}/m$ and one has $\hbar_{gr} \propto m$. For 10 Hz frequency would in the range bio-photon energies (visible and UV).

(d) The rotation of rollers occurs without slippage with velocity v. The rotation frequency around the central cylinder is $\Omega = 2\pi F = v/R$. The spin velocity of the rollers with of radius r around their axis $\omega = v/r$ and by a factor R/r higher than Ω. During acceleration Ω is in the range 9-10 Hz. This frequency defines fundamental biorhythm - alpha rhythm- so that the analogy with TGD inspired quantum biology suggests itself strongly. 10 Hz frequency could be critical rotation frequency for the rollers around central cylinder.
The energy transfer between MB and BB could take place resonantly at this frequency. Other important resonance frequencies could correspond to those assignable to EEG. The cyclotron frequencies of those biologically important ions that can occur as mechanical resonance frequencies in the system are especially interesting and would represent coupling between MB and BB. In particular, proton has cyclotron frequency 300 Hz in B_{end}. The spinning frequencies of the rollers bring in additional frequencies above 10 Hz determined by their rotating velocities with respect to the central cylinder.
The analogy with biology forces to ask whether the phase transitions generation of flux walls is central also in quantum biology: consider flux walls possibly assignable to axonal membranes.

(e) The biologically important cyclotron frequencies in magnetic field $B_{end} = .2$ Gauss should correspond to rotation frequencies of the rotating magnetic system. The scaling down of the system should not be problematic. $\Omega = v/R$ means that keeping Ω constant and reducing R, reduces also v in same proportion. Note that centripetal acceleration v^2/R produces problems for too large value of R. Rotation frequencies should not change in the scaling. Since one has $\omega = v/R$ this allows reduction of the size of the system if rotation velocities are scaled in the same matter. The scaling of magnetic and electric fields need not be so simple thing.

8.5.2 Updated model for rotating magnetic systems

The observed anomalies suggest change for the arrow of time and this makes the interpretation as macroscopic BSFR at MB of the system plausible interpretation. The value of h_{eff} should increase to generate the observed effects analogous to self-organization in long scales. Quantum coherence length would increase.

What could happen at MB before the transition

What could happen at MB in the phase transitions? Consider first the MBs before the transition.

(a) Before phase transition monopole flux tubes form MB carrying dark matter. Monopole flux tubes would be in question and this requires permanent magnet for which the monopole part of magnetic field would not require currents as sources. The magnets created by electromagnetic currents do not satisfy this condition.

(b) One can of course ask whether the magnetic flux tubes of the stator magnet are really at rest. Could the interaction with the flux tubes of the rotating rollers force also them to rotate so that the two magnetic fields would form single coherent rotating structure?

(c) Before the transition the flux tubes of the MBs of the rollers would rotate as a whole around the central cylinder. The flux tubes would also rotate around the axis of the roller with the rotation velocity of the rollers. Also the dark matter at the flux tubes of rollers would rotate.

What could happen at MB in transition

What would happen in the transition.

(a) What suggests itself is that the magnetic flux tubes of the stator magnet increase in thickness and fuse to the observed magnetic walls having thickness about 5 cm and

distance about .5 meters. The field strength is of order .05 Tesla. The cylinders would be closed surfaces carrying monopole flux so that torus-like configurations obtained by taking flux tube which is closed solid torus highly stretched in vertical direction rotating it around vertical axis outside it and near to the second side. This gives torus topology with flux flowing through the section with constant height. Various walls would correspond to this kind of structures inside other looking like cylinders.

(b) What would happen to the flux tubes of the rotating rollers? Could also these fuse to form magnetic walls in shorter scale? What about these structures: could also these fused to larger cylindrical structures accompanying magnetic walls. There are no reports about their possible occurrence.

(c) Does it make sense to speak about rotating flux walls? In Maxwellian electrodynamics this is not possible without breaking of the rotational symmetry. In TGD framework this is possible since Kähler gauge potential would be different for rotating Kähler magnetic field and correspond to different space-time surface having different induced metric. Rotating Faraday disk develops a voltage between its boundary and center giving rise to electric field $E = v \times B$. This observation is problematic from the point of view of Maxwellian theory since strong parity breaking is involved.

On the other hand, this observation suggest that the assumption about rotation of the magnetic flux tubes of the stator magnet would not mean too strong deviation from Maxwellian view in TGD. h_{eff} hierarchy in TGD allows strong parity breaking effects, which are indeed present in living matter. Also the earlier model of the system involves parity breaking assigned with the dependence of the effect on the direction of rotation.

As a matter of fact, the exact cylindrical symmetry is broken by the magnetic cogwheel structure of rollers (12-fold cyclic symmetry) and stator magnetic ($12 \times 12 = 144$-fold cyclic symmetry) preventing the slipping of the rollers.

The following remarks about magnetic fields and corresponding cyclotron frequencies suggest that dark electrons play an important role.

(a) The magnetic field strength for stator and rotor magnets was $B_M \sim 1$ Tesla. For electron this corresponds to cyclotron wavelength $\lambda = c/f = 1$ cm. The thickness of the magnetic walls was 5-6 cm. If the monopole flux part of the magnetic field is roughly $r = 2/5$ of the measured field as in the case of B_E, the cyclotron wavelength increases by a factor 5/2 to 2.5 cm, which is roughly one half of the thickness of magnetic walls. There could be thus be a connection.

(b) The magnetic field $B \sim .05$ Tesla of magnetic walls corresponds to electron's cyclotron wavelength $\lambda_c = .2$ meters. The distance between magnetic walls was $d = .5 - .6$ meters. If the value of the monopole part of the flux is 2/5 of the entire flux as for B_E, λ_c increses to $\lambda_c = .5$ meters.

Also endogenous magnetic field B_{end} is involved

The appearance of biologically important frequencies suggests that besides the magnetic fields associated with the magnetic walls also the endogenous magnetic field B_{end} plays an important role.

(a) Also $B_{end} = .2$ Gauss could play a central role defining the monopole part of Earth's magnetic field could play a role. The transition correspond to frequencies around 10 Hz frequency of rotation around stator magnet and the transition begins around 9 Hz frequency. Around 10 Hz rotation frequency one might expect a resonance coupling of the rotating motion of the rollers to cyclotron transitions in $B_{end} = .2$ Gauss at this frequency. Iron ions have cyclotron frequency around 11 Hz in B_{end} to be distinguished from the magnetic fields of the stator magnet and rollers.

The metal ions possible in the system would have cyclotron frequencies and these should be realizable as rotation frequencies using suitable radii for rollers. Resonance would require correlation between the radii and atomic numbers of the metals involved. A strong analogy with biologically important ions would emerge.

(b) B_{end} is by factor 4×10^{-4} weaker than the magnetic field $B \sim .05$ Tesla at magnetic walls. The frequencies associated with the system cannot correspond to B. The value of

$n = h_{gr}/h_0$ required by the assumption that ELF frequencies correspond to bio-photon energies is very large - the order of magnitude is of order $n \sim 10^{13}$ for 10 Hz frequency. For h_{gr} must be assigned to gravitational flux tubes carrying no monopole flux with single sheet carrying B_{end}.

(c) One can of course consider the interpretation of the measured magnetic field B in many-sheeted space-time. Does the measured B correspond to the sum of identical magnetic fields B_{end} over the $n = h_{eff}/h_0$ sheets of many-sheeted space-time? Cyclotron frequencies as purely local quantities would correspond to the field B_{end} at single sheet. If the measured magnetic field is $B_{meas} = n \times B_{end}$, one would obtain the estimate $n \sim 2.5 \times 10^3$. This could be interpreted in terms of the proposed electromagnetic variant $h_{em} = nh_0$ of h_{gr} having much smaller value.

Could the important mechanical frequencies of the system are equal to cyclotron frequencies in B_{end}?

(a) $F = 10$ Hz, which corresponds roughly to the cyclotron frequency f_c of Fe^{++} ion in B_{end}.

(b) Proton's cyclotron frequency in endogenous magnetic field $B_{end} = .2$ Gauss is $f_c = 300$ Hz. Can one get this frequency as a mechanical frequency? There were $N_r = 23$ rollers.

i. The ratio r/R was integer $N \geq 12$. The frequency associated with the rotation of roller is $f_r = v/r = NF \geq 12F = 120$ Hz. $N = 30$ ($r = 5/3$ cm) would give $f_r = 300$ Hz but $N = 30$ looks too large.

ii. The periodicity of the roller configuration implies frequency $f = N_r F = 23F = 230$ Hz for $F = 10$ Hz but allowing no identification of f as cyclotron frequency.

iii. The realization of magnetic cogwheel involves 12-fold periodicity of the roller giving frequency $12 \times 23F = 2.760$ Hz frequency. At stator one obtains $N \times 12$ fold periodicity of stator surface and $12N \times 10 \geq 1,440$ Hz frequency.

About the energetics of the dark matter after the transition

What happens to the dark matter at flux tubes in the phase transition? Especially interesting is the energetics of the transition. One can use observations about cooling associated with magnetic walls and molecular emission lines near rollers. The dissipation of energy by dark matter at magnetic walls and at MBs of the roller possibly fused together could could explain these observations.

(a) A transfer of energy, angular momentum, and momentum must take place between the system formed by rotating rollers and MB carrying dark matter. This would happen in the phase transition/quantum jump. Dark matter at flux quanta must lose angular momentum, energy and momentum to the BB of the roller system. Most naturally the MBs of rollers are in question. This requires that roller flux tubes fuse to flux walls. About whether this occurs there is no direct experimental information.
If also the flux tubes of stator magnet rotate they can fuse to single magnetic wall and if the dark matter comes the transfer of conserved quantities to roller system would take place. The fusion of flux tubes to flux walls would force the acceleration.

(b) After the transition occurs dissipation in reversed time direction making itself visible as cooling at magnetic walls assignable to the stator magnet. In standard time direction the rotating system accelerates but in reversed time direction it loses energy and angular momentum and possibly also momentum. This would be induced by time reversal at MB. Does the time reversed dissipation occur via MB of stator magnet or directly?
Does the cooling of environment correspond to

i. dissipation of the energy of the MB of stator magnet or

ii. dissipation of the energy of rotating system via the MB of stator magnet?

For the latter option one could say that the MB of stator magnet extracts thermal energy from environment and provides it to the rotating system. For the first option also rotating system would do this and this does not look plausible since the time scales for time reversals are much shorter for ordinary matter. For second option the time reversed classical time evolution would provide a correlate for the quantum jump in accordances with quantum classical correspondence.

(c) The emission lines from molecular transitions should take place after the transition as time reversed emission of dark photons from MB transforming to counterparts of bio-photons absorbed by the molecules of air and looking like molecular emission lines in standard time direction. Since dark photons transform first to ordinary photons standard observer would see emission of ordinary photons at bio-photon energies.
The density of excited molecules would grow as time increases in non-standard direction. For the standard observer this would look reductio of the density of excited states. If the dark photons would have energies in visible and UV range, ionization would be gradually reduced in standard time direction and seen as emissio of photos with bio-photon energies. Since roller MBs are nearest to rollers, the MBs of the rollers would naturally provide energy, angular momentum, and momentum to the roller system in the transition. This could occur if the flux tubes of rollers fuse to flux walls so that the dark matter at them can come to rest after fusion. Time reversed absorption of dark photons from the rollers could cause the molecular emissions.

The transfer of conserved quantities after the transition

The first question whether there is any classical description for the transition itself or is the only description in terms of what happens after it. If the quantum jump occurs discontinuously, this seems to be the case. Quantum classical correspondence suggests that the classical description based on what happens after the transition is the only possibility. The observer would talk about extraction of energy from environment. Time reversed dissipation would be the description of the system itself.

Suppose that both roller flux tubes and and those of stator magnet fuse to magnetic walls and contain after transition dark ions rotating around the walls and that there is also momentum in longitudinal direction with opposite momentum in the magnetic system causing the observed change of the weight. Suppose also that dark matter rotates and there is compensating angular momentum contributing to the of the roller system.

The natural identification for the transfer of conserved quantities would be in terms of energy, momentum, and spin, and angular momentum of dark photons.

(a) In the transition energy and angular momentum are transferred to the roller system instantaneously. Energy and rotational angular momentum are dissipated in reversed time direction and for the external observer the roller system seems to accelerate and gain energy.

(b) Photons have also momentum. The roller system would receive momentum in the quantum jump. The dissipation of this momentum would be seen as a force meaning gradual change of weight by external observer. The simplest option is that the momenta at BB and MB of the system are opposite in the final state after which dissipation starts.
Why the sign of weight change depends on the direction of rotations. This would suggest that large parity breaking effects characterizing also living matter are involved. Dark photons (expected to have ELF frequencies) transfer both momentum and spin and rotational angular momentum.

The states corresponding to different directions of rotation are mirror images from the behavior of magnetic field in reflection. How good approximation reflection symmetry P is?

(a) If parity is not violated the behavior $p \to -p$ and $J \to J$ in reflection P implies increase or loss of weight depending on the direction of rotation as indeed observed. Acceleration of rotation would take place in *both cases* as observed. The critical rotation frequency is different so that parity violation takes place. In standard model framework parity violation is large.
In this case the helicity of photons proportional to the inner product $p \cdot s$ and $p \cdot J$ of photon momenta would be different for the two cases. The helicities $p \cdot s$ of dark photons would be different in the two case cases and correlated with the direction of rotation.

(b) Note that the generation of $E = v \times B$ for Faraday disk involves also parity violation and could take place also now for the rotating magnets. This electric field has non-vanishing divergence and the divergence giving charge density is opposite for the two rotation

directions. This should give rise to the charge density of the system a contribution depending on the direction of rotation.

8.5.3 Is the cooling of the environment enough to explain the acceleration

The classical description of the energy transfer after the transition by standard observed would suggest that the MB of stator magnet extracts energy from the thermal energy of air leading to the lowering of the temperature by about 6 degrees. The MB of roller system fused to a single magnetic wall would extract energy from the transitions of the air molecules visible as emissions of ordinary as dark photons transform to ordinary photons and also from the air near the rollers. The energy from MBs would be transferred to the roller system.

One can make a rough estimate for the contribution of thermal energy to see whether it is significant.

(a) The mass density of O_2 molecules $\rho = 1.225$ kg m^{-3} giving for the number density of O_2 molecules $n = 3.4 \times 10^{25}$ m^{-3}.

(b) Temperature is $T = 290$ K and is lowered by about 6 K. Thermal energy of molecule associated with translational motion is $e_T = 3kT/2 \simeq 4.4 \times 10^{-2}$ eV at room temperature. The density of thermal energy $\rho_T = ne_T = 1.5 \times 10^{23}$ eV/m^3 . Energy of 1 eV corresponds to $eV = 1.6 \times 10^{-19}$ J so that one has $\rho_T = 2.4 \times 10^4$ Jm^{-3}.
The change of thermal energy is for the reduction of temperature by 6 K equal to 6×10^{-4} eV fraction $\epsilon = 1.8 \times 10^{-2}$ of thermal energy. The energy gain per volume equals to

$$\rho_g = \epsilon \rho_T = 4.2 \times 10^2 \mathrm{Jm}^{-3} \ .$$

(c) Assume that magnetic wall associated with the stator magnet has thickness $\Delta R = .05$ meters and radius of $R_{min} = .5$ meters. Walls are reported to appear at radii $R_n \sim nR_{min}$, $n = 1, 2, ...$ No upper bound for their heights h is given. They could correspond to the return flux for the magnetic system or stator magnet.
For a wall of height h_n (the real height is larger) the volume of the wall with radius R_n is

$$V_n(h_n) = n \times 2\pi R_{min} \times \frac{h_n}{m} = .16n \times \frac{h_n}{m} \mathrm{m}^3 \ .$$

This gives energy gain

$$E_n(h_n) = nE_1 \times \tfrac{h_n}{m} \ , \quad E_1 = \rho_T V_1(h/m = 1) = .7 \times 10^2 \ \mathrm{J} \ .$$

The total energy transferred would be

$$E_{tot} = \sum_{n<n_{max}} E_n(h_n) = \sum_{n<n_{max}} n \times \frac{h_n}{m} \times .7 \times 10^2 \ \mathrm{J}$$

.
The order of magnitude looks reasonable and could explain considerable fraction of the energy needed for acceleration.

(d) One can estimate from the empirically determined power feed the needed power feed if power comes from thermal energy alone. A rough estimate for the total energy transfer is as $E = \int Pdt =< P > T$, where T is the duration of the period of accelerated motion and $\langle P \rangle$ the average power. P was in the range 1-7 kJ/s. Equating the estimated total energy E with the estimate $E = \sum E_n(h)$, one obtains a rough estimate for the parameters if thermal energy alone is enough.

8.5.4 About the scaling of the system

The system of Roschin and Godin is rather massive and a natural question is whether it could be scaled down or made less massive otherwise.

(a) Consider first the geometric scaling. If the interpretation of 10 Hz frequency as cyclotron frequency assignable to Fe ions, which can appear as dark ions in $B_{end} = 0.2$ Gauss is correct, then it would seem that the frequencies involved should scale down. This would mean geometric scaling of both radii and possibly also heights of the magnets.
For instance, scaling by factor $x = 1/10$ would produce stator radius $R = 5$ cm and rollers with radius $r = 5/12 \simeq .42$ cm for $N = 12$. The single basic unit at roller circumference would have length $2\pi r/N = \times 10\pi/N^2 = 10\pi/144 \simeq .22$ cm, which is rather small value.

(b) What about the scaling of magnetic fields? The magnetic field strength is about 1 Tesla originally. The distance between magnetic walls is about .5 m and corresponds to the radius of stator, which is very natural. On the other hand, if the monopole part of $B = .05$ Tesla for walls is 2/5 of B as in case of B_E, the distance between magnetic walls would be cyclotron wavelength .5 m of electron. If the monopole fraction of 1 Tesla magnetic field is also 2/5, cyclotron wavelength would be 2.5 cm whereas the thickness of flu walls is 5-6 cm.
If one requires that cyclotron wavelength of electron corresponds to the stator radius, then one should scale B by the inverse of the same factor for lengths. This would for scaling factor 1/10 mean $B = 10$ Tesla not easy to realize. 1 Tesla seems to be upper bound for the field strength of commercially available magnets (`http://tinyurl.com/q286tm4`) and 50 Tesla the maximum field strength achieve in lab (`http://tinyurl.com/y9lgk6qr`). Maybe the reason for the massive size of the magnetic system is just this.

(c) One might think of curing the situation by using a hollow cylindrical stator of same or even larger radius to reduce B. As argued, the structure of MB of stator could consist of very long dipole flux loops rotated by 2π to get flux walls having torus topology and located inside each other. The walls would correspond to a slicing of the stator by hollow cylinders inside each other.
If the total flux is conserved and the number of walls is N and they have same thickness and field strength, one has

$$B\pi R^2 = B_{wall} \sum 2\pi R_n d = B_{wall} \sum_0^N n \times 2\pi R d = \frac{N(N+1)}{2} B_{wall} 2\pi R d \ .$$

This gives for the number of walls

$$N(N+1) = \frac{B}{B_{wall}} R d \ .$$

For $B/B_{wall} = 20$ and $R/d = 10$ this would give $N(N+1) = 200$ and $N = 1/2(-1 + \sqrt{801}) \simeq 13.6$. The number N of walls would be about 13. Replacing stator with a cylinder of radius 5 cm would still give single wall at distance of .5 m.
If the dark matter at magnetic walls extracts thermal energy from environment, the energy feed to the system would be reduced but this need not be fatal concerning if one is interested only in the demonstration and study of the effect using less massive system.

8.6 Appendix: Classical model fails

One can wonder whether the accelerated rotation could be explained in terms of Maxwell's theory. Could the transfer of energy, momentum, and angular momentum from classical fields to the rotating system allow to understand the acceleration rotation? The basic formulas for the stress tensor of Maxwell field in non-relativistic formalism are given at `http://tinyurl.com/ztdskmp` and help to understand the following.

Consider first the static fields.

(a) External voltage sources is used to generate a radial electric field E corresponding to voltage of 20 kV, which presumably correspond to voltage difference between the stator and ground. This field would be in reasonable approximation $1/\rho$ as function of transversal distance from the stator origin. There are also a vertical magnetic fields associated with the rollers giving rise to rotor. The strength of this field is estimated to be of order .5 Tesla.

(b) If the system is closed the energy momentum from the em fields can be transferred to the magnetic system and the total rate for these quantities for em fields equals to the negative of that for the magnetic system. It is enough to calculate what happens for energy momentum tensor of em field.

Energy momentum tensor $T^{\alpha\beta}$ for em field can be expressed in terms of its 3-D projection T^{ij}- stress tensor and $T^{ij} \equiv S^j$ and knowns as Poynting vector, whose components are given by the cross product $S = E \times B$ represents energy flow per surface area in its one direction. Now the direction is azimuthal. Flow lines of energy current rotate around the stator.

The divergence of em stress tensor integrated over surface S bounding a volume V gives the sum of total force f experienced by the matter in the volume V and of change of the momentum of the em field inside V given by the integral of $\partial S/\partial t$ over V. The flow of energy momentum from radiation fields to the volume can be calculated from the knowledge of fields outside the roller and stator.

The flux of the momentum from the system is given by the flux defined by the stress tensor over the surface. Stress tensor T^{ij} has a component analogous to pressure and magnetic and electric contributions of form B^iB^j and E^iE^j. In the approximation that pressure term is constant within roller, the pressure contribution vanishes. This is not quite true for electric field and the resulting small net force is radial and vanishes at the limit when roller is very thin. For magnetic field the flux integral vanishes and for electric field one can have small radial force. No torque is obtained. Therefore Maxwell's theory cannot explain the claimed "antigravitational effect" in terms of transfer of momentum from em field to the system.

(c) One can also calculate directly the rate for the transfer of angular momentum from em field to the magnetic system. One has $dJ^i/dt = \epsilon^i_{jk} \int dS_k(x^iT^{kj} - x^jT^{ki})$. Here integral is over the surface of each roller cylinder since only rollers are allowed to rotate. Pressure term in energy momentum tensor proportional to δ^{kj} gives by rotational symmetry of the roller a vanishing contribution. Magnetic term vanishes identically at the surface of the cylinder. Also electric field gives identically vanishing contribution.

The presence of magnetic walls of thickness about 5 cm suggest the possibility of standing em waves with momentum in the radial direction and wavelength of order .5 meters. These waves are oscillating and this implies that the possible transfer of energy, momentum, and angular momentum over the period of oscillation vanishes. One can also perform calculations similar to those above for standing waves with radial electric field and vertical magnetic field and wave vector in radial direction to find that also now the transfer of angular momentum is vanishing. There can be small transfer of momentum in radial direction to a roller. One can consider the situation also for longitudinal standing wave but now the transfer of longitudinal momentum is vanishing by the standing wave property.

The conclusion is that Maxwell's theory does not explain the reported findings.

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Part III

ZERO ENERGY ONTOLOGY AND BIOLOGY

Chapter 9

Zero energy ontology

9.1 Introduction

Zero energy ontology (ZEO) has become gradually one of the corner stones of quantum TGD. This motivates the collection of material related to ZEO in a single chapter providing an overall view about the development of ideas. The sections are independent and reflect different views about ZEO.

9.1.1 ZEO in its recent form (2021)

The following gives a brief summary of the most recent view (2021) of ZEO [L96].

(a) The notion of a causal diamond (CD) (see **Fig. 20**) is a central concept. Its little cousin "cd" can be identified as a union of two half-cones of M^4 glued together along their bottoms (3-D balls). The half-cones are mirror images of each other. CD=$cd \times CP_2$ is the Cartesian product of cd with CP_2 and obtained by replacing the points of cd with CP_2. The notion of CD emerges naturally in the number theoretic vision of TGD (adelic physics [L60])via the $M^8 - H$ duality [L90, L104, L105].

(b) In ZEO, quantum states are not 3-dimensional if the determinism does not fail as it actually does, but superpositions of 4-dimensional deterministic time evolutions connecting ordinary 3-dimensional states. For the strongest form of holography implied by general coordinate invariance (GCI), the time evolutions are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution.
The failure of determinism probably implies that a given 3-surface at the passive boundary of CD (PB) corresponds to a finite number of 4-D minimal surfaces and that the minimal surface can be regarded as an analog of soap film spanned by a frame having fixed parts at the boundaries of CD and dynamically generated parts in the interior of CD. The frame can be identified as a topological analog of a Feynman diagram.

(c) Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced by a new superposition. The classical determinism of individual time evolution is not violated. This solves the basic paradox of quantum measurement theory. There are two kinds of SFRs: BSFRs (counterparts of ordinary SFRs) changing the arrow of time (AT) and SSFRs (analogs of "weak" measurements) preserving the arrow of time that give rise to an analog of the Zeno effect (`https://cutt.ly/yl7oIUy`) [L96]. The findings of Minev *et al* [L83] provide strong support for ZEO [L83].

9.1.2 Topics of the chapter

The goal is to provide some conceptual background for the attempts to identify scattering amplitudes in the framework provided by ZEO.

In the section "*Zero Energy Ontology in its original form*" the basic ideas and implications of ZEO are described. I will represent motivations for ZEO in TGD framework, compare ZEO

with the ordinary positive energy ontology, and try to make clear the implications of ZEO for quantum measurement theory since they relate also directly to the notion of conscious observer as it is understood in TGD inspired theory of consciousness.

In the section "*Some comments related to Zero Energy Ontology*" the basic ideas and notions of ZEO in its original form are critically discussed and also TGD based theory of consciousness is formulated in this framework.

In the section "*Still about quantum measurement theory in ZEO*" quantum measurement theory in ZEO framework is considered with a particular emphasis on number theoretic universality brought in by number theoretic aspects of TGD [L59, L60].

In the section "*Some questions concerning zero energy ontology*" the most recent(2021) view about ZEO is developed by making making objections against the the earlier view [L59, L60]. This view provides a formulation of ZEO at the level of "world of classical worlds" (WCW) and provides surprisingly insights to quantum TGD and TGD inspired theory of consciousness.

For a fixed 3-surface at PB, quantum non-determinism corresponds to a discrete classical non-determinism due to the failure of a strict determinism. The classical orbits of the 3-surface form a tree and zero energy states are superpositions of paths of this tree. Interestingly, this notion of non-determinism is equivalent with the notion of association sequence that I introduced in the early developmental phases of TGD inspired theory of consciousness.

9.2 Zero Energy Ontology in its original form

Zero energy ontology has changed profoundly the views about the construction of S-matrix and forced to introduce the separate notions of M-matrix and U-matrix. M-matrix generalizes the notion of S-matrix as used in particle physics. The unitary U-matrix is something new having a natural place in TGD inspired theory of consciousness. Therefore it it best to begin the discussion with a brief summary of zero energy ontology.

9.2.1 Motivations For Zero Energy Ontology

Zero energy ontology was first forced by the finding that the embeddings of Robertson-Walker cosmologies to $M^4 \times CP_2$ are vacuum extremals. The interpretation is that positive and negative energy parts of states compensate each other so that all quantum states have vanishing net quantum numbers. One can however assign to state quantum numbers as those of the positive energy part of the state. At space-time level zero energy state can be visualized as having positive energy part in geometric past and negative energy part in geometric future. In time scales shorter than the temporal distance between states positive energy ontology works. In longer time scales the state is analogous to a quantum fluctuation.

Zero energy ontology gives rise to a profound distinction between TGD and standard QFT. Physical states are identified as states with vanishing net quantum numbers, in particular energy. Everything is creatable from vacuum - and one could add- by intentional action so that zero energy ontology is profoundly Eastern. Positive *resp.* negative energy parts of states can be identified as states associated with 2-D partonic surfaces at the boundaries of future *resp.* past directed light-cones, whose tips correspond to the arguments of n-point functions. Each incoming/outgoing particle would define a mini-cosmology corresponding to not so big bang/crunch. If the time scale of perception is much shorter than time interval between positive and zero energy states, the ontology looks like the Western positive energy ontology. Bras and kets correspond naturally to the positive and negative energy states and phase conjugation for laser photons making them indeed something which seems to travel in opposite time direction is counterpart for bra-ket duality.

9.2.2 Zero Energy Ontology

Zero energy ontology (ZEO) is one of the cornerstones of TGD and has become part of TGD during last six years. Zero energy states are identified as superpositions of pairs of positive and negative energy states assigned with the future and past boundaries of causal diamonds

(CDs) and correspond in ordinary ontology to physical events with positive and negative energy parts of the state identified as counterparts for the initial and final states of the event. Effective 2-dimensionality allows a further reduction to the level of partonic 2-surfaces: also their 4-D tangent space data matter. Symmetry considerations lead to a beautiful view about generalizations S-matrix to U-matrix in terms o forthogonal M-matrices which in turn are expressible as products of orthogonal basis of hermitian square roots of density matrices and unitary S-matrix [K68]. One can say that quantum theory is "complex" square root of thermodynamics.

Therefore one should try to find tests for ZEO.

The hierarchy of CDs

The basic assumption is that the sizes of CDs come as integer multiples of CP_2 scale R and for prime multiples of R correspond to secondary p-adic length scales $L_{p,2} = L_{p,1}\sqrt{p}$, $L_{p_1} = R\sqrt{p}$, where R denotes CP_2 scale. For electron with $p = M_{127} = 2^{127} - 1$ one has $T_{p_2} = .1$ seconds and defines a fundamental bio-rhythm. This time scale should have preferred role in physics. More generally the secondary p-adic time scales assignable to elementary particles should define time scales relevant to macroscopic physics. The corresponding size scale can be assigned to the magnetic body of the elementary particle. Also it should be possible to assign to quark mass scales special biological time scales as has been indeed done [K17]. h predictions could be tested.

Generalization of standard conservation laws in ZEO

ZEO together with sub-manifold geometry provides a new view about conservation laws and resolves the problem posed by the fact that gravitational interactions do not seem to respect energy conservation in cosmological time scales. Conservation laws holds true only in the scale associated with given CD, not universally (this would allow only single infinitely large CD).

Superconducting coherent states involve quantum superposition of states with different numbers of Cooper pairs and therefore break the super-selection rule associated with fermion number in ordinary ontology. In ZEO they could be understood without giving up the super-selection rule associated with fermion number.

Experimental tests should try to prove that quantum number conservation is a length scale dependent notion. For instance, creation of matter from vacuum is possible in ZEO, and one might hope that its occurrenece could be in some scale for CDs aritficially.

Breaking of second law in standard form

In standard physics second law states that all systems are entropic but a system can reduce its entropy by feeding its entropy to the environment. Negentropic entanglement carries genuine information and life can be seen as islands of negentropy in the sea of entropy. This forces to generalized second law. The proposed generalization (see `http://tinyurl.com/ybg8qypx`) [L14] [K64] can be characterized as maximally pessimistic.

The generation of negentropic entanglement is assumed to be accompanied by generation of compensating entropic entanglement. The modified form of second law is suggested by the mechanism of directed attention based on negentropic entanglement assignable to magnetic flux tube connecting selfandtarget. Negentropic entanglement prevails during the attention but disappears after state function reduction giving rise to entropy at the level of ensemble. Second law would hold true above time scale assignab le to the duration of negentropic entanglement.

There are also other reasons to reconsider second law. The breaking of second law in standard form since the arrow of geometric time can change locally. Living systems are indeed accompanied by syntropic effects as realized by Italian quantum physicist Fantappie [J30, J36]. These effects could be understood as entropic effects but with a reversed arrow of geometric time. The mechanism would be based on negative energy signals. Phase conjugate laser waves

are known to obey second law in reversed direction of geometric time. Cooling effects due to the absorption of negative energy signals inducing the breaking of the standard form of the second law are predicted to be possible. One can also imagine a spontaneous excitation of atoms generating radiation in the return to ground state in a situation when there is a target able to receive negative energy signals emitted in spontaneous excitation.

Standard form of second law assumes that quantum coherence is absent in the scales in which it is applied. Both the hierarchy of Planck constants and negentropic entanglement however make possible macroscopic quantum coherence characterized by the scale involved and the natural guess is that the time scale associated with causal diamond in question defines the scale above which one can expect second law to hold. There is evidence for the breaking of second law in time scale of.1 seconds [D6].

Negative energy signals

Zero energy ontology allows to assign to zero energy states an arrow of time naturally since one can require that states have well defined single particle quantum numbers at either upper or lower boundary of CD. Also the spontaneous change of the arrow of geometric time is possible. The simplest possible description for U-process is that U-matrix relates to each other these two kinds of states and state function reductions can occur at upper and lower boundaries of CD meaning reduction to single particle states with well defined quantum numbers. The precise correlates for the generation of geometric arrow of time are not completely understood.

Negative energy signals to geometric past would serve as counterparts for time reversed states in the case of radiation and phase conjugate laser waves are natural counterparts for them. The signal property requires a dissipative process proceeding in preferred time direction and this kind of process has been assigned to sub-CDs and should proceed as state function reduction sequence in preferred direction of time determined by the quantum arrow of time for the zero energy state. This process would be essential for the experience of flow of time in preferred direction and for generation of arrow of geometric time as explain in previous chapter and also in [K13]. For phase conjugate laser beams the reversed time direction for dissipation is observed.

Negative energy signals make possible remote metabolism as sucking of energy from remote energy source provided resonance conditions for transitions are satisfied. The counterpart of population inverted laser could serve as ideal source and the negative energy signal could serve as a control switch inducing phase transition like process taking the excited atom like systems to ground state (induce emission). This process should occur in living matter. Anomalous excitation of atomic state by absorbing energy by remote metabolism and subsequent generation of radiation could also serve as a signature. It could also lead to cooling effects breaking second law.

Negative energy signals would also make possible realization of intentional action by initiating the activity already in geometric past. This would be very desirable in rapidly changing circumstances. The time anomalies of Libet for active aspect of consciousness could be interpreted in terms of time mirror mechanism [J5] and further experiments in longer time scales might be perhaps carried out.

Negative energy signals could be also essential for the mechanism of long term memory. They would induce a breakdown for a system analogous to population reversed laser via induced emission meaning generation of strong positive energy signal [K87].

Definition of energy in zero energy ontology

The approach relying on the two super conformal structures of quantum TGD gives hopes of defining the notion of energy for positive and negative energy parts of the state.

(a) CD allows translational invariance only in its interior and since partonic two surfaces are located to the boundary of CD, one can argue that translations assigned to them lead out from CD. One can however argue that if it is enough to assign eigenstates of four-momentum to partons and require that only the total four-momentum generators acts on the physical state by shifting CD. Since total four-momentum vanishes for CD

this would mean that wave function in cm degrees of CD is just constant plane wave. Super-conformal invariance would indeed allow to assign momentum eigenstates to the super-conformal representations.

(b) A more stringent condition would be that four-momentum generators act as translation like operators on partons themselves. Since light-like 3-surfaces assignable to incoming and outgoing legs of the generalized Feynman diagrams are the basic objects, one can hope of having enough translational invariance to define the notion of energy. If translations are restricted to time-like translations acting in the direction of the future (past) then one has local translation invariance of dynamics for classical field equations inside $\delta M^4_{\pm}$ as a kind of semigroup. Also the M^4 translations leading to interior of X^4 from the light-like 2-surfaces surfaces act as translations. Classically these restrictions correspond to non-tachyonic momenta defining the allowed directions of translations realizable as particle motions. These two kinds of translations can be assigned to super-symplectic conformal symmetries at $\delta M^4_{\pm} \times CP_2$ and and super Super-Kac-Moody type conformal symmetries acting as super-symplectic isometries. Super-symplectic algebra is realized in terms of second quantized spinor fields and covariantly constant modes of right-handed neutrino. Symplectic group has as sub-group symplectic isometries and the Super-Kac-Moody algebra associated with this group and represented in terms of spinor modes localized to string world sheets plays also a key role in TGD.
Finite M^4 translations to the interior of CD do not respect the shape of the partonic 2-surface. Local M^4 translations vanishing at the boundary of CD however act as Kac-Moody symmetries of the light-like 3-surfaces and reduce physically to gauge transformations: hence one could allow also the deformations of the partonic 2-surface in the interior of the light-like 3-surface. This corresponds to the effective metric 2-dimensionality stating that all information both about the geometry of WCW and quantum physics is carried by the partonic 2-surfaces X^2 resulting as intersections of the light-like 3-surfaces X^3_l and space-like 3-D surfaces X^3 at the boundaries of CD and the distribution of 4-D tangent planes of X^2.

(c) The condition selecting preferred extremals of Kähler action is induced by a global selection of $M^2 \subset M^4$ as a plane belonging to the tangent space of X^4 at all its points [K31] and interpreted as a plane of nonphysical polarizations so that direct connection with number theory and gauge symmetries emerges. The M^4 translations of X^4 as a whole in general respect the form of this condition in the interior. Furthermore, if M^4 translations are restricted to M^2, also the condition itself - rather than only its general form - is respected. This observation, the earlier experience with p-adic mass calculations, and also the treatment of quarks and gluons in QCD encourage to consider the possibility that translational invariance should be restricted to M^2 translations so that mass squared, longitudinal momentum and transversal mass squared would be well defined quantum numbers. This would be enough to realize zero energy ontology. Encouragingly, M^2 appears also in the generalization of the causal diamond to a book-like structure forced by the realization of the hierarchy of Planck constant at the level of the embedding space.

(d) That the cm degrees of freedom for CD would be gauge like degrees of freedom sounds strange. The paradoxical feeling disappears as one realizes that this is not the case for sub-CDs, which indeed can have non-trivial correlation functions with either upper or lower tip of the CD playing a role analogous to that of an argument of n-point function in QFT description. One can also say that largest CD in the hierarchy defines infrared cutoff.

Objection against zero energy ontology

In Zero Energy Ontology (ZEO), the basic geometric structure is causal diamond (CD), which is a subset of $M^4 \times CP_2$ identified as an intersection of future and past directed light cones of M^4 with points replaced with CP_2. Poincare symmetries are isometries of $M^4 \times CP_2$ but CD itself breaks Poincare symmetry.

Whether Poincare transformations can act as global symmetries in the "world of classical worlds" (WCW), the space of space-time surfaces - preferred extremals - connecting 3-surfaces

at opposite boundaries of CD, is not quite clear since CD itself breaks Poincare symmetry. One can even argue that ZEO is not consistent with Poincare invariance. By holography one can either talk about WCW as pairs of 3-surfaces or about space of preferred extremals connecting the members of the pair.

First some background.

(a) Poincare transformations act symmetries of space-time surfaces representing extremals of the classical variational principle involved, and one can hope that this is true also for preferred extremals. Preferred extremal property is conjectured to be realized as minimal surface property realize in terms of appropriately generalized holomorphy property meaning that field equations are separately satisfied for Kähler action and volume action apart from 2-D string world sheets and their boundaries to which one can assign the analog of Kähler action.

(b) String world sheets and their light-like boundaries carry elementary particle quantum numbers identified as conserved Noether charges assigned with second quantized induced spinors solving modified Dirac equation determined by the action principle determining preferred extremals. Quantum classical correspondence (QCC) states that classical charges are equal to the eigenvalues of Poincare generators in Cartan algebra of Poincare algebra. This would hold quite generally.

(c) The ground states of super-symplectic and super-Kac-Moody representations correspond to spinor harmonics with well-defined Poincare quantum numbers. Excited states are obtained using generators of symplectic algebra and have well-defined four-momenta identifiable also as classical momenta.

(d) In ZEO one assigns opposite total quantum numbers to the boundaries of CD: this codes for the conservation laws. The action of Poincare transformations can be non-trivial at second (active) boundary of CD only and one has two kinds of realizations of Poincare algebra leaving either boundary invariant. Since Poincare symmetries extend to Kac-Moody symmetries analogous to local gauge symmetries it should be possible to achieve trivial action at passive boundary of CD so that the Cartan algebra of symmetries acts non-trivially only at the active boundary of CD. Physical intuition suggests that Poincare transformations on the entire CD treating it as a rigid body correspond to trivial center of mass quantum numbers.

How do the Poincare transformations act on 3-surfaces at the active boundary of CD?

(a) Zero energy states are superpositions of 4-D preferred extremals connecting 3-D surfaces at boundaries of CD, the ends of space-time. One should be able to construct the analogs of plane waves as superpositions of space-time surfaces obtained by translating the active boundary of CD and 3-surfaces at it so that the size of CD increases or decreases. The translate of a preferred extremal is a preferred extremal associated with the new pair of 3-surfaces and has size and thus also shape different from those of the original. Classical theory becomes obviously an essential part of quantum theory.

(b) Four-momentum eigenstate is an analog of plane wave which is superposition of the translates of a preferred extremal. In practice it is enough to have wave packets so that in given resolution one has a cutoff for the size of translations in various directions. As noticed, QCC requires that the eigenvalues of Cartan algebra generators such as momentum components are equal to the classical charges.

9.2.3 The Anatomy Of Quantum Jump In Zero Energy Ontology (ZEO)

Zero energy ontology (ZEO) emerged around 2005 and has had profound consequences for the understanding of quantum TGD. The basic implication is that state function reductions occur at the opposite light-like boundaries of causal diamonds (CDs) forming a hierarchy, and produce zero energy states with opposite arrows of time. Also concerning the identification of quantum jump as moment of consciousness ZEO encourages rather far reaching conclusions. In ZEO the only difference between motor action and sensory representations is that the arrows of embedding space time (CDs) are opposite for them. Furthermore, sensory perception

followed by motor action corresponds to a basic structure in the sequence of state function reductions and it seems that these processes occur fractally for CDs of various size scales.

(a) State function reduction can be performed to either boundary of CD but not both simultaneously. State function reduction at either boundary is equivalent to state preparation giving rise to a state with well defined quantum numbers (particle numbers, charges, four-momentum, etc...) at this boundary of CD. At the other boundary single particle quantum numbers are not well defined although total conserved quantum numbers at boundaries are opposite by the zero energy property for every pair of positive and negative energy states in the superposition. State pairs with different total energy, fermion number, etc.. for other boundary are possible: for instance, the coherent states of superconductor for which fermion number is ill defined are possible in zero energy ontology and do not break the super-selection rules.

(b) The basic objects coding for physics are U-matrix, M-matrices and S-matrix. M-matrices correspond to hermitian square roots of density matrices multiplied by a universal S-matrix which depends on the scale n of CD in very simple manner: $S(n) = S^n$ giving thus a unitary representation for scalings. The explicit construction of a unitary U-matrix in terms of M-matrices is carried out in [K68]: U-matrix elements are essentially inner products of M-matrices associated with CDs with various size scales. One can say that quantum theory is formally a square root of thermodynamics. The thermodynamics in question would however relate more naturally to NMP rather than second law, which at ensemble level and for ordinary entanglement can be seen as a consequence of NMP.
The non-triviality of M-matrix requires that for given state reduced at say the "lower" boundary of CD there is entire distribution of states at "upper boundary" (given initial state can lead to a continuum of final states). Even more, all size scales of CDs are possible since the position of only the "lower" boundary of CD is localized in quantum jump whereas the location of upper boundary of CD can vary so that one has distribution over CDs with different size scales and over their Lorentz boots and translates.

(c) The quantum arrow of time follows from the asymmetry between positive and negative energy parts of the state: the other is prepared and the other corresponds to the superposition of the final states resulting when interactions are turned on: also quantum superposition over CDs of different sizes with second boundary belonging to the same fixed $\delta M^4_{\pm}$ is possible. What is remarkable that the arrow of time at embedding space level (at least) changes direction as quantum jump occurs to opposite boundary.
It is however possible to have sequences of quantum jumps occurring at the same boundary: these periods are counterparts for repeated state function reductions, which do not change the state at all in standard quantum measurement theory. During these periods the superposition of opposite boundaries of CDs and states at them change, and the average distance between the tips of CDs tends to increase, hence the flow of subjective time and its arrow.
NMP dictates when the first quantum jumps to the opposite boundary of CD takes place. The sequence of state function reduction at the same boundary defines self as a conscious entity and the increase of the average distance between the tips of CD defines the life-time of self.
This brings strongly in mind the old proposal of Fantappie [J30] that in living matter the arrow of time is not fixed and that entropy and its diametric opposite syntropy apply to the two arrows of the embedding space time. The arrow of subjective time assignable to second law would hold true but the increase of syntropy would be basically a reflection of second law since only the arrow of the geometric time at embedding space level has changed direction. The arrow of geometric at space-time level which conscious observer experiences directly could be always the same if quantum classical correspondence holds true in the sense that the arrow of time for zero energy states corresponds to arrow of time for preferred extremals. The failure of strict non-determinism making possible phenomena analogous to multi-furcations makes this possible.

(d) This picture differs radically from the standard view and if quantum jump represents a fundamental algorithm, this variation of the arrow of geometric time should manifest itself in the functioning of brain and living organisms. The basic building brick in the function-

ing of brain is the formation of sensory representation followed by motor action/volition realized as the first reduction at the opposite boundary.
These processes look very much like temporal mirror images of each other such as the state function reductions to opposite boundaries of CD look like. The fundamental process could correspond to a sequences of these two kinds of state function reductions at opposite boundaries of CDs and maybe independently for CDs of different size scales in a "many-particle" state defined by a union of CDs.

How the formation of cognitive and sensory representations could relate to quantum jump?

(a) The earlier view was based on the idea that p-adic space-time sheets can transform to real ones and vice versa in quantum jump and these process correspond to a realization of intention as action and formation of though. This view is mathematically awkward and has been replaced with the adelic vision in which all systems have both sensory (real space-time sheets) and cognitive (p-adic space-time sheets) space-time correlates. The real and p-adic number fields form a book like structure - adele- with an algebraic extension of rationals as its back. Same applieds at the level of embedding space, space-time surfaces, and WCW. In this framedwork holography makes it possible to understand real and p-adic space-time surfaces as continuations of string world sheets and partonic 2-surfaces to space-time surfaces, either real or p-adic. The string world sheets themselves are in the intersection of reality and various p-adicities in the sense that the parameters characterizing them belong to an extension of rational numbers.

(b) Self having the mental image about intention can be be seen as the agent transforming intention to action. By NMP negentropy is typically generated in this transition tending to increase the value of Planck constant $h_{eff} = n \times h$ and thus reducing quantum criticality and occurring therefore spontaneously. Negentropy Maximization Principle eventually forces the occurrence of volitional action - self experiences the urge to perform the action so strong that cannot resist. Subself representing the mental image about intention tries to prevent it as long as possible because it means death: all living systems try to stay at the existing level of criticality and avoid the fatal final state function reduction by practicing homeostasis and using metabolic energy. Weak form of NMP states that self has freedom to decide whether it performs the reduction producing maximal entanglement negentropy. It can also perform ordinary quantum jump reducing entanglement entropy to zero and destroying entanglement. The outcome is isolation from the external world. The motivation for the weak form of NMP is that we do not live in the best possible world and have free will to choose between Good and Evil. Strong form of NMP would produce always mazimal negentropy gain and would mean best possible world.ur in various length scales in fractal manner.

9.2.4 Conscious Entities And Arrow Of Time In TGD Universe

"Fractality from your blog" posed an interesting question about possible asymmetry between boundaries of causal diamond CD. The answer to the question led to recall once again the incomplete understanding of details about how the arrow of time emerges in zero energy ontology (ZEO).

The basic vision is following.

(a) CDs form a fractal scale hierarchy. Zero energy states possess a wave function in moduli degrees of freedom characterizing sizes of CDs as well telling what Lorentz boost leaving boundary invariant are allowed for them. Boosts form by number theoretic constraints a discrete subgroup of Lorentz group defining analogs of lattices generated by boosts instead of translations.

(b) The arrow of subjective time maps to that of geometric time somehow. The origin of arrow comes from the fact that state function reductions can occur to either boundary of given CD and reduction creates time-asymmetric state since second boundary of CD is in a quantum superposition of different sizes and there is a superposition of many-particle states with different particles numbers and quantum number distributions. It is possible that each state function reduction leaving the passive boundary intact, involves localization in the moduli space of CDs with second boundary fixed.

(c) Subjective existence corresponds to a sequence *of moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD. This predicts that the arrow of time is not constant. In fact, there is considerable evidence for the variation of the arrow of time in living systems and Fantappie [J30] introduced long time ago the notion of syntropy to describe his view about the situation.

(d) The first very naïve proposal was that state function reductions occur *alternately* to the two boundaries of CD. This assumption would be indeed natural if one considered single fixed CD rather than superposition CDs with different size and state function reduction localizing their either boundary: restriction to single CD was what I indeed did first.

(e) This assumption leads to the question about why do we do not observe this alternation of the arrow of time all the time in our personal experience. Some people actually claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. But why do we experience the arrow of time as stable in the standard state of consciousness?

One possible way to solve the problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately!

I made this totally trivial observation only after I had realized that also in this process the wave function in the moduli space of CDs change in these reductions. Zeno effect in ordinary measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions do not affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say.1 seconds. It would allow to understand why we do not observe continual change of arrow of time.

Maybe living systems are working hardly to keep the personal arrow of time un-changed - living creatures try to prevent kettle from boiling by staring at it intensely. Maybe it would be extremely difficult to live against the collective arrow of time.

An objection against this picture as compared to the original one assuming alternate reductions to the opposite boundaries of CD is that is that one can understand state preparation as state function reduction to the opposite boundary. This interpetation makes sense almost as such also in the new picture if the average time period for which the reductions occur to a given boundary is shorter in elementary particles scales than in macroscopic scales characteristic for human consciousness. The approximate reversibility in elementary particle scales can be understood as summing up of the two arrows of time to no arrow at all.

This picture allows also to identify self as a continuous entity as the sequence of state function reductions occurring at the same boundary of CD. The average increase of the temporal distance between the tips of cD defines the life-time of self. The number of reductions would give a measure for the subjectively experienced of life-time of self.

In elementary particle time scales reversibility is a good approximation and this suggests that in elementary particle scales the number of state function reductions at the same boundary of CD is small so that the effects due to the change of the arrow of time cancel on the average.

NMP would eventually force "death" of self since the state function reduction at opposite boundary would generate more negentropy. "Death" of self would mean birth of self asssociated with the opposite boundary of CD. The age of self identified as the proper time distance between the tips would increase in statistical sense even when its arrow can change. The act of volition would have a natural identification as the first state function reduction at the opposite boundary of CD.

This picture raises a series of questions. Do our wake-up periods correspond to sequences of state function reductions for self and are sleeping periods wake-up periods of the self at the

opposite boundary of CD? The arrow of geometric time should change at some space-time sheet associated with the self hierarchy. How could one demonstrate this? Are the memories of the "other" self predictions of future from our point of view? Do we sleep in order to get information from future, to remember what the future will be?

How the hierarchy of Planck constants defining a hierarchy of quantum criticalities does relate to this picture? The ageing of self having has as a correlate the increase of the size scale of CD. Could this increase be due to the increase of h_{eff} expected to occur spontaneously since it corresponds to a reduction of criticality and therefore to the appearance of new physical degrees of freedom as symplectic gauge degrees of freedom transform to physical ones in gauge symmetry breaking. This is not the case. The time evolution must be analogous to shift in time rather than scaling. This of course corresponds to the QFT view about time evolution.

In the first state function reduction to the opposite boundary of CD however scaling of CD is possible and would correspond to the scaling of CD represented by exponent of infinitesimal scaling operator as in conformal field theories. The emergence of bew physical degrees of freedom suggest increasing perceptive and cognitive capabilities. The increase of h_{eff} could be seen as evolution as also the associated increase of resources of negentropic entanglement suggests. The total increase of h_{eff} measured by the ratio $h_{eff}(final)/h_{eff}(initial)$ could be seen as a measure for the progress per single life period of self.

9.2.5 Copenhagen interpretation dead: long live ZEO based quantum measurement theory!

I encountered a very interesting ScienceDaily article "*Physicists can predict the jumps of Schrödinger's cat (and finally save it)*" (see `http://tinyurl.com/y5lpe2eo`). The experimental findings described in the article are extremely interesting from the point of view provide by TGD inspired quantum measurement theory relying on Zero Energy Ontology (ZEO) and provides a test for it.

In standard quantum measurement theory (Copenhagen interpretation) of Bohr quantum jump is random in the sense that it occurs with predictable probabilities to an eigenstate of the measured observables. Their occurrence cannot be predicted and even less prevented - except by monitoring - Zeno effect.

The findings of Minev *et al* are described in the article "*To catch and reverse a quantum jump mid-flight*" [L83] (see `https://arxiv.org/abs/1803.00545`). The outcome of quantum jump is indeed unpredictable but the time of occurrence is to high degree predictable: there is a detectable warning signal, period of "flight" from the initial to the final state!

A curious feature is that the external signal responsible for the quantum jump can be stopped during the "flight" from the initial to final state. As if the quantum jump is analogous to a domino effect. It is also claimed that the jump can be reversed during flight period by a control signal: if jump has already occurred then one might argue that the control signal induces quantum jump in opposite direction when applied at time which is roughly the mid-time of "flight".

If the findings by Minev *et al* are replicable, one is forced to give up the basic assumption of the standard quantum measurement theory stating that state function reductions occur completely randomly and instantaneously. State function reduction (SR) looks like a continuous, deterministic process. Bohr's theory would be dead also officially and one must finally go back to the blackboard and start serious thinking about fundamentals. It took 92 years - almost a century! State function reduction (SR) is definitely more complex phenomenon than predicted by Bohr.

What is most intriguing that SR looks smooth, deterministic classical time evolution although the outcome is not predictable. People loving hidden variables might be happy but better to think about this more precisely before jumping to any conclusions. Authors apply so called quantum trajectory theory to describe the findings [B12] and report that the model is able to predict the parameters of the parameterization with one per cent accuracy.

Zero energy ontology (ZEO) based view about quantum measurement and the relationship between geometric and subjective time explains why state function reduction looks like a

deterministic process. Unfortunately, what ZEO is, is not completely clear [L88]. This allows to consider two options.

(a) Both options imply that one can apparently anticipate quantum jump. This could be however an illusion: the observed classical time evolution could occur *after* the quantum jump in opposite direction of time. The fact that the absence of the signal inducing quantum jump does not affect the occurrence of quantum jump suggests that the "flight" period indeed represents the classical evolution after the quantum jump in the reversed direction of time so that the absence of the external signal would not anymore affect the situation. Generalized Zeno effect is essential element ZEO based quantum measurement theory so that SR might be prevented. Perhaps a more plausible interpretation is that the control signal induces the reversal of the quantum jump already occurred. A careful analysis to distinguish between subjective and geometric time and arrows of time for the observer and atom would be needed.

(b) The more conventional option nearer to the interpretation of experimenters is that the observered time evolution occurs *before* the quantum jump in standard direction. The period before quantum jump consists of a sequence of "small" state function reductions - "weak" measurements. $M^8 - H$ duality suggests a concrete assignment of the moments of time to them [L88] and there would be also the last moment of this kind. After these things proceed to "big" state function reduction in analogy with domino effect. It is not however obvious why the classical time evolution should appear to converge to the final outcome deterministically.

First ZEO based based view about the findings

What about TGD and zero energy ontology (ZEO) based quantum measurement theory [K68]? Could it explain the revolutionary findings?

(a) The new element is that quantum states are not time= constant snapshots for time evolution but superpositions of entire deterministic time evolutions at the level of space-time surfaces and at the level of induced spinor fields. SR replaces super position of classical time evolutions with a new one. This like selecting and starting new deterministic computer program. Non-determinism is in these choices [L62].

(b) The notion of causal diamond (CD) identified as an intersection of future and past directed light-cones of M^4 with points replaced with CP_2 is crucial. The notion of CD is strongly suggested by the gigantic symmetries of CD essential for the construction of quantum TGD. CD could be seen as embedding space correlate for the perceptive field of a conscious entity - self. The upper boundary of CD - to be called active boundary A represents the boundary for space-time region from which self can receive classical signals and is therefore natural. The lower boundary, to be called passive boundary B, brings in mind cosmic expansion and follows as a prediction from $M^8 - H$ duality.

(c) There are two kinds of state function reductions in ZEO.

   i. In "small" SRs (SSRs) the states change at active boundary of causal diamond (CD) (call it A) but remain unchanged at passive boundary (call it P): generalized Zeno effect occurs at the passive boundary and "weak measurements" (see `http://tinyurl.com/zt36hpb`) at A. The observables measured commute with those determining the states at P as their eigenstates. In particular, the location of A is measured localizing it and corresponds to the measurement of time as distance between the tips of CD.

   "Big" SRs (BSRs) reverse the arrow of time of zero energy states and the roles of A and P. BSR is preceded by a sequence of SSRs - "weak" or almost classical measurements. In TGD inspired theory of consciousness [L62, L88] [K54] this sequence defines the life cycle of a conscious entity - self.

What is of crucial importance that BSR creates the illusion that it is an outcome of a continuous process: this realizes quantum classical correspondence (QCC). Standard observer assumes standard arrow of time and the space-time surfaces in the final time reversed state seem to lead to the 3-surface serving as a correlate for the final state! As if BSR would be

outcome of a smooth deterministic process, which it is not! There is actually a superposition of these 3-surfaces at A after BSR but in the resolution used this is not detected. Putting it more precisely:

(a) The time reversal of time evolution is in good approximation obtained by time reflection symmetry T but not quite since T is slightly broken. This is extremely small effect.

(b) Before BSR one has a distribution of 3-surfaces X^3 defining the ends of space-time surfaces X^4 at A: 3-surfaces X^3 corresponds to different outcomes of BSR and can differ dramatically. Observer is not conscious of this. This is like a situation of Schrödinger cat before measurement: it is impossible to be conscious about the superposition of dead and alive cat.
After BSR one has quantum superposition of space-time surfaces directed to geometric past. Near the end of space-time at A they look like leading to a unique classical counterpart of final state of state function reduction. As if the state function reduction were a smooth, continuous, deterministic process. BSR guarantees this but BSR is not a smooth evolution.

The experimental findings could be understood by applying this general picture.

(a) One can assign to the evolution from initial state G of atom at P to final state E at A a sequence of small reductions, weak measurements and also superposition of classical time evolutions approximated by single evolution in given measurement resolution. The state E is superposition of various measurement outcomes and each of them corresponds to a superposition of space-time surfaces identical in the measurement resolution used.

(b) Then occurs the BSR: atom jumps from state E to state D. This selects from the superposition of space-time surfaces/time only the evolutions apparently leading to D. Or more precisely: the superposition of reversed time evolutions starting from D at A and very similar near A but deviating farther from it. The illusion about continuous, smooth, deterministic time evolution from G to D is created!

(c) Also the possibility to anticipate the reduction would be an illusion due to the different arrows of time for observer and the observed system after BSR. The time reversed time evolution actually starts from the final state. The warning signal (absence of photon emission would be natural consequence of the reduction but in reversed arrow of time. The illusion would be due to the identification of arrows of time of observer and the atom that made state function reduction. This conforms with the observation that one can drop away the periodic signal inducing the quantum jumps during the "flight" period identified as the deterministic process representing the quantum jump.
The lesson would be that one must always check whether the arrow of time for the target of attention is same as my own. Not a good idea to be on the wrong lane (means death also in ZEO based consciousness theory).
It is also claimed that on can prevent the quantum jump using a signal during the "flight" period. Generalized Zeno effect is basic element of TGD but the signal forcing the state to remain in P would be present before the quantum jump. This would suggest that the control signal induced quantum jump in opposite direction. To really understand the situation a careful analysis of the relationships between subjective and geometric times of observer and between geometric time of observer and atomic system after and before the quantum jump would be needed.

Also Libet's findings about active aspects of consciousness [J5] can be interpreted in ZEO along the same lines. The observation that the neural activity begins before conscious decision can be understood by saying that the act of free will as a big state function reduction changed the arrow of time for an appropriate subsystem of the system studied. Tte time reversed classical evolutions from the outcome of the volitional action were interpreted erratically as a time evolution leading to the conscious decision. A less precise manner to say this is that conscious decision (big state function reduction) sent a classical signal to geometric past with opposite arrow of time initiating neural activity. Libet's finding led physicalistic neuroscientists to conclude that free will is an illusion. The actual illusions were physicalism and the belief that arrow of time is always the same.

To sum up, ZEO is fantastic magician. Maybe this magic is necessary for the mental health of observer: a world without this illusion would be like nightmare where one cannot trust anything.

Second ZEO based based view about the findings inspired by $M^8 - H$ duality

I have learned to take experimental findings very seriously and I am ready to aks whether the above described option the only possibility allowed by ZEO or can one think other alternatives? It would be nice to answer "No" but one can consider variants of ZEO [L88] inspired by so called $M^8 - H$ duality [L52, L100].

The sequence of "small" state function reductions (SSRs) should have the last one. Is the "big" state function reduction (BSR) forced by some condition? One idea is that the life cycle of self corresponds to a measurement of all observables assignable to the active boundary A of CD and commuting with those defining the unaffected states at passive boundary P are measured (time as a location of A belongs to these observables measured in each SSR).

I have discussed in [L88] possible modifications of ZEO inspired by so called $M^8 - H$ duality [L52, L100]. One motivation is that time flow as shifting M^4 time $t = constant$ hyper-plane can be argued to be more natural than that for light-cone boundary. Light-cone boundaries are however favored by its huge symmetries essential for the definition of the geometry of "world of classical worlds" (WCW). $M^8 - H$ duality forces passive light-cone boundary P and the identification of A as boundary of region where sensory signals can arrive to self is natural.

$M^8 - H$ duality allows to consider variants the original ZEO.

1. $M^8 - H$ duality

Let us first briefly summarize what $M^8 - H$ duality [L52] is.

(a) $M^8 - H$ duality is one of the key ideas of TGD, and states that one can regard space-times as surfaces in either complexified octonionic M^8 or in $M^4 \times CP_2$. The dynamics M^8 is purely algebraic and requires that either tangent or normal space of space-time surface is associative (quaternionic).

(b) The algebraic equations for space-time surfaces in M^8 state the vanishing of either the real or imaginary part (defined in quaternionic sense) for octonion valued polynomial $P(o)$ with real coefficients. Besides 4-D roots one obtains as universal exceptional roots 6-spheres at boundary of the light-cone of M^8 with radii given by the roots r_n of the polynomial in question. They correspond to the balls $t = r_n$ (t is octonionic real coordinate) inside Minkowski light-cone with each point have as fiber a 3-sphere S^3 with radius contracting to zero at the boundary of the light-cone of M^4. These 6-spheres are clearly analogous to branes connected by 4-D space-time surfaces.

(c) The intersections of space-time surfaces with 6-spheres would be 2-D and I have interpreted them as partonic 2-surfaces identifiable as topological particle reaction vertices - partonic 2-surfaces - at which incoming and outgoing light-like 3-surfaces meet along their ends. These light-like 3-surfaces - partonic orbits - would represent the boundaries between space-time regions with Euclidian and Minkowskian signatures of the induced metric. Partonic 2-surfaces would be analogs of the vertices of Feynman diagrams. The boundaries of string world sheets predicted as singularities of minimal surfaces defining space-time surfaces would be along the partonic orbits and give rise to QFT type description using cognitive representations and analogs of twistor diagrams consisting of lines.

2. $M^8 - H$ duality and consciousness

One can ask whether $M^8 - H$ duality and this braney picture has implications for ZEO based theory of consciousness. Certain aspects of $M^8 - H$ duality indeed challenge the recent view about consciousness based on ZEO (zero energy ontology) and ZEO itself.

(a) The moments $t = r_n$ defining the 6-branes correspond classically to special moments for which phase transition like phenomena occur. Could $t = r_n$ have a special role in consciousness theory?

i. For some SSRs the increase of the size of CD reveals new $t = r_n$ plane inside CD. One can argue that these SSRS define very special events in the life of self. This would not modify the original ZEO considerably but could give a classical signature for how many ver special moments of consciousness have occurred: the number of the roots of P would be a measure for the lifetime of self and there would be the largest root after which BSR would occur.

ii. Second possibility is more radical. One could one think of replacing CD with single truncated future- or past-directed light-cone containing the 6-D universal roots of P up to some r_n defining the upper boundary of the truncated cone? Could $t = r_n$ define a sequence of moments of consciousness? To me it looks more natural to assume that they are associated with very special moments of consciousness.

(b) For both options SSRs increase the number of roots r_n inside CD/truncated light-one gradually and thus its size? When all roots of $P(o)$ would have been measured - meaning that the largest value r_{max} of r_n is reached -, BSR would be unavoidable.
BSR could replace $P(o)$ with $P_1(r_1 - o)$: r_1 must be real and one should have $r_1 > r_{max}$. The new CD/truncated light-cone would be in opposite direction and time evolution would be reversed. Note that the new CD could have much smaller size size if it contains only the smallest root r_0. One important modification of ZEO becomes indeed possible. The size of CD after BSR could be much smaller than before it. This would mean that the re-incarnated self would have "childhood" rather than beginning its life at the age of previous self - kind of fresh start wiping the slate clean.
One can consider also a less radical BSR preserving the arrow of time and replacing the polynomial with a new one, say a polynomial having higher degree (certainly in statistical sense so that algebraic complexity would increase).

3. Is a more conservative view possible?

Could this picture allow to build a more conservative picture more akin to that proposed by experimenters?

(a) The interpretation of the detected time evolution as that *before* the quantum jump would conform with the interpretation of experimentalists that a kind of domino effect is involved and also with the observation that stopping the signal causing the quantum jumps does not anymore affect the situation.

(b) It is however unclear how to understand why the evolution looks like leading to the outcome unless the sequence of r_n:s defines a sequence of steps gradually taking the system near the final state.

(c) What about preventing the BSR by external signal and even reversing the quantum jump? This would require an external perturbation of the octonionic polynomial increasing the value of the largest root r_{max} or even the degree of the polynomial and bringing in additional significant moments of life. Is it possible to speak about external perturbations of the coefficients of polynomials assumed to be rational numbers? The perturbations would come from a higher level in the hierarchy of selves (experimentalist), and one can imagine them in the framework of many-sheeted space-time.

To sum up, to my opinion (which could change) the first option looks more plausible. The introduction of moments $t = r_n$ as special moments in the life of self looks highly attractive and also the possibility of wiping the slate clear.

9.2.6 Could ZEO allow over-unity effects and quantum error correction mechanism?

The notion of free energy used by free energy researches is different from the standard notion of free energy appearing in thermodynamics. Free energy researchers typically claim over-unity effects. In strong form it would mean non-conservation of energy and academic community concludes that since energy is conserved, these claims are crackpot non-sense. In weaker form the claims would mean transformation of heat to work with efficiency larger than the upper bound predicted by Carnot law.

Second law kills hopes about perpetual motion machines based on this kind of over-unity effects. Second law however assumes fixed arrow of time. There exists however strong empirical evidence for the possibility that the arrow of time can change - phase conjugate waves are the key example. This led Fantappie [J30] to propose the notion of syntropy as entropy in reversed time direction. Second law in reverse time direction could also allow an error correction mechanism in quantum computation: Nature itself would do it. Phase conjugate waves are indeed known to perform error correction.

Quantum TGD relies on zero energy ontology (ZEO). ZEO allows both arrows of time and a temporary change of the arrow of time could make possible to break the standard laws of thermodynamics at least temporarily and in short enough scales. ZEO indeed plays a key role in TGD inspired quantum biology and quantum theory of consciousness.

In the following I will consider the issue of energy conservation in ZEO. Classically energy is well-defined and conserved in TGD Universe. But what about energy conservation in quantum sense? ZEO involves delocalization of states in time and this could allow energy conservation only in some resolution determined by the scale of the increment of time in given state function reduction inducing a shift of the active boundary of CD farther from the passive one.

Energy is conserved classically in TGD but what about conservation in quantum sense in ZEO?

ZEO guarantees classical conservation laws. What about the situation at quantum level? Could the energy associated with the positive energy part of zero energy state increase in quantum transitions and lead to over-unity effects? In principle, conservation laws do not prevent this quantally.

(a) Recall that zero energy states [K68] [L62] are identified as superpositions of pairs (a, b) formed from states a and b having opposite total quantum numbers and being assigned with the opposite boundaries of causal diamond (CD). The states at the passive boundary B of CD are not affected whereas the states at the active boundary A are affected by a sequence of unitary time evolutions also shifting A farther away from B (in statistical sense at least).
Each unitary evolution induces a de-localization of A in its moduli space and "small" SFR induces its localization (including time localization meaning time measurement). This sequence would approximately conserve the energies of the states in the superposition. This in the approximation that their energies are large in the energy scale $\Delta E = \hbar_{eff}/Deltat$ defined by the time increment Δt in single unitary time evolution. Large value of h_{eff} makes the conservation worse for a given Δt. Unitarity together with the approximate energy conservation implies that the average energy is approximately conserved.

(b) Negative energy signals sent from A to its geometric past and received at B in remote metabolism would correspond to "big" SFR. If the notion of remote metabolism giving effectively rise to over-unitary effect is to make sense, the approximate energy conservation should fail in "big" SFRs in quantal sense. For this to be the case, the first unitary evolution of B followed by "small" SFR energy conservation should be a bad approximation. This does not however seem plausible if one assumes energy conservation for the next state function reductions. What could be so special in the first state function reduction?

(c) Why the energy conservation made approximate by the finite size of CD and finite duration of unitary evolution, should fail badly in some situations? According to the number theoretic vision [L60], "small" SFRs preserve the extension of rationals defining the adele and therefore also $\hbar_{eff}/\hbar_0 = n$ identifiable as the dimension of the extension. $\hbar_{eff}/\hbar_0 = n$ can however change $n_{old} \to n_{new}$ in "big" SFRs forced to occur when "small" SFRs preserving n_{old} are not anymore possible. If a large increase of h_{eff} occurs in the "big" SFR, the $\Delta E = \hbar_{eff}/Deltat$ increases if Δt is still of the same order of magnitude. The approximate energy conservation could fail badly enough to make possible remote metabolism.

(d) In the subsequent SFRs energy conservation should however hold true in good approximation. The values of Δt should be large in the subsequent "small" SFRs, and Δt should scale as $\Delta t \propto n$ to guarantee that ΔE remains the same. As a quantum scale Δt analogous to Compton length is indeed proportional to n. In the first reduction one must have of $n = n_{old}$ but in the subsequent reductions one must have $n = n_{new}$ to guarantee energy conservation in the same approximation as before.
To sum up: in the first "small" SFR one should have $\Delta E \propto n_{new}$ and $\Delta t \propto n_{new}$. Can one really deduce this from the basic TGD?

(e) ZEO suggests that evolution [L68] means a continual increase of the size of CD so that arbitrarily small CD could eventually grow to even cosmic size (whether this occurs always or whether zero energy state can become pure vacuum at both boundaries of CD remains an open problem). CD with a cosmic size should however have huge energy. This would not only require non-conservation of energy in quantal sense but also its increase in statistical sense at least. Why should the energy increase?
The increase would relate directly to the basic defining property of ZEO. Preferred time direction means that the transfer of quantum numbers, in positive energy with fixed sign, can take place only from the active boundary of CD to the passive boundary in "big" SFR. This allows interpretation as remote metabolism implying increase of the magnitude of energy.

Criticism

Quite recently (towards end of 2019) I found a more precice formulation for the intuitive notion of remote metabolism, which strongly suggests that energy is conserved in ZEO. There is a decomposition to system and the energy energy source: call them A and B. Intuitively, A receives energy from B by sending negative energy to B. What does this really mean?

(a) A "big" state function reduction reversing arrow of time takes place: this would correspond to sending negative energy signal to past. The energy of A+B in the final time reversed state at new passive boundary of CD would be shared in new manner such that one can say that A has received from B the metabolic energy.

(b) Energy would be conserved. I have also considered the interpretation that the total energy of the system associated with CD increases [K68] [L98]: since CD itself breaks Poincare invariance, it seems that one cannot exclude this. However, the Poincare invariance is realized at the level of moduli space for the positions of the either boundary of CD, and one can assume energy conservation. Even the wave functions at the boundary of CD can be taken to be in the representations of Lorentz group acting as its isometries. Plane waves correspond to wave functions in the moduli space for the boundary of CD keeping second boundary fixed.

(c) To make this more precise one must define metabolic energy more precisely by introducing the hierarchy of Planck constants and the fact that the increase of h_{eff} of sub-system keeping other parameters constant increases it energy. Second law means that A tends to loose energy due to the decrease of h_{eff} for its sub-systems. This is true also for the time-reversed state but in opposite direction of geometric time so that with respect to standard direction of time the energy increases. This would provide extremely general purely thermodynamical mechanism of remote metabolism.

Could Nature provide an error correction mechanism for quantum computation?

Error correction has turned out to be major problem in the attempts to construct quantum computers. It is believed to be necessary because quantum entanglement is extremely fragile for the standard value of Planck constant. In TGD the situation changes. Large values of h_{eff} increasing the time scale of entanglement are possible and reversed time evolutions in quantum sense imply second law in reversed time direction meaning spontaneous reduction of entropy in the standard time direction. Nature itself would provide the needed error correction mechanism perhaps applied routinely in living systems (for instance, to correct mutations of DNA and transcription and translation errors).

To sum up, this picture is extremely interesting from the point of view of future technologies. One can even challenge the cherished law of energy conservation at quantum level (classically it remains exact in TGD Universe). Could one consider the possibility that the energy of system could be increased by the evolution by "big" state function reductions increasing the value of h_{eff}? Could one at least temporarily reduce entropy by inducing time evolutions in opposite time direction? TGD strongly suggests that these mechanisms are at work in biology. Maybe energy and iquantum nformation technologists could learn something from living matter?

9.2.7 Ballistic resonance and zero energy ontology

The popular article "*Scientists have discovered a new physical paradox*" (`https://cutt.ly/lp6VL4l`) tells about the work of Vitaly A. Kuzkin *et al* published in Phys Rev E (`https://cutt.ly/Jp8XHYY`) as an article [D16] with title "*Ballistic resonance and thermalization in the Fermi-Pasta-Ulam-Tsingou chain at finite temperature*" . The article describes very interesting experimental findings, which could provide a direct application of zero energy ontology (ZEO) based theory of self-organization.

The findings and their explanation provided by experimenters

Researchers from the Peter the Great St. Petersburg Polytechnic University (SPbPU) have discovered a new physical effect: the amplitude of mechanical vibrations can grow without external influence in which system converts its thermal energy to mechanical energy. The phenomenon is known as ballistic resonance. The description of the phenomenon involves also an abnormally high heat conductivity - one speaks of ballistic heat conductivity.

The electromagnetic analogy is very high electric conductivity: the work of Bandyopadhyay related to effects of oscillating voltage on currents flowing along microtubules demonstrates ballistic conductivity possibly reflecting underlying super-conductivity [L26].

This behavior seems to be in conflict with second law of thermodynamics telling that the vibrations should be attenuated. The researchers propose also a theoretical explanation of this paradox (`https://cutt.ly/Cp6V52j`) based on a model assuming ballistic heat conduction. One can of course wonder whether the notion of ballistic heat conduction is consistent with second law in its standard form.

Fermi-Past-Ulam-Tsingou problem (`https://cutt.ly/cp8CxtA`) was a finding about a theoretical model of a vibrating string with a non-linear dynamics. The expectation was that the situation develops ergodic so that energy is evenly divided between the modes of the string. It however turned out that the behavior was essentially periodic. The model explaining the behavior relies on solitons assignable to Korteveg-de-Vries equation. This phenomenon is different from the ballistic resonance observed in the experiments. In Korteveg de-Vries equation there is no dissipative term and the unexpected phenomenon is that wave pattern preserves it shape. Dissipation without energy feed would attenuate the wave.

ZEO based model for the findings

TGD suggests that a genuine explanation requires a profound change in the thinking about time- in particular the relationship between geometric time and experienced time must be updated. I call the new conceptual framework zero energy ontology ZEO) [L96]. The identification of these two times in standard ontology is in conflict with simple empirical facts, and leads to a paradox related to state function reduction (SFR) taking place in quantum measurement. The non-determinism of SFR is in conflict with the determinism of Schrödinger equation.

(a) According to ZEO in ordinary state function reduction (SFR) the arrow of time subsystem changes: this solves the basic paradox of quantum measurement theory. The experiments of Minev *et al* [L83] give impressive experimental support for the notion in atomic scales, and sow that SFR looks completely classical deterministic smooth time evolution for the observer with opposite arrow of time. This is just what TGD predicts. Macroscopic

quantum jump can occur in all scales but ZEO takes care that the world looks classical! The endless debate about the scale in which quantum world becomes classical would be solely due to complete misunderstanding of the notion of time.

(b) Non-standard arrow of time forces a generalization of thermodynamics. For time reversed system generalized second law applies in reverse direction of time. Dissipation with reversed arrow of time extracts energy from environment, in particular thermal energy from internal thermal environment. The energy feed necessary for self-organization reduces to dissipation in reversed arrow of time.
This explains why self-organization is possible [L91]. Standard form of the second flow would imply that also energy flows between systems go to zero: this would mean thermodynamical equilibrium everywhere - heat death. This has led to desperate theoretical proposals such as life as gigantic thermodynamical fluctuation. The recent empirical understanding suggests that this giant fluctuation would have occurred in the scale of the entire Universe and continue forever!

(c) Macroscopic quantum coherence is however a necessary prerequisite for macroscopic effects. TGD predicts hierarchy of phases of ordinary matter residing at magnetic body (MB) of the system with value of effective Planck constant $h_{eff} = nh_0$ ($h = 6h_0$) of h_{eff} behaving like dark matter and controlling ordinary matter. The larger the value of h_{eff}, the longer the scale of quantum coherence scale at MB. MB acts as master for ordinary matter in the role of slave and induces coherent behaviour. This gives rise to self-organization.

This picture could explain the observations of self induced resonance using thermal energy. A subsystem or its MB in time reversed mode would extract the thermal energy. There are many other applications. The phenomenon of stochastic resonance in which system extracts energy from external noise could have explanation along these lines. Stochastic resonance plays an important role in sensory perception by making possible amplification of weak signal in large background. There is evidence for it even in astrophysical scales. In biology metabolic energy could be extracted from metabolites and maybe also from thermal energy by time reversed dissipation by some subsystems related to metabolism.

TGD picture does not exclude the possibility of delicate models mimicking this behavior in the framework of thermodynamics. The basic challenge in this kind of effective model is to describe the presence time reversed dissipation inducing self-organization and the presence of dark matter at magnetic body phenomenologically. Energy feed as parameter gives rise to states far from thermodynamical equilibria.

For instance, the thermodynamics of ion distributions inside and outside cell is far far from thermodynamical equilibrium and and non-equilibrium thermodynamics has been developed for the modelling of this kind of systems utilizing the notions of ionic pumps and channels. The phenomenological description introduces chemical potentials as parameters to describe the non-equilibrium situation in the framework ordinary thermodynamics. Chemical potentials would model the neglected presence of $h_{eff} \geq h$ phases of dark matter at magnetic body of the system.

9.2.8 $M^8 - H$ duality and consciousness

$M^8 - H$ duality is one of the key ideas of TGD and one can ask whether it has implications for TGD inspired theory of consciousness and it indeed forces to challenge the recent ZEO based view about consciousness [L62] .

Objections against ZEO based theory of consciousness

Consider first objections against ZEO based view about consciousness.

(a) ZEO (zero energy ontology) based view about conscious entity can be regarded as a sequence of "small" state function reductions (SSRs) identifiable as analogs of so called weak measurements at the active boundary of causal diamond (CD) receding reduction by reduction farther away from the passive boundary, which is unchanged as also the

members of state pairs at it. One can say that weak measurements commute with the observables, whose eigenstates the states at passive boundary are. This asymmetry assigns arrow of time to the self having CD as embedding space correlate. "Big" state function reductions (BSRs) would change the roles of boundaries of CD and the arrow of time. The interpretation is as death and re-incarnation of the conscious entity with opposite arrow of time.

The question is whether quantum classical correspondence (QCC) could allow to say something about the time intervals between subsequent values of temporal distance between weak state function reductions.

(b) The questionable aspect of this view is that $t_M = constant$ sections look intuitively more natural as seats of quantum states than light-cone boundaries forming part of CD boundaries. The boundaries of CD are however favoured by the huge symplectic symmetries assignable to the boundary of M^4 light-cone with points replaced with CP_2 at level of H. These symmetries are crucial or the existence of the geometry of WCW ("world of classical worlds").

(c) Second objection is that the size of CD increases steadily: this nice from the point of view of cosmology but the idea that CD as correlate for a conscious entity increases from CP_2 size to cosmological scales looks rather weird. For instance, the average energy of the state assignable to either boundary of CD would increase. Since zero energy state is a superposition of states with different energies classical conservation law for energy does not prevent this [L98]: essentially quantal effect due to the fact that the zero energy states are not exact eigenstates of energy could be in question. In BSRs the energy would gradually increase. Admittedly this looks strange and one must be keen for finding more conventional options.

(d) Third objection is that re-incarnated self would not have any "childhood" since CD would increase all the time.

One can ask whether $M^8 - H$ duality and this braney picture has implications for ZEO based theory of consciousness. Certain aspects of $M^8 - H$ duality indeed challenge the recent view about consciousness based on ZEO (zero energy ontology) and ZEO itself.

(a) The moments $t = r_n$ defining the 6-branes correspond classically to special moments for which phase transition like phenomena occur. Could $t = r_n$ have a special role in consciousness theory?

   i. For some SSRs the increase of the size of CD reveals new $t = r_n$ plane inside CD. One can argue that these SSRS define very special events in the life of self. This would not modify the original ZEO considerably but could give a classical signature for how many ver special moments of consciousness have occurred: the number of the roots of P would be a measure for the lifetime of self and there would be the largest root after which BSR would occur.

   ii. Second possibility is more radical. One could one think of replacing CD with single truncated future- or past-directed light-cone containing the 6-D universal roots of P up to some r_n defining the upper boundary of the truncated cone? Could $t = r_n$ define a sequence of moments of consciousness? To me it looks more natural to assume that they are associated with very special moments of consciousness.

(b) For both options SSRs increase the number of roots r_n inside CD/truncated light-one gradually and thus its size? When all roots of $P(o)$ would have been measured - meaning that the largest value r_{max} of r_n is reached -, BSR would be unavoidable.

BSR could replace $P(o)$ with $P_1(r_1 - o)$: r_1 must be real and one should have $r_1 > r_{max}$. The new CD/truncated light-cone would be in opposite direction and time evolution would be reversed. Note that the new CD could have much smaller size size if it contains only the smallest root r_0. One important modification of ZEO becomes indeed possible. The size of CD after BSR could be much smaller than before it. This would mean that the re-incarnated self would have "childhood" rather than beginning its life at the age of previous self - kind of fresh start wiping the slate clean.

One can consider also a less radical BSR preserving the arrow of time and replacing the polynomial with a new one, say a polynomial having higher degree (certainly in statistical sense so that algebraic complexity would increase).

Could one give up the notion of CD?

A possible alternative view could be that one the boundaries of CD are replaced by a pair of two $t = r_N$ snapshots $t = r_0$ and $t = r_N$. Or at least that these surfaces somehow serve as correlates for mental images. The theory might allow reformulation also in this case, and I have actually used this formulation in popular lectures since it is easier to understand by laymen.

(a) Single truncated light-cone, whose size would increase in each SSR would be present now since the spheres correspond to balls of radius r_n at times r_n. If $r_0 = 0$, which is the case for $P(o) \propto o$, the tip of the light-cone boundary is one root. One cannot avoid association with big bang cosmology. For $P(0) \neq r_0$ the first conscious moment of the cosmology corresponds to $t = r_0$. One can wonder whether the emergence of consciousness in various scales could be described in terms of the varying value of the smallest root r_0 of $P(o)$.
If one allows BSR:s this picture differs from the earlier one in that CDs are replaced with alternation of light-cones with opposite directions and their intersections would define CD.

(b) For this option the preferred values of t for SSRs would naturally correspond to the roots of the polynomial defining $X^4 \subset M^8$. Moments of consciousness as state function reductions would be due to collisions of 4-D space-time surfaces X^4 with 6-D branes! They would replace the sequence of scaled CD sizes. CD could be replaced with light-one and with the increasing sequence $(r_0, ...r_n)$ of roots defining the ticks of clock and having positive and negative energy states at the boundaries r_0 and r_n.

(c) What could be the interpretation for BSRs representing death of a conscious entity in the new variant of ZEO? Why the arrow of time would change? Could it be because there are no further roots of $P(o)$? The number of roots of $P(o)$ would give the number of small state function reductions?
What would happen to $P(o)$ in BSR? The vision about algebraic evolution as increase of the dimension for the extension of rationals would suggest that the degree of $P(o)$ increases as also the number of roots if all complex roots are allowed. Could the evolution continue in the same direction or would it start to shift the part of boundary corresponding to the lowest root in opposite direction of time. Now one would have more roots and more algebraic complexity so that evolutionary step would occur.
In the time reversal one would have naturally $t_{max} \geq r_{n_{max}}$ for the new polynomial $P(t - t_{max})$ having $r_{n_{max}}$ as its smallest root. The light-cone in M^8 with tip at $t = t_{max}$ would be in opposite direction now and also the slices $t - t_{max} = r'_n$ would increase in opposite direction! One would have two light-cones with opposite directions and the $t = r_n$ sections would replace boundaries of CDs. The reborn conscious entity would start from the lowest root so that also it would experience childhood.

This option could solve the argued problems of the previous scenario and give concrete connection with the classical physics in accordance with QCC. On the other hand, a minimal modification of original scenario combined with $M^8 - H$ duality with moments $t = r_n$ as special moments in the life of conscious entity allows also to solve these problems if the active boundary of CD is interpreted as boundary beyond which classical signals cannot contribute to perceptions.

What could be the minimal modification of ZEO based view about consciousness?

What would be the minimal modification of the earlier picture? Could one *assume* that CDs serve as embedding space correlates for the perceptive field?

(a) Zero energy states would be defined as before that is in terms of 3-surfaces at boundaries of CD: this would allow a realization of huge symmetries of WCW and the active boundary A of CD would define the boundary of the region from which self can receive classical information about environment. The passive boundary P of CD would define the boundary of the region providing classical information about the state of self. Also now BSR would mean death and reincarnation with an opposite arrow of time. Now however

CD would shrink in BSR before starting to grow in opposite time direction. Conscious entity would have "childhood".

(b) If the geometry of CD were fixed, the size scale of the $t = r_n$ balls of M^4 would first increase and then start to decrease and contract to a point eventually at the tip of CD. One must however remember that the size of $t = r_n$ planes increases all the time as also the size of CD in the sequences of SSRs. Moments $t = r_n$ could represent special moments in the life of conscious entity taking place in SSRs in which $t = r_n$ hyperplane emerges inside CD with increased size. The recent surprising findings challenging the Bohrian view about quantum jumps [L83] can be understood in this picture [L83].

(c) $t = r_n$ planes could also serve as correlates for memories. As CD increases at active boundary new events as $t = r_n$ planes would take place and give rise to memories. The states at $t = r_n$ planes are analogous to seats of boundary conditions in strong holography and the states at these planes might change in state function reductions - this would conform with the observations that our memories are not absolute.

To sum up, the original view about ZEO seems to be essentially correct. The introduction of moments $t = r_n$ as special moments in the life of self looks highly attractive as also the possibility of wiping the slate clear by reduction of the size of CD in BSR.

9.3 Some comments related to Zero Energy Ontology (ZEO)

Zero energy ontology (ZEO) lies behind TGD based quantum measurement theory in turn giving rise to a theory of consciousness by making observed part of system as a conscious entity - self [L62]. ZEO solves the basic paradox of quantum measurement theory forcing to give up ontology altogether in the Copenhagen interpretation. ZEO has become a key aspect of the entire TGD based physics.

The basic prediction of ZEO is that ordinary ("big") state function reductions (BSFRs) involve change of the arrow of time. There is a lot of support for this prediction. The recent highly counterintuitive findings of Minev *et all* provided support for the time reversal in atomic systems [L83] [L83]. Fantappie [J30] proposed decades ago time reversal in living systems and introduced syntropy as time reversed entropy. In living matter the generation of more complex molecules from their building bricks can be seen as decay in time reversed direction. Phase conjugate laser beams are known to obey time reversed second law.

Also Libet's findings [J5] related to the active aspects of conscious experience find a nice explanation in terms of the time reversal. The latest application is to the understanding of the mysterious looking findings about earthquakes and volcanic eruptions suggesting that macroscopic quantum jumps involving time reversal are in question [L86]. This suggest that experimental verification of the time reversal and occurrence of macroscopic quantum jumps is possible by studying causal anomalies. For these reasons is important to try to develop the details of the view about ZEO as precise as possible.

In the sequel I will consider more precise mathematical formulation and physical interpretation of ZEO. ZEO forms also the cornerstone of TGD inspired theory of consciousness and quantum biology and I will consider also some related aspects of ZEO such as the notions of free will and intentionality, the notions of memory and precognition as its time reversal, intuitive in contrast to formal reasoning, and remote metabolism as a universal thermodynamical mechanism of metabolism in ZEO based thermodynamics.

9.3.1 General view about ZEO

The details of ZEO - in particular the technical details related to the conservation laws BSFR and SSFR - are from well-understood and the following is an attempt to fix these details by using analogy with cosmology.

Rough view about ZEO

Consider first what ZEO roughly means.

(a) The realization of ZEO [L99, L62, L72, L95] involves besides the notions of "small" (SSFR) and "big" state function reduction (BSFR) also the notion of causal diamond (CD). CD defines perceptive field of conscious entity as a 8-D region $cd \times CP_2$, where cd is the 4-D causal diamond of M^4 defined as the intersection of future and past directed light-cones.

(b) At the classical level the basic entity is space-time surface connecting 3-surfaces at the opposite boundaries of CD. The space-time surfaces inside sub-CD continue outside and there is a hierarchy of CDs with largest CD beyond which space-time surfaces do not continue. This defines a space-time correlate for the hierarchy of selves.
Space-time surfaces are preferred extremals of the basic action principle defined by the twistor lift of TGD [L80]. Minimal surfaces with 2-D string world sheets as singularities would be in question. They connect 3-surfaces at the boundaries of CD and are analogous to Bohr orbits so that not any pair is possible and the conditions characterizing preferred extremal property might even imply 1-1 correspondence between these 3-surfaces.

(c) Zero energy states are superpositions of preferred extremals. One can also understand zero energy states as superpositions of deterministic programs - quantum programs, functions in the sense of quantum biology, or quantum behaviors. ZEO allows to solve the basic paradox of quantum measurement theory since the non-determinism of quantum jump between zero energy states corresponds to the causality of free will and is not in conflict with the classical determinism realizing the causality of field equations. Experienced time and geometric time are not same but there is a strong correlation between them.

(d) In SSFRs the active boundary of CD shifts to future - at least in statistical sense. This is preceded by a unitary time evolution generating superposition of CDs with different sizes but having fixed passive boundary and same superposition of 3-surfaces at it. SSFR involves time-localization to single CD with fixed temporal distance between its tips. Essentially time measurement is in question.

(e) In BSFR the arrow of time changes and one can say that state function reduction measuring set of observables takes place at the active boundary of CD, which becomes a passive boundary at which state does not change during subsequent SSFRs in which CD increases in opposite direction with the former passive boundary becoming an active boundary. The change of the arrow of time in BSFR creates the illusion that instantaneous quantum jump corresponds to a smooth and deterministic time evolution leading to the final state [L83] [L83].

The mathematical and physical details of the picture are not completely nailed down, and the best manner to proceed is to return to basic questions again and again and to challenge the details of the existing picture. In the following I will do my best to invent nasty arguments against ZEO.

ZEO and conservation laws

The geometry of CD breaks Poincare invariance. Lorentz invariance with respect to the either tip of CD is exact symmetry and is extremely attractive in the construction of members of state pairs in ZEO. Classically Poincare invariance is exact and one can deduce expressions for conserved quantities for both bosonic and fermionic sector: the latter have interpretation as operators, whose eigenvalues in Cartan algebra are by quantum classical correspondence (QCC) identified as classical values of conserved quantities.

ZEO involves the somewhat questionable assumption that one can assign well-defined Poincare quantum numbers to both boundaries and that these quantum numbers are opposite: this motivates the term ZEO.

(a) $M^8 - H$ duality [L90] allows to assign to CDs with either boundary fixed a moduli space, which corresponds to Poincare group. The proposal is that Poincare invariance is realized at this level and that the values of conserved charges in Cartan algebra correspond to the

Poincare quantum numbers labelling these wave functions. The wave functions at the boundaries of CD could be arranged in representations of Lorentz group acting as exact symmetry of the boundary.

(b) There is further little nuisance involved. Only time translations, which correspond to a non-negative time value as distance from the fixed boundary of CD are possible. One would obtain momentum eigenstates restricted to a future or past light-cone. This is of course what happens in TGD based cosmology. Maybe one must just accept this as a physical fact forcing to give up mathematical idealization.
Formally one would replace the plane wave basis with a basis multiplied by characteristic function for future or past light-cone equal to 1 inside the light-cone and vanishing elsewhere. This basis is closed with respect to summation. This would mean that the states are not anymore exact eigenstates of momentum globally but superposition of Lorentz boosts of the basic momentum obtained by Fourier expanding the characteristic function of future/past light-cone.
But what about CD which is intersection of future and past directed light-cones? Can one really assign to both boundaries wave functions defined in entire future (or past) directed light-cone? It seems that this is the case. Zero energy state would be entangled state as a superposition of products of boosted momentum eigenstates with opposite momenta representing the characteristic function of CD.
The usual idea about unitary time evolution for Schrödinger amplitude would be given up inside CD, and replaced by a sequence of unitary time evolutions producing de-localization of the active boundary of CD and followed by a localization.

(c) There is still a problem. A complete de-localization for the boundaries of CD is not consistent with the intuitive idea that CD has definite size scale. In wave mechanics the plane waves are only idealizations and in the real world one replaces plane waves with wave packets. Gaussian wave packets have the nice feature that they remain Gaussian in Fourier transformation.
If one has Gaussian wave packet for the temporal distance between the tips of CD concentrated on certain value of time, the Fourier transform for this is Gaussian wave packet concentrated around certain relative energy, which is two times the energy assignable to say passive boundary of CD. Instead of sharp value of time as distance between the tips of CD one would have Gaussian distribution for its value. This is consistent with Lorentz invariance since zero energy states allow superposition over states with varying momenta assignable to say active boundary. The wave function would be essentially Gaussian in energy in the rest system and one can consider also wave functions in Lorentz group leaving the passive boundary of CD invariant.

SSFRs in ZEO

In the proposed picture the sequence of SSFRs could mean gradual widening of the Gaussian wave packet for the value of measured time as the temporal distance between the tips of CD by discrete steps.

The basic condition is that the states at passive boundary of CD identified as superpositions of 3-surfaces remain unaffected during the sequences of SSFRs increasing the size of CD. This corresponds to generalized Zeno effect and in consciousness theory thr unchanging part of zero energy state corresponds to unchanging part of self, one might call it soul. One can imagine two options.

Option I: CD increases statistically in SSFRs but classical energy is conserved for space-time surfaces connecting its boundaries. Energy density would decreases as CD increases. This does not seem too bad actually: it would be analogous to matter dominated cosmology.

Not only superpositions of 3-surfaces at passive boundary of CD would be conserved but also their 4-D tangent spaces would be unaffected: this is unnecessarily strong a condition for generalized Zeno effect.

Option II: CD increases but classical energies decrease. This looks more plausible- if not the only - option and is strongly favoured by the analogy of CD with expanding cosmology. It also conforms with uncertainty principle. The process would be essentially quantum analog of

cooling or analog for what happens for particle in a box expanding adiabatially. The classical energies of the space-time surfaces in zero energy state would thus decrease as CD increases.

Also this option allows the states as superpositions of 3-surfaces to at passive boundary of CD to remain unffected in expansion of CD. The classical energies can however decrease because the space-time surfaces - tangent spaces of space-time surfaces at passive boundary - can change so that also energies can change.

This option is completely analogous to quantum adiabatic change in which the coefficients in the superposition of energy eigenstates are unaffected but energies change.

Option II looks more natural and will be considered in more detail.

(a) The constraint that SSFRs as quantum measurements are for observables, which commute with observables, whose eigenstate the state at the passive boundary is, poses very strong constraints on what happens SSFR. Furthermore, preferred extremal is analog of Bohr orbit and cannot cannot be arbitrary pair of 3-surfaces. Therefore, when the CD changes, the preferred extremal also changes as a whole meaning also that also energy changes. These conditions could force adiabatic picture and the analog of Uncertainty Principle for classical energies as function of CD size.

(b) The sequence of SSFRs could be also analogous analogous to what happens for a particle in box as the size of the box increases adiabatically: adiabaticity would actually be a hypothesis about what happens in the steps consisting of unitary evolution and SSFR. In adiabatic approximation the coefficients in the superposition of the energy eigenstates do not change at all: only the energies would change.

(c) In thermodynamics this kind of process would correspond to a cooling, which could serve as a natural quantum correlate for the cooling in cosmology. In accordance with the idea that quantum TGD in ZEO corresponds to a complex square root of thermodynamics, one could interpret zero energy state as complex square root of thermal partition function for cosmology assignable to CD. The hierarchy of CDs would define Russian doll cosmology.

(d) A further manner to understand this is in terms of Uncertainty Principle. As the size scale of CD given by temporal distance between its dips increases, the classical energy decreases. Intuitively the reduction of the classical energy is easy to understand. Increasing CD and keeping the 3-surface as such at passive boundary reduces time gradients at the passive boundary and space-time surface becomes more flat. Energy density is proportional to time gradients of coordinates and its therefore reduced. This argument is also used in inflation theories.

(e) Change is the prerequisite of conscious experience and there would be indeed change also at the passive boundary of CD contributing to conscious experience. But in some sense this contribution - the "soul" - should *not* be changing! "Adiabaticity" would translate this idea to the language of physics.

What happens to CD in long run? There are two options.

(a) The original assumption was that the location of formerly passive boundary is not changed. This would mean that the size of CD would increase steadily and the outcome would be eventually cosmology: this sounds counter-intuitive. Classically energy and other Poincare charges are conserved for single preferred extremal could fail in BSFRs due to the fact that zero energy states cannot be energy eigenstates.

(b) The alternative view suggested strongly $M^8 - H$ duality [L52] is that the size of CD is reduced in BSFR so that the new active boundary can be rather near to the new passive boundary. One could say that the reincarnated self experiences childhood. In this case the size of CD can remain finite and its location in M^8 more or less fixed. One can say that the self associated with the CD is in a kind of Karma's cycle living its life again and again. Since the extension of rationals can change in BSFR and since the number of extensions larger than given extension is infinitely larger than those smaller than it, the dimension of extension identifiable in terms of effective Planck constant increases. Since $n = h_{eff}/h_0$ serves as a kind of IQ, one can say that the system becomes more intelligent. Also the temperature assignable to CD remains finite. In cosmological scales it could correspond to the analog of the temperature assignable to CMB. TGD based view about

stars as blackhole like entities [L84] leads to the identification of the Hagedorn temperature assignable to the volume filling flux tube giving rise to star with the Hawking temperature of dark radiation at gravitational flux tubes. Even CMB temperature could be assigned with dark photons at gravitational flux tubes. The asymptotic temperature for CD before BSFR could correspond to this temperature.
One expects that the center of mass coordinates of cm do not appreciably change during the quantum evolution. The hierarchy of CDs would imply that the Universe decomposes effectively to sub-Universes behaving to some degree independently. The view about Karma's cycles provides a more precise formulation of the pre-ZEO idea that systems are artists building themselves as 4-D sculptures. In particular, this applies to mental images in TGD based view about brain. The assumption that stars correspond to repeatedly reincarnating conscious entities allows to solve several time anomalies in cosmology [L84] so that there would be a direct connection between cosmology and theory of consciousness.

There could be a relationship between quantal flow of geometric time by SSFRs and p-adic variant of time coordinates giving a reason why for p-adicity.

(a) TGD predicts geometric time as a real variant and p-adic variants in extensions of various p-adics induced by given extension of rationals (adelic space-time and adelic geometric time). Real and p-adic times share discrete points in the extension of rationals considered: roots of octonionic polynomials defining space-time surfaces as roots for their "real" and "imaginary" parts in quaternionic sense [L88]. The roots of the real polynomial with rational coefficients giving octonionic polynomial as its continuation define space moments of M^4 linear time assignable to special SSFRs. p-Adic time associated with the p-adic balls assignable the points are not well-ordered. One cannot tell about two moments of time which is earlier and which later.

(b) This could relate to the corresponding lack of well ordering related to "clock time" associated with self at given level of evolutionary hierarchy defined by the extension of rationals. The increase of "clock time" as a distance between tips of CD for a sequence of small state function reductions (weak measurements) occurs only in statistical sense and "clock time" can also decrease. The moments of time correspond to roots of the real polynomial define "special moments in the life of self", one might say.
At the limit of infinite-D extension the roots of the polynomial define algebraic numbers forming a dense set in the set of reals. Cognitive representation becomes dense set. These "special moments" need not however become dense.

(c) One can raise an interesting question inspired by self inspection. As one types text, it often happen that the letters of the word become in wrong order, change places, and even jump from a word to another one. The experienced order of letters assignable to a sequence of SSFRs is not the same as the order of letters representing the order for the moments of geometric time. When one is tired, the phenomenon is enhanced.
Neuroscientists can certainly propose an explanation for this. But could this be at deeper level quantum effect based on the above mechanism and have a description in terms of p-adicity assignable to prime p defining a ramified prime for the extension of rationals involved? When one is tired the metabolic resources have petered out and the IQs $n = h_{eff}/h_0$ defined by dimensions of extensions of rationals for the distribution of extensions tend to reduce, cognitive resolution for time becomes lower and mistakes of this kind become worse.

There is a further technical detail involved. For SSFRs the temporal distance between active boundary and passive boundary increases at least in statistical sense. It seems that one must define the inner product in S-matrix elements for the unitary step preceding SSFR using the previous state basis as sub-basis of the new state basis in the case that CD increases. In adiabatic approximation the S-matrix elements would be overlaps for the states with different size of CD and analogous to matrix elements between states of particle in boxes with the same fixed end but different moving end.

BSFRs in ZEO

Details of BSFR are not completely fixed. One can consider two options. Both options must satisfy the condition that the states at passive boundary of CD identified as superpositions of 3-surfaces remain invariant during the sequence of SSFRs. The tangent space-to the space-time surfaces need not however remain invariant. Therefore the classical energies of space-time surfaces can change since the energy densities are proportional to time derivatives of embedding space coordinates.

(a) The size of CD increases steadily as was the original proposal and is thus not reduce in BSFRs. The problem with the steady increase seems to be that the size of CD becomes infinite eventually and the state evolves to what looks like cosmology. If the energy assignable with zero energy state is conserved, the energy density of matter inside CD increasing without limit becomes arbitrarily small. Is this a catastrophe?
For TGD inspired cosmology this is the case at the limit of big bang in the sense that the energy density goes like $1/a^2$ (cosmic string dominance) and energy in a co-moving volume vanishes like a, where a is light-cone proper time. One can think that CD defines only perceptive field and that space-time surfaces continue also outside CD up to the maximal size of CD in the hierarchy of selves involved. The zero energy state would have finite energy energy but density of energy would go to zero at the boundary of CD. The perceptive field of conscious entity would increase steadily in size.
As found, energy need not be conserved in the subsequence SSFRs because Gaussian wave packets of CDs around given size are required so that eigenstates of energy are not in question and the reduction of the width of Gaussian in the sequence of SSFRs implies reduction of average energy. Only the superpositions of 3-surfaces at the passive boundary of CD would be conserved.
Even the conservation of energy combined with the increase of CD need not be a catastrophe. In matter dominated cosmology the conservation of mass takes place with respect to cosmological time which corresponds to the proper time measured as temporal distance from the passive tip of CD. This cosmological mass is not energy but closely relates to it. What looks of course counter-intuitive is that every self would evolve to a cosmology.

(b) The size of CD could be also reduced in BFSR [L88]. $M^8 - H$ duality and existence of "braney" solutions encourages to take this option serious. The 6-D brane like entities correspond to $t = constant$ sections for linear M^4 time t. They would represent special moments in the life of self. The exceptional 6-D roots of octonionic polynomials as branes would emerge to the perceptive field conscious entity at these moment. Discontinuity of classical space-time evolution as SSFR. Every time-reversed re-incarnation of self would have have "childhood" and experience increase of CD from some minimal size to maximal size.
Since the size of CD can be reduced, it could happen that the CD remains stuck below certain maximal size for ever. The associated mental images would continue living in the geometric past of bigger CD associated with self. The sub-CDs in past would represent memories of self. Cosmos in 4-D sense would be full of life. The interpretation of CD as perceptive field allows this. CD could also increase and become even a cosmology! This picture looks attractive from the view point of consciousness.

(c) One can however invent an objection against ZEO, one might even speak about paradox.

   i. Suppose that in biological death I indeed re-incarnate with opposite arrow of time and continue to live towards geometric past. Suppose also that I re-incarnate as more advanced human being - at least in statistical sense. Human beings have parents. But how can I have parents in the former geometric future, if my parents how have already died live in the former geometric past?

   ii. The only solution of the paradox seems to be that the magnetic body (MB) - the boss - does not disappear in the death of biological body (BB). The MBs of my parents continue their existence and in my biological death means their separation in stanard time direction and meeting in the new time direction. They meet, fall in love, and give rise to my birth but all this in opposite time direction.
   This would provide an answer to a long-standing question about whether MBs are

preserved in biological death or not. My view has been that biological death is more or less that MB loses interest in my BB and directs attention to something more interesting. One could however argue that also MB is generated in birth and genes code also for it so that it would die. If directing attention corresponds to BSFR MB would continue to exist after biological death. This particular reincarnation - CD - would be like vortex in the flow of time.

iii. Can one find any support for this crazy looking proposal? TGD Universe is fractal and lower levels in the length scale hierarchies are slaves. In particular, bio-chemical level serves as the slave of MB expected to obey kind of shadow dynamics. If the proposed topological dynamics of MBs solving the above paradox has a miniature representation at the level of DNA, one could take the proposal with some seriousness. In meiosis (`http://tinyurl.com/n5eqkdn`) germ cells, whose chromosomes are coctails of paternal and maternal chromoses (PCs and MCs), are formed. In fertilization (`http://tinyurl.com/ngzwhcq`) - in some sense a (time?) reversal of meiosis - pairs of PCs and MCs are formed. The fusion of paternal and maternal germ cells could be indeed seen in topological sense as a time reversal of replication. The replication of soma cells involves mitosis (`http://tinyurl.com/p35lkwr`) forming pairs of chromosomes of PCs and MCs.
Could the chromosomal dynamics be a miniature version of the proposed dynamics at the level of MB even at the level of organisms? If so, mitosis at the level of MB would correspond to a loose pairing of paternal and maternal MBs - formation of a relationship. Our personal MBs as analogs of germ cells would be coctails of MBs of PCs and MCs formed by reconnection process.
What about replication? In the case of asexual reproduction (`http://tinyurl.com/y8odomtf`) one could speak about replication at the level of MB of the entire organism. Also cell - and DNA replication would represent examples of asexual reproduction and in meiosis sexual reproduction of also DNA would take place.

When does BSFR occur? I have imagined several options, which need not exclude each other.

(a) Could BSFR occur, when there are no observables at the active boundary commuting with those diagonalized at passive boundary. Measurement of observable at means generation of eigenstate in the extension of rationals and it typically occurs that the resulting state is outside the extension. Could BSFR occur when there are no observables in the extension of rationals in question.

(b) M^8-H duality predicts universal special solutions besides 4-D space-time surfaces. These 6-D analogs of branes correspond to n moments of linear M^4 time, where n is the polynomial whose octonionic continuation defines space-time surfaces in M^4 as roots of its real or imaginary part in quaternionic sense. At these branes 4-D space-time surfaces are glued together along their ends- space-time looks is analogous to piecewise continuous curve in time direction - and they would correspond to "special moments in the life of self" [L88]. When all these moments as special roots of the octonionic polynomial are experienced, BSFR would be the only possibility. The polynomial with rationals coefficients defining the octonionic polynomial defines the extension of rationals used so that this option could be consistent with the first option.

(c) Is BSFR is forced to occur because there are no preferred extremals connecting the pairs of 3-surfaces exists anymore. Could it happen that the state becomes increasingly classical during the sequence of SSFRs and thus becoming more and more local in WCW (the "world of classical worlds", which is essentially the space of 3-surfaces at either boundary of CD). The unchanging part of the zero energy state associated with the time-reversed state as outcome of BSFR at the new passive boundary would be maximally classical. This might relate to the fact that the world looks so classical. Also the fact BSFRs themselves look classical smooth time evolution ending to the outcome of BSFR, creates the illusion of classicality [L83].

9.3.2 ZEO, life, and consciousness

The most important implications of ZEO relate to consciousness and quantum biology. One can understand act of free will and motor action in terms of BSFR. BSFR corresponds to motor action and its time-reversal. SSFRs correspond to sensory perception in either direction of time [L77]. Model for memory is one prediction and predicts precognition as time reversal of memory [K87] [L101]. Also the relationship between generation of insight and mechanical logic deductions can be understood. In biology ZEO leads to remote metabolism as a universal purely thermodynamical mechanism of metabolism. One can also understand zero energy states as superpositions of deterministic programs - quantum programs, functions in the sense of quantum biology, or quantum behaviors.

Act of free will, intentionality, and ZEO

Act of free will would correspond to BSFR that is quantum jump leading to final state with opposite arrow of time. Final state is a superposition of deterministic time evolution connecting the 3-surfaces in the superpositions defining initial and the final states. In this picture state function reduction leads to final state inducing time reversed time evolution so that classically the causal order is changed. What in standard picture - say neural activities - causes the outcome, is caused by the outcome. Could it be that mere volitional act with sharp enough intention is needed? The correct deterministic time evolution is dictated by intention as consequence rather than cause!

Here I cannot avoid the temptation to tell about my own strange experiences. At this age one must remember to take the pills every morning. I have the habit of filling my pill dispenser every Monday morning. I do not bother to count the pills one by one. I just take randomly a bunch of them hoping that their number is correct. And it is! Quite too often! Similar thing happens in market when I pay with coins: I do not count the coins but just take a handful of them. The sum of the coins is correct quite too often! Could a mere sharp intention dictate the outcome. Could one learn gradually this kind of sharp intentions.

Could this be crucial for various skills like playing tennis or computer game, where one simply cannot react rapidly by computing the outcome since time does not allow it? Could this explain also mathematical/physical/.. intuition as skill to solve problems by making quantum jump directly to the solution of the problem.

Precognition and ZEO

It seems that neuroscientists are beginning to take remote mental interactions such as precognition, telepathy, and psychokinesis seriously. The popular article entitled "*Scientists Discover That The Heart & Brain Respond To Future Events – Before They Happen*" (see `http://preview.tinyurl.com/y494hw5u`) describes changing views of neuroscientists towards precognition.

In ZEO precognitions are naturally time-reversed memories. Classical signals giving rise to sensory experience arrive from geometry future in the standard frame. During sleep state precognition should be possible if sleep corresponds to time-reversed state for the self.

In the associative and computational models of brain our ability to predict the future is taken to be an extrapolation based on memories and experience of earlier life. This looks very reasonable but when one asks how these memories are represented, problems begin to appear. In TGD framework ZEO predicts that memories correspond to mental images in geometric past, in the simplest case, when the original event took place. This solves a huge problem of standard since memory storage becomes brain in 4-D sense rather than in 3-D sense [K87].

ZEO however implies that also time reversed memories are possible. If sleep state correspond to time reversed self about which we do not have direct memories, memories with reversed arrow of time would be possible in this state. Precognition becomes possible if these memories can be communicated to the wake-up state with the ordinary arrow of time. In dreams some parts of brain are awake and they could make possible this communication. The communicated information could be also conscious to some selves above or below us in the hierarchy. Dreams

can indeed predict what happens during the next day. The classical book "*An Experiment with Time* " (see `http://tinyurl.com/jtqysty`) of J. W. Dunne tells about precognitive dreams that he experienced.

Intuitive and formal logical reasoning in ZEO

The basic vision is that adelic space-time geometry provides correlates for sensory experience and cognition/imagination. Fermionic degrees of freedom would represent quantal Boolean mind. In ZEO given deterministic time evolution for 3-surface and induced spinor fields would give rise to sensory and cognitive time evolution and to Boolean evolution having interpretation as analog of logical deduction leading from premises to conclusions.

(a) The basis of fermionic Fock states can be regarded as Boolean algebra. Superpositions and thus entanglement of fermionic qubits are however possible and one can speak about quantum Boolean logic. In standard view concepts are formally regarded as sets containing the instances of concept as elements. Quantum concepts could be superposition of quantum states representing the instances so that quantum abstraction would be much more complex notion than ordinary abstraction. Non-classical Boolean states would be superpositions of statements identifiable as abstractions. Schrödinger cat would be seen abstraction. "Dead" and "alive" would represent instances of this abstraction.

(b) Zero energy states are superpositions of initial and final fermion states and there is also a superposition over 3-surfaces, and could be interpreted as representations for implications. The sum $\sum_n S_{mn}|n\rangle$, where S denotes unitary S-matrix, represents a superposition over all transitions $|m\rangle \to |n\rangle$ allowed by laws of physics. These transitions could be interpreted as logical implications.
One could argue that by diagonalizing S-matrix one obtains only diagonal transitions and the situation is rather trivial: just logical identities. The point is however that in number theoretical physics the diagonalization of S would in general lead outside the extension of rationals determining the adele and is therefore not possible. Same number theoretical mechanism would also stabilize negentropic entanglement and could force BSFR. Only state big state function reduction extending the extension of rationals can reduce this kind of entanglement.

(c) Probably every mathematician has pondered the mystery of mathematical insight. How for instance mathematical insight is generated? What eureka experience is basically? Insight would correspond naturally to a big state function reduction leading to a new state reversing the arrow of time.
Truth can be deduced in given system of axioms also mechanically - at least in principle. How does insight relate to a logical deduction leading to a theorem? The final state of quantum jump is superposition of classical time evolutions leading from the final state to geometric past. With respect to standard arrow of time it is superposition of logical deductions leading from various initial states- initial assumptions - to the final state - to the outcome of the deduction. Superposition of states at boundary of CD could be seen as an abstraction. Deterministic time evolutions would represent the mechanical deductions.
Note however that in the time reversed state arbitrary long time evolution in opposite time direction is in principle possible and would correspond to an arbitrary long ordinary deduction or computation [L45]. After that a return to the original arrow of time would take place and provide the solution. The formal deduction leading to the outcome would be indeed forced by the outcome rather than vice versa?

Metabolism in ZEO

ZEO has also deep implications for biology. As already explained, ZEO allows to understand what behaviors, biological functions are at fundamental level.

Why metabolism is needed can be understood in TGD view about dark matter as phases of ordinary matter labelled by the value of effective Planck constant $h_{eff} = n \times h_0$, where n has also interpretation as dimension of extension of rationals giving rise to the extension

of adeles [L60, L59]. n serves as a kind of IQ labelling different evolutionary levels and is bound to increase in statistical sense. Not only biology but also self-organization involving also energy feed could be understand in terms of the hierarchy of Planck constant.

In ZEO remote metabolism suggests itself as a completely universal purely thermodynamical mechanism of metabolism. Usually system loses its energy by dissipation. If the arrow of time is non-standard, systems seems to receive energy from environment. Note that the duration of time spent in time reversed state does not matter! What matters is the increment of time between states with same arrow of time! Sleep state could be seen also as a way to collect metabolic energy. BSFR can be seen as an act of free will - motor action and sucking of metabolic energy from "environment" would be very natural.

The interpretation for the return to the original time direction by second BSFR would be as beginning of sensory perceptions in standard arrow of time as sequences of SSFRs. During this period subsystem would be dissipating energy to environment.

9.3.3 Under what conditions does BSFR take place and what happens in it?

In the following the question under what conditions "Big" state function reduction (BSFR) takes place and what happens in it.

Two kinds of state function reductions

The discussion however requires the basic ideas of ZEO as background.

1. "Small" state function reductions (SSFRs)

Small state function reductions (SSFRs) are counterparts of so called "weak measurements", which are rather near to classical measurements in the sense that nothing drastic happens.

(a) The passive boundary of CD does not shift but changes in size because active boundary shifts and this induces change of size. For state pairs defining zero energy states the members at passive boundary do not change and the coefficients of possibly time-entangled state defined as their superposition do not change. The members of state pairs at active boundary change and this change is induced by unitary time evolution between too SSFRs. This time evolution could be regarded as a generalization of adiabatic time evolution.

(b) In statistical sense the active boundary shifts towards future and the size of CD increases. The temporal distance between the tips defines clock time in one-one correspondence with SSFRs. Note that the unitary evolution forms a superposition of CDs with different sizes and SSFR means localization to single CD size.

(c) The moment "Now" of self would naturally correspond to the M^4 hyper-plane dividing CD into two pieces of identical size. The radius of this 3-ball would be $r = T/2$, where T is the temporal distance between the tips of CD. At this hyperplane expansion of 3-ball with light-velocity would transform to contraction.

(d) The mental images of self would correspond sub-CDs and also they would shifts towards geometric future in the sequence SSFRs. They would form a kind of log file about the life history of self such that geometric time order would be opposite to subjective time order. Self could remember these experiences by sending signals to geometric future reflecting back in time direction - seeing in time direction would be in question.
What is in sharp conflict with natural expectation is that the memories would be stored in geometric future and part of them would become un-changing permanent part for the time reversed re-incarnation of self- kind of Karma.
Note however that self might have also mental images represented as sub-CDs in geometric past.

$M^8 - H$-duality suggests space-time picture about the "log files".

(a) 4-D space-time surfaces in complexified M^8 having interpretation as complexified octonions are 4-D roots for octonion valued polynomial obtained as an algebraic continuation of a real polynomial with rational or even algebraic coefficients. $M^8 - H$ correspondence maps thee surfaces to minimal surfaces with 2-D singularities in H [L90, L88].

(b) Besides this one obtains for any polynomial also special solutions as analogs of branes in M-theory. They have topology of 6-D ball and their projection to M^4 is $t = r_n$ hyperplane intersecting CD and with topology of 3-ball. r_n is a root of P and thus an algebraic number. I have called $t = r_n$ "very special moments in the life of self". Generalized vertices for particle reactions would correspond to partonic 2-surfaces localized at these 6-surfaces. At these surfaces incoming and outgoing partonic orbits would be glued together along their ends. The roots define positions of external particles at the boundaries of CD.

(c) In SSFRs these balls at the active half of CD would shift towards future and new roots would emerge. These roots wold define a geometric representation of the memories of CD as "log file" increasing in size. If there are sub-CDs associate with them, one would have mental images shifting towards future.

2. "Big" state function reductions (BSFRs)

"Big" state function reductions (BSFRs) correspond to ordinary state function reductions (SFRs) in ZEO. In BSFR the roles of active and passive boundaries of CD are changed and the arrow of geometric time changes since the formerly passive boundary starts to shift to opposite time direction. State function reduction not commuting with the observables defining states at passive boundary as their eigenstates would takes place and the state at passive boundary would be changed. It would be however fixed by quantum dynamics. The findings of Minev *et al* provide support for the change of the arrow of time in ordinary SFR [L83].

The passive boundary can be shifted towards future so that the size of CD would decrease. One can say that the re-incarnate would be experience childhood. Note that also part of the "log file" about often personal experiences of self towards end of its life defining the permanent part of self-hood of the re-incarnate would disappear. The interpretation in terms of Karma is suggestive.

Remark: During a discussion with Marko Manninen, Marko noticed that people who have had near death experience often report that they experienced their entire life like a film during these moments. Could the "log file" representing stored mental images give rise to this experience at the moment of death?

What happens in biological death from TGD perspective?

What happens in biological death can be taken as a guideline in attempts to understand what happens in BSFR.

(a) Death certainly occurs if there is no metabolic energy feed to the system. Metabolic energy feed is guaranteed by nutrition using basic molecules as metabolites. Since the increase of h_{eff} quite generally requires energy if other parameters are kept constant and since the reduction of h_{eff} can take spontaneously, the metabolic energy is needed to keep the distribution of values of h_{eff} stationary or even increase it - at least during the growth of organism and perhaps also during the mature age when it would go to increase of h_{eff} at MB.
If the size of CD for at least MB correlates with the maximum value of h_{eff} or its average, the size of CD cannot grow and can be even reduced if the metabolic energy feed is too low. The starving organism withers and its mental abilities are reduced. This could correspond to the reduction of maximum/average value of h_{eff} and also size of CD.
One can argue that if the organism loses metabolic energy feed or is not able to utilize the metabolic energy death and therefore also BSFR must take place.

(b) In ZEO self-organization reduces to the second law in reversed direction of geometric time at the level of MB inducing effective change of arrow of time at the level of biological body [L91]. The necessary energy feed correspond to dissipation of energy in opposite time direction. In biological matter energy feed means its extraction from the metabolites

fed to the system. One could say that system sends negative energy to the systems able to receive it. A more precise statement is that time reversed subs-system dissipates and metabolites receive the energy but in reversed time direction.
In living matter sub-systems with non-standard arrow of time are necessary since their dissipation is needed to extract metabolic energy. The highest level dissipates in standard time direction and there must be a transfer of energy between different levels. This hierarchy of levels with opposite arrows of geometric time would be realized at the level of MB.

Death as a re-incarnation with opposite arrow of time

These observations suggest that one should consider the reincarnation with opposite arrow of time with wisdom coming from the death of biological systems.

(a) We know what happens in death and birth in biological systems. What happens in biological death should have analogy at general level. In particular, in death the decay of the system to components should occur. Also the opposite of this process with reversed arrow of time should take place and lead at molecular level to the replication of DNA and RNA and build-up of basic biomolecules and at the cell level to cell replications and development of organs. How these processes could correspond to each other?

(b) The perceived time corresponds to the hyperplane $t = T/2$ dividing CD to parts of same size. Here T is the distance between the tips of CD and therefore to maximal diameter of temporal slice of cd, which is 3-ball. The part of CD above it shifts towards future in SSFRs. In BSFR parts of the boundary of space-time surfaces at the active boundary of CD become unchanging permanent parts of the re-incarnate - kind of log file about the previous life. One can say that the law of Karma is realized.
If CD decreases in size in BSFR the former active boundary keeps its position but its size as distance between its tips is scaled down: $T \to T_1 \leq T$. The re-incarnate would start from childhood at $T - T_1/2$ and would get partially rid of the permanent part of unchanging self-hood corresponding to interval $[T - T_1/2, T/2]$ so that the permanent part of reincarnate would correspond to $[T - T_1/2, T]$. Reincarnate would start almost from scratch, so to say. The part between $T - T_1/2$ and T would be preserved as analog of what was called BIOS in personal computers.

(c) At the moment of birth CD possibly would thus decrease in size and the former passive boundary now in the range $[T - T_1/2, T - T_1]$ and lower tip of new CD at $T - T_1$ would become active and the seat of sensory experience. Arrow of time would change. Where the analog of biological decay is located? The region of CD in the range $[T/2, T - T_1/2]$ disappearing from "log file" is the natural candidate. This region is also the place, where the events related to birth in opposite time direction should take place.

(d) The decay of the organism should therefore correspond to the development and birth of re-incarnated organism at the level of MB (it must be also remembered that genuine time reversal takes place at the level of MB and induces only effective time reversal at the level of ordinary bio-matter). The decay of organism dissipates energy in standard time direction: this energy could used by the re-incarnate as metabolic energy. How long lasting biochemical processes have effective time reversals depends on the quantum coherence scale determined by the size scale of corresponding CD.

Could the re-incarnations with opposite arrow of time be seen in bio-chemistry?

The possible occurrence of effective time reversals at the level of bio-chemistry could be perhaps tested experimentally.

(a) Could the replication of DNA and RNA and build-up of various bio-molecules be effective time-reversals for their decays. Could the same apply to the replication of cells and generation of organs. Replication of DNA is self-organization process in which second DNA strand serves as a template for a new one. The decay of DNA should therefore involve two DNA strands such that the second DNA strand serves as a template for the effectively time reversed replication. The double strand structure indeed makes possible

for the other strand to decay first. Cell replication should use another cell as replicate and same would happen in the cell decay.

(b) An interesting mental exercise is to imagine the time reversals of various basic processes like transcription and translation. In the time reversal of translation of mRNA to amino-acid sequence the amino-acid sequence and mRNA would return to ribosome machinery, and amino-acid and tRNA codon associated with tRNA would return to form tRNA. mRNA strand would shift one step backwards and the process would repeat itself and finally mRNA strand would return to open DNA strand. In the time reversal of transcription of DNA to mRNA, mRNA strand would return to open part of DNA strand, decay to RNA codons and eventually DNA strand would close. It should be easy to check whether these processes really occur in the decay process.

(c) The formation of stem cells involves de-differentiation. Could it mean time reversal of the entire process leading to a differentiated cell? Also this idea could be tested.

In biology pairs of various structures often occur. Could they correspond in some sense to effective time reversals of each other whereas at the level of magnetic body one would have genuine time reversals

(a) Could the opposite inherent chiralities of MBs of DNA strands correspond to opposite arrows of time at the level of MB of DNA realizing dark genetic code [L37]? Could this be seen as a kind of explanation for the double strand structure of DNA. Could the passivity of DNA strand with respect to transcription correspond to opposite arrow of time at the level of MB? Could the passive strand become active in time reversal?

(b) Even brain has this kind of pairing. Right brain hemisphere is passive in the sense that it does not seem to contribute to wake-up intelligence (presumably identified as analytic intelligence). Could either hemisphere serve as a template in the development of brain or could this happen only at the level of MB of brain? Could different time arrows at the level of MB be used to understand the strange passive character of right brain and could one one understand the holism of right brain *viz.* analytic reductionism of left brain as reflection of the fact that dissipation as decay corresponds to time reversal for self-organization generating structures at the level of MB.

What about ordinary re-incarnation?

A couple of comments relating to the notion of re-incarnation in standard sense are in order.

(a) Eastern philosophies talk about the possibility of liberation from Karma's cycle. Can one imagine something like this? The above picture would suggest that in this kind of process the reduction of the size of CD does not occur at all and therefore there would be no decay process equivalent to the growth of time reversed organism. This would serve as an empirical signature for the liberation - if possible at all. CD would continue to increase in size or perhaps keep its size. It would seem that a new kind of non-biological source of metabolic energy would be needed.

(b) Reincarnation is a basic notion in Eastern philosophies. In ordinary reincarnation person has memories about life of a person, who lived earlier. There is evidence for this. This cannot be understood in terms of time reversed re-incarnation.
Recall that there would be a hierarchy of selves and corresponding CDs within CDs. It has remained an open question whether CDs could also overlap? Could re-incarnation in ordinary sense be explained in terms of this kind of overlap?
Suppose that one has two overlapping CDs: CD_1 and CD_2 and that CD_2 extends farther to the future of CD_1. The sub-CDs of CD_1 shift to future as the active part of CD_1 shifts to future and increases in size giving rise to a kind of log file defining the personal memories of CD_1. In this kind of situation the mental images of CD_1 can enter to CD_2 and become mental images of CD_2. This would be sharing of mental images but in different sense as compared to the fusion of mental images by entanglement, which could also require intersection of sub-CDs of mental images.
Could one imagine that the cosmos is full of selves serving as counterparts of memes wandering around and finding for selves hosting them by providing metabolic energy? Note

that ZEO means that CD center of mass degrees of freedom do not carry any conserved quantum numbers so that the motion of these lonely CDs would not be restricted by conservation laws!

(c) This picture suggests that CD:s form a conscious fractal atlas consisting of charts with various resolutions analogous to the atlas defining a covering of manifold by open sets. The earlier proposal was that in biological death MB redirects its attention to a new system. This picture would be modified: the MB of of CD_1 would still attend the time-reversed system and experience time-reversed life. Some sub-CDs of CD_1 would however belong to a new CD in its geometric future - CD_2. This conforms with the intuitive expectation that space-time surfaces continue outside CD and only the perceptive field of conscious entity is restricted to CD.

(d) Mental images should correspond to sub-selves and therefore sub-CDs of CD. Contrary to what I have proposed earlier, it seems that after images cannot correspond to BSFR type re-incarnations of mental images nor re-incarnations in standard sense.
Mental images would shift towards the future together with active part of CD and form a kind of log file. Could after images be memories of previous mental images involving a signal time reflect from the the mental image in log file and creating the after image as a sensory memory of the earlier visual mental image? Or could one understand after images in terms of propagation of dark photon signals along closed magnetic loops giving rise to periodically occurring mental images.

In [L109] I discussed how the evolution of self by BSFRs could correspond to a transition to chaos as iteration of the polynomial defining the space-time surface. The proposed picture was that the evolution by SSFRs corresponds to iteration of a polynomial P assignable to the active boundary of CD. This would predict a continual increase of the degree of the polynomial involved. This is however only one possibility to interpret the evolution of self as iteration leading to chaos.

(a) One could argue that the polynomial $P_{nk} = P_n \circ .... \circ P_n$ associated with the active boundary remains the same during SSFRs as long as possible. This because the increase of degree from nk to $n(k+1)$ in $P_{nk} \to P_{nk} \circ P_n$ increases h_{eff} by factor $(k+1)/k$ so that the metabolic feed needed to preserve the value of h_{eff} increases.
Rather, when all roots of the polynomials P assignable to the active boundary of CD are revealed in the gradual increase of CD preserving P_{nk}, the transition $P_{nk} \to P_{nk} \circ P_n$ could occur provided the metabolic resources allow this. Otherwise BSFR occurs and self dies and re-incarnates. The idea that BSFR occurs when metabolic resources are not available is very natural for this option.

(b) Could $P_{nk} \to P_{nk} \circ P_n$occur only in BSFRs so that the degree n of P would be preserved during single life cycle of self - that n can increase only in BSFRs was indeed the original guess.

While preparing this contribution I learned about a highly interesting claim (`https://tinyurl.com/yap8ss4p`) made by the research group led by Harold Katcher. The claim is that the epigenetic age (there are several measures for it such as methylation level of DNA) of rats has been reduced up to 50 percent. The theory goes that epigenetic age of molecules would be controllable by hormonal signalling globally.

BSFR would mean death of conscious entity and its reincarnation with opposite arrow of time. The system would rejuvenate in the transition starting a new life in opposite time direction from childhood so to say - rejuvenation would be in question. Doing this twice would lead to life with original arrow of time but starting in rejuvenated state. The claim of the group suggests that living matter could do this systematically using hormonal control.

Tukdam and TGD

This piece of text was inspired by a document (`https://rb.gy/abt8za`) about a strange phenomenon known as Tukdam. What happens is that in Tukdam the person is physically dead but is believe to be in a continued meditation. There is no EEG, the heart does not beat, and there is no normal metabolism. However, the decomposition processes do not start. The

condition can last up to a couple of weeks. Similar longer-lasting ones have been reported: a yogi can be buried underground for months in an oxygen-free state and then wake up.

This challenges neuroscience's view of the brain as the seat of consciousness. According to reports there could be awareness and a sensory experience consisting of different light sensations. The Tibetan Book of the Dead describes these experiences. Near-death experiences have many similar features [L124].

In the body in Tukdam, the area of the heart is reported to feel warmer to the touch than the rest of the body, but the thermometer does not detect this difference. This would indicate that the body receives metabolic energy at the cellular level from some other source than in the normal metabolism, and that living matter can detect what measuring devices based on the recent knowledge provided by modern physics cannot detect. Where could this energy come from? If one wants to answer this, one must also ask what happens in death and what is consciousness and what is life.

(a) Dark energy and matter are the two basic puzzles of recent day physics. In the TGD approach, I have identified dark matter as a phase of ordinary matter, for which the effective Planck constant h_{eff} is much larger than normally.
In particular, the gravitational Planck constant $h_{eff} = h_{gr}$ assignable to gravitational flux tubes can be very large and makes quantum coherence possible even on astrophysical scales. Large Planck constants would be associated with the dark matter magnetic body, which would be the TGD counterpart to the magnetic field of Maxwell's theory, but would differ from it in many respects. As a quantum coherent unit, this magnetic body would control the ordinary biological body and induce its coherence. The classical energy of a magnetic body, consisting of volume energy and magnetic energy, would be dark energy.

(b) In the TGD Universe dominated by zero energy ontology, consciousness is a universal phenomenon and present on all scales, from elementary particles to the level of the cosmos. Even galaxies, stars and planets would be conscious beings. Also life and death would be universal phenomena. Likewise, the biological decomposition process associated with death would correspond to the universal decomposition process, which would essentially correspond to the decomposition of magnetic monopole flux tubes (magnetic catabolism), which would induce the catabolism of the breakdown of biomolecules. Its time-reversed version would be magnetic anabolism and induce the building of bio-structures such as molecules.

(c) The fundamental metabolic processes would be essentially magnetic anabolism and catabolism induced by "big" state function reductions (BSFRs) changing the arrow of time and inducing the biological anabolism and catabolism. Death would mean reincarnation with the opposite arrow of time.

In Tukdam, the biological body would be dead, but the magnetic body would still be alive and prevent the biological decay from starting. The disintegration of the magnetic body would start in Tukdam much later than normally, and initiate the disintegration of the biological body. The content of the conscious experience in Tukdam, light sensations and deep peace, would come from the magnetic body. The dead biological body would not provide contribution from sensory input, motor activity, and cognition.

By a strange accident, just before seeing the document about Tukdam, I wrote an article [L166, L174] about a seemingly completely unrelated topic, solar flares related to the reversal of the direction of the sun's magnetic field in the solar cycle, which has a period of 11+11 years.

The reversal of the Sun's magnetic field would correspond to magnetic catabolism as the breakdown of long monopole flux tubes into very short parts. It would be followed by magnetic anabolism as their re-fusion into long flux tubes. The solar cycle would correspond to the sleep-wake cycle, or more precisely: a series of lives in different directions of time. Death would only be a change of time's arrow, nothing final.

The model unexpectedly leads to a biological analogy and to understanding what might happen to the magnetic body in biological death.

9.3.4 Conditions on the periods with reversed arrow of time

In zero energy ontology (ZEO) falling asleep (death at"my" level of self the hierarchy) corresponds to ordinary - or "big" - state function reduction (BSFR) and also means a reincarnation with opposite arrow of time. We would be therefore conscious during sleep and wake-up would correspond to falling sleep of that other, time reversed self.

When I fall asleep, I wake-up later tomorrow morning for instance, not yesterday morning. It is interesting to see what kind of conditions this implies and whether it is possible to satisfy this easily and even more interesting is to see whether a time travel to the geometric past - maybe the Golden Youth - could be possible.

The following assumptions are made about what happens in BSFR.

(a) Causal diamond (CD) is a correlate for self. CD is obtained by gluing together two identical half-cones along their bottoms. Moment "Now" corresponds to the largest hyperplane $T_{now} = T$ (origin of time coordinate is at either (call it "lower") tip of CD) .

(b) During the sequence of SSFRs defining self, the 3-surfaces at the passive boundary of self are fixed although their 4-D tangent space changes and corresponds to the unchanging part of selfhood - soul one might say. The opposite active boundary of CD and 3-surfaces at it change and shift towards geometric future.This gives rise to wake-up consciousness involving sensory input and thoughts, emotions etc. induced by it. Each SSFR is preceded by the analog of unitary time evolution.

(c) BSFR means a death of self (subself) and its reincarnation with an opposite arrow of time. One can equally well speak about the analog of falling in sleep and waking up after that for some level of hierarchy of selves. The self born in the death of the self with an opposite arrow of time self has no direct memories about the state. Self can however have memories about dreams in which part of say brain is awake. These memories store information about what self experienced during the sleep.

In BSFR the active boundary of the CD becomes passive and is frozen. The size of CD is scaled down so that CD becomes small: this implies that the reincarnated self has a childhood and much of the memories - often not pleasant - stored near the active boundary as subselves living forth and back as conscious entities disappear. The surviving memories of self become "silent wisdom" of the reincarnated self.

(d) If CD belongs to a larger CD, call it CD_{super} representing a larger unit of consciousness, the sub-CDs must shift to the same direction as the active boundary of CD_{super}. Otherwise the sub-CDs would drop from the flow of consciousness. This is analogous to co-movement of matter in cosmology.

Note that the mental images of self correspond to sub-CDs around T_{now} and shift towards geometric future as CD increases and new mental images emerges at T_{now} plane: by $M^8 - H$ correspondence these special moments in the life of self correspond to roots of the polynomial defining space-time surface and reside are the upper half-cone of the CD. As CD increases, new roots pop up inside the upper half-cone near the T_{now} hyper-plane for some particular SSFRs. Completely counterintuitively, the mental images about past experiences are therefore in the geometric future of T_{now} hyperplane!

The proposed picture must be consistent with everyday experience. Call the two periods of self sleep wake-up and sleep label the two different BSFRs by "sleep" and "wake-up".

(a) In each SSFR CD size increases - at least in statistical sense this implies that T grows. Each SSFR corresponds to a scaling for the CD shifting its active boundary towards the geometric future. During its life cycle CD experiences scaling Λ:

$$T_{now} \to T_{now,sleep_1} = \Lambda(SSFR) T_{now} \quad , \quad \Lambda(SSFR) > 1 \quad .$$

(b) When the system falls in sleep the size of CD is scaled down so that also the value of T_{now} is scaled down by $\Lambda_{BSFR} < 1$:

$$T_{now,sleep_2} = (1-\Lambda(BSFR)) 2 T_{now,sleep_1} = (1-\Lambda(BSFR))\Lambda(SSFR) 2 T_{now} \quad , \quad \Lambda(BSFR) < 1 \quad .$$

After that the CD begins to increase in size by small scalings in SSFRs to opposite time direction and T_{now} begins to decrease from its value $T_{now,sleep}$ begins to decrease.

(c) If CD belongs to a bigger CD - call it super-CD - representing a larger unit of consciousness with a longer life cycle, one can argue that the CD must shift to the same direction as the larger CD increases. Otherwise the CD would drop from the flow of consciousness defined by super-CD. This is analogous to co-movement of matter in cosmology. Therefore a given life cycle corresponds also a shift ΔT of sub-CDs towards the growth direction of super-CD takes place and one has for the time coordinate $T_{super,now}$ of the super-CD. Therefore one must perform shift$T \to T + \Delta T$ for $T_{now,sleep_1}$ and $T_{now,sleep_2}$ to take into account the drifting. This gives for the moments "Now" before ad after the shrinking of CD in BSFR (falling asleep):

$$T_{super,now,sleep_1} = T_0 + T_{now,sleep_1} + \Delta T \ ,$$

$$T_{super,now,sleep_2} = T_0 + (1 - \Lambda(BSFR))2T_{now,sleep_1} + \Delta T \ .$$

(d) Similar formula holds true for the moment of wake-up. In the previous formula T_{now} is replaced with $T_{now,sleep_2}$ and one has

$$T_{super,now,wakeup_1} = T_0 + \Lambda^{1)}(SSFR)T_{now,sleep_2} + \Delta T^{1)} \ ,$$

$$T_{super,now,wakeup_2} = T_0 + (1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2T_{now,sleep_2} + \Delta T^{1)} \ .$$

The parameter T_0 depends on the choice of the origin of time for super-CD but is irrelevant.

One can deduce a consistency condition for the parameters of the model.

(a) During the sleep period the time coordinate $T_{super,now}$ for moment "Now" in the coordinates of larger CD changes in the following manner:

$$T_{super,now,sleep} = T_0 + T_{now,sleep_1} \to T_{super,now,wakeup}$$

$$= T_0 + \Lambda^{1)}(BSFR)T_{super,now,sleep_2} + \Delta T^{1)} \ .$$

T_0 is an irrelevant parameter associated with super-CD. Note that there is breaking of time reversal symmetry since self associated with CD_{super} has fixed arrow of time unlike CD. Hence ΔT has at least in a statistical sense the same sign irrespective of the arrow of time of self.

(b) This picture should be consistent with what we observe. When the tired average self fall a sleep at the evening, it wakes wake-up at the morning and is full of energy. Quite generally, wake-up occurs after time $\Delta T(sleep)$ meaning that the value of time T_{super} has increased by

$$T_{super,now,wakeup} = T_{super,now}(sleep_1) + \Delta T(sleep) \ .$$

These two expressions for the value of $T_{super,now}(wakeup)$ must be consistent and this gives a conditions on the parameters involved:

$$(1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2T_{now,sleep_1} + \Delta T^{1)}$$

$$= T_{now,sleep_1} + \Delta T + \Delta T(sleep) \ .$$

$\Delta T(sleep)$ is given by

$$\Delta T(sleep) = [(1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2 - 1]T_{now,sleep_1} + \Delta T^{1)} - \Delta T \ .$$

Intuitively it seems clear that for a given arrow of time it is not possible to wake-up before one falls asleep, and the condition $\Delta T(sleep) > 0$ for the standard arrow of time gives a constraint on the parameters. One cannot however exclude the possibility of time travel without dying or falling asleep first of the duration of time travel is much longer than that of wave-up period: $\Delta T^{1)} - \Delta T$.

A special solution corresponds to $\Delta T(sleep) = \Delta T^{1)} - \Delta T$ and $(1 - \Lambda^{1)}(BSFR))2\Lambda^{1)}(SSFR) = 1$ giving $T_{now,sleep_2} = T_{now}$.

9.4 Still about quantum measurement theory in ZEO

The relation between zero energy ontology (ZEO) based quantum measurement theory and adelic vision could be much clearer. The following considerations suggest a more precise picture about cognitive representations and formulation of quantum measurement theory for them.

In the sequel ZEO based theory of consciousness [L62, L96] as quantum measurement theory is discussed first by starting with a criticism of physicalism and after that introducing ZEO based view about consciousness as quantum measurement theory as a solution to the problems of physicalism.

After this the relation between zero energy ontology (ZEO) based quantum measurement theory and adelic vision [L59, L60] is discussed. The considerations suggest a more precise picture about cognitive representations and formulation of quantum measurement theory for them. One can generalize classical cognitive representations as number theoretical discretizations of space-time surfaces in the extension of rationals considered to their quantum counterparts as wave functions in the Galois group of the extension and introduce also fermions as spinors in the group algebra of Galois group. The strongest option is purely number theoretical representations of spinors as spinors in this group algebra. Presumably however M^8 spinors are required and have interpretation in terms of octonion structure.

An attractive vision is that number theoretical quantum measurements reduce to measurement cascades involving a sequence of state function reductions reducing the entanglement between wave functions in sub-Galois group H and group G/H and ends up to a prime Galois group for group algebra has prime dimension and represents Hilbert space prime not decomposable to tensor product.

Also time measurement is considered from the number theoretic perspective assuming M^8-H duality [L88]. Clock readings are realized as roots of the rational polynomial determining the space-time surface in M^8. Time measurement would involve a localization to a definite extension of rationals, whose dimension n must be proportional to the temporal distance T between the tips of causal diamond (CD) to guarantee fixed time and energy resolution.

9.4.1 ZEO based theory of consciousness as quantum measurement theory

Consider first zero energy ontology (ZEO) based quantum measurement theory as a theory of consciousness.

Criticism of physicalism

It is good to start with a criticism of physicalism.

(a) In physicalism consciousness would reduce to a physical property, like energy, momentum or charge and one would have the hard problem. There would be absolutely no idea why for instance sensory qualia emerge and how they correspond to sensory input. For instance, the assignment of sensory qualia to brain regions leads to a mystery: auditory, visual, etc. areas look exactly the same. How they can give rise to so different qualia?
Remark: The answer to the question is that this is not possible. I n TGD framework macroscopic quantum coherence and ZEO allow to assume that sensory qualia are seated at sensory organs [L51].

(b) This is not the only problem: free will is not possible and we must stop talking about ethics and moral as we have indeed done in modern free market economy, which threatens to destroy our civilization.

(c) The third problem of physicalism and also idealism is that conscious experience is about something: it carries information about something, external world, my body, even about my thoughts. It is associated with a pair of systems- me and the rest of the world - rather than single system as consciousness as a physical property implies. This "aboutness", kills the physicalistis view and actually idealism and under reasonable assumptions also dualism. Standard ontologies of consciousness fail.

Physicalistic approach has also problems with quantum measurement theory. The basic problems are basically due to the fact that observer as a conscious entity remains an outsider: observations affect the measured system but theory cannot say anything about observer as subjective entity. In ZEO the situation is different [L96] (`http://tinyurl.com/wd7sszo`) .

(a) Quantum jump defines the basic building brick of conscious experience. It is something between two different quantum worlds, not in the world as a physical property of quantum system. Consciousness is a moment of re-creation. This a solves the hard problem and problem of free will.

(b) Also the paradox of state function reduction can be solved if one can understand the problems related to the notion of time. There are two times: experienced time and geometric time, or the clock time. They are very different. Experienced time irreversible and has preferred moment "Now". Geometric time reversible and without preferred "Now". For some reason these times have been however identified.

ZEO based quantum measurement theory

In ZEO physical states as time= constant snapshots are replaced by pairs of "initial" and "final" states A and B or - by holography - with superpositions of deterministic time evolutions from A to B with respect to geometric time - note the analogy with computer program in computer science, behavior pattern in neuroscience, and function in biology.

(a) In "small" state function reductions (SFRs) -"weak" measurements - the superposition of time evolutions from A to B is replaced with a new one such that states A at passive end - "initial state" - are not changed. Classical determinism is respected although one has quantum jump and generalization of quantum measurement theory. Two times - two causalities. The temporal distance T between A and B increases in statistical sense and this gives the correspondence between experienced time as sequence of state function reductions and geometric time is identified as T. These measurements changing B correspond to "weak" measurements analogous to classical measurements and to sensory input. A represents permanent part of selfness, "soul" one might say.

(b) In "big" (ordinary) state function reductions (BSFRs) the roles of "initial" and "final" states change and the arrow of geometric time changes. Self dies and reincarnates with an opposite arrow of geometric time.

(c) In more precise view the pairs of time=constant snapshots are replaced with what I call causal diamonds (CDs). The assumption that the size of CD is preserved In BSFR as assumed originally leads to some paradoxical looking implications. For instance, the size of CDs assignable to our sub-selves identifiable as mental images would increase without bound. M^8-H duality suggests strongly that the sizes of CDs can decrease in BSFR: the formerly active boundary would be frozen but the temporal distance of formerly passive boundary would be reduced so that the size of CD would decrease. One could say that self has childhood and starts from scratch with all sins of previous life forgiven.

This picture about state function reduction finds considerable empirical support.

(a) The paradoxical experimental findings of Minev *et al* in atomic systems challenging standard quantum measurement theory give strong support for the reversal of the arrow of time in BSFR [L83] [L83] (`http://tinyurl.com/yj9prkho`).

(b) Also Libet's finding that experience of free will [J5] seems to be preceded - caused - by neural activity, can be understood. It is not anymore support for the claim that free will is an illusion. State function reduction changing time order happens, and free will causes neural activity in the geometric past.

(c) There is are lot of support for the new view about time from biology. For instance, self-organization - not only biological - could be understood as involving time reversal meaning that the time reversed reduction of order implied by generalization of second law looks from standard observer's viewpoint like increase of order. Self-assembly and generation of structures in long scales would involve increase of time order. Evolution is second aspect of self-organization and reduces to the unavoidable increase of h_{eff} as dimension for extension of rationals. Also the need for energy feed - metabolic energy

feed in living matter - can be understood because the increase of h_{eff} keeping other parameters constant, increases energy scale. Dark matter would be visible everywhere in sharp contrast with standard prejudices.

(d) There is support even from cosmology and astrophysics, where TGD predicts quantum jumps in macroscopic scales. For instance, stars older than Universe can be understood in more detailed picture about ZEO [L84, L86] (`http://tinyurl.com/tf38xnx`).

One can of course criticize the view about the role of clock time as the distance T between the tips of CD as over-simplified [L96].

(a) The state function reductions preceding SSFRs are preceded by unitary processes U. What one can say about "time evolution" U. First of all, U is assumed to produce a zero energy state de-localized in the space of CDs - in particular with respect to the distance T between the tips of CD.
The simplest guess is that in SSFR a complete localization in T - measurement of T - and other moduli of CD (say boost with respect to the lower tip of CD) occurs. Can one reduce the localization in T to a SSFR reducing quantum entanglement or is time measurement something different? What entanglement of CD sizes with different values of T with the measurement apparatus could mean? What the presence of a measurement apparatus for time T - the clock at fundamental level, could mean mathematically? Later also the question whether one could reduce this measurement to pure number theory emerges?

(b) The notion of completely localized state is over-idealization and also mathematically poorly defined. Gaussian wave packet over classical states with well-defined classical conserved energy (by Poincare invariance) with respect to T localized around some value T_0 is a more realistic notion and time measurement would mean localization to a wave packet around T_0.
In [L96] the proposal that the time evolution of self could be seen an analog of cooling process analogous to cosmic cooling is considered. This would correspond to an adiabatic time evolution happening for a particle in box whose size increases slowly. In this process the coefficients in a superposition of states with given classical energy remain unaffected but the classical energies of the states themselves decrease. This would conform with Uncertainty Principle stating that the classical energies scale as $1/T$.

A more detailed view about quantum measurement in ZEO

Consider next in more detail what state function as quantum measurement means in TGD.

(a) In standard quantum measurement theory quantum measurements are often thought to be performed by humans only. In TGD one assumes that state function reduction as analog of quantum measurement is universal and can take place for any pair of mutually entangled systems unentangled from its complement.

(b) Density matrix for the entangled pair of systems is the fundamental observable. This applies to both BSFRs and SSFRs at active boundary of CD, which correspond to "weak" measurements commuting with the observables diagonalized at the passive boundary of CD and thus leaving the states at it invariant.

(c) Quantum measurement involves typically measurement of several observables. This is realized as a measurement cascade. First the quantum measurement of density matrix occurs for some pair formed sub-system S_1 and its complement S_2 forming together system S. After the same occurs for S_1 and S_2. Observables correspond to density matrices in this cascade. One proceeds as along as new decompositions are found. If the final state belongs to a sub-space with prime dimension the cascade stops since there is no further decomposition to tensor product.

(d) The density matrix for subsystem in general case decomposes to a sum of projectors t sub-spaces and the state function reduction takes to one of them. The outcome of the measurement can be sub-space rather than ray.
Number theoretic vision suggests also a second possibility. The SSFR would take place only if the eigenvalue of density matrix having probability interpretation associated with the subspace or ray is in the extension of rationals associated with the matrix elements

of the density matrix and space-time surfaces considered (defining the cognitive representation). If one assumes frequency interpretation of probability theory, this probability must be rationals. Entanglement can be number theoretically stable. This would that one can have stable entanglement.
It is natural to assume that BSFR can can increase the extension of rationals associated with the eigenvalues of density matrix in the extension of the extension associated with its matrix elements.

(e) Stable entanglement could be crucial for quantum computation as also the possibility of large values of h_{eff} and of time reversal. One can also assign to entanglement with coefficients in an extension of rationals p-adic variant of entanglement entropy by replacing logarithms of probabilities with the logarithms of their p-adic norms. These p-adic entanglement negentropies can be positive so that the entanglement carries information. This negentropy is different from the real negative entropy due to the loss of precise knowledge about entangled states. Quite generally, the sum of p-adic negentropies can be larger than real entropy. This would explain the paradoxical looking fact that highly evolved biological systems are highly entropic [I98] [L30]. england

9.4.2 The relationship between adelic physics and ZEO based quantum theory

The challenge is to formulate quantum measurement theory taking into account the constraints from adelic physics [L59, L60]. One can consider the possibility is that the quantum physics could reduces at the level of cognitive representations to purely number theoretic physics. This would mean huge simplification. I have considered quantum theory at the level of cognitive representations from the point of view of number theory in [L93] and from the perspective of scattering amplitudes in [L92].

Two kinds of cognitive representations

One can consider two kinds of cognitive representations. The cognitive representations considered hitherto correspond to number theoretical discretization of space-time surface determined by an extension of rationals, they are "classical". The bosonic wave functions in Galois group of extension acting on cognitive representations and their fermionic counterparts based on fermionic dynamics in the group algebra of Galois group and its normal subgroups (Galois groups too) would define quantal cognitive representations.

(a) There are cognitive representations both at the classical level in terms number theoretical discretizations of space-time surfaces defined by the extension of rationals and at the quantum level based on spinorial wave functions in Galois group of the representation. Also the spinorial wave functions in factor sub-groups and normal subgroups of Galois group are involved.

(b) One can assign preferred primes p_{pref} to the classical space-time dynamics as ramified primes p_{ram} of the extension. For these the polynomial defining extension has double root in $O(p) = 0$ approximation. This would be the realization of quantum criticality for cognition: criticality is typically in potential models a situation in which two or more extrema of the potential function co-incide - catastrophe theory of Thom is classical example.

(c) At the level of state (spinorial) space wave functions in Galois group acting on cognitive representations are natural candidate for a bosonic state space. Quantum states would be wave functions in Galois group G with normal subgroup H acting as a Galois group of lower-D extension.
G/H is group itself and one can express wave functions in G as superpositions of products wave functions in G/H and H. The wave functions in G/H and H define naturally a tensor product and an attractive idea is that state function reduction can be regarded as measurement in G/H or equivalently in H. When H has prime order further reduction is not possible since Hilbert spaces with prime dimension are primes of tensor product.

A natural candidate for preferred primes p_{pref} is as orders of smallest possible normal subgroups of Galois group, kind of primitive generating Galois groups.
Remark: One must consider also the possibility that quark and possibly also leptonic degrees of freedom are present as additional spinor indices. The fact that M^8 has octonionic structure could require also M^8 spinor structure.

(d) In TGD dark matter is identified as $h_{eff} = n \times h_0$ phases of ordinary manner. n is identified as the order of Galois group of Galois extensions and thus of the extension itself. For ordinary value of Planck constant empirical inputs suggests the identification $h = 6h_0$ [L43, L70].
Quite interestingly, one has $6 = 2 \times 3$ so that there is factorization to 2-D and 3-D subspaces assignable to massless particles, and massive gauge bosons. This indeed suggests that number theoretical vision could allows to represent all many-particle states in terms of wave functions (spinor fields) in the group algebra of Galois group.

(e) How to construct cognitive representations for fermions? A natural generalization of the bosonic dynamics in n-D group algebra of Galois group is introduction of spinor structure in terms of 2^k-dimensional spinors in the group algebra. For $k = n$ both chiralities are present and for $k = n-1$ only second chirality. In fact, one could pose even more chirality conditions giving $2^{n/2}$-D ($[n+1]/2$-D) spinors for even (odd) n. Indeed, the recent view about SUSY in TGD framework suggests that only quarks - second embedding space chirality - appear as fundamental fermions and that leptons are local composites of 3 quarks - spartners of quarks in well-defined sense [L97] (`http://tinyurl.com/y4pdb2xz`). The simplest option is that at the level of cognitive representations the fermionic oscillator operator algebra corresponds to the oscillator operator algebra creating fermions states having at most $k = n$, $k = n-1$,...$n/2$ ($[n+1]/2$) fermions assignable to these spinors in finite measurement resolution. Entire quantum dynamics at the level of cognitive representations would reduce to the dynamics of fermions in the group algebra of Galois group and its Galois sub-groups.

(f) There is also question about the Galois groups of the extensions of various p-adic number fields Q_p induced by the extension of rationals with dimension n. For p-adic numbers in approximation the extension reduces to a finite field $G(p,k)$, $k \leq n$, and one has k-dimensional extension. Galois group G_p is smaller than the Galois group G for rationals. G_p would act naturally in the p-adic counterparts of cognitive representations and the representations of G would reduce to direct sums of representations of G_p. Note that the distinction between sensory and cognitive (real and p-adic) would emerge only at the quantum level.
For $p < n+1$ the fact that one has $x^{p-1} = 1$ for $G(p)$ implies that the irreducible polynomial P defining the extension Q reduces to a polynomial with degree $nmodp-1 \leq p-1$. Information is lost for $p < n+1$. For $p \geq n+1$ situation is different but also in this case the reduction occurs for ramified primes since polynomial P as in this case multiple roots. This would be the counterpart of quantum criticality at the level of cognitive representations.

(g) Could the primes appearing as factors of n be preferred p-adic primes? Since these primes as p-adic primes mean a loss of information, they are distinguished but hardly preferred in p-adic evolution. Ramified primes larger than n are more plausible candidates and can be assigned even with polynomials of order 2. The preferred p-adic primes assignable to elementary particles are indeed large: electron would correspond to $M_{127} = 2^{127} - 1 \sim 10^{38}$ [K59].

Quantum measurement theory for cognitive representations

What can one say about quantum measurement theory for cognitive representations? The basic questions concern the tensor products. How many tensor factorizations there are and can one pose some conditions on them? Assume that fermionic Fock states for second quantized spinor fields in n-D group algebra are enough for quantum physics at the level of cognitive representations.

(a) Tensor product decomposition for n-D group algebra corresponds to the factorization

$n = k \times l$. All factorizations of n define a possible quantum measurement situation and state function reduction can take place in bosonic sector to k or equivalently l-dimensional space. These factorizations would be highly unique since they correspond to pairs of Galois group G and its Galois subgroup H. They are defined modulo discrete automorphism of G. It is not clear whether the choice of this automorphism has physical content: one might consider a discrete variant of gauge invariance.
For the fermionic oscillator algebra analogous statement holds true. Now the decompositions are induced by $n = k \times l$ decompositions.

(b) State function reduction cascades would correspond to sequences of Galois subgroups $G \supset G_1 \supset ....G_k$ such that G_k corresponds to either trivial group of group with prime order. In this case the final state would be reached by a factorization in which the density matrix for G_k does not allow eigenvalues in the extension considered. This extension could be G, G_1 or perhaps rationals (frequency interpretation for probabilities).

$M^8 - H$ duality and measurement cascade

$M^8 - H$ duality [L88] suggests much more concrete picture about the measurement cascade.

(a) $M^8 - H$ duality predicts that the roots r_n of a rational polynomial defining the space-time surfaces at the level of M^8 correspond "very special moments in the life of self" $t = r_n$ for the M^4 linear time in the rest system of CD, and that once these moments have been experienced, BSFR can take place. This is possible but not the only possible interpretation.

(b) M^8-H duality and the view about evolution as analog of genetic evolution in which genes are conserved suggests that the polynomials can be regarded as functional composites of simple polynomials $P = P_{n_1} \circ P_{n_2} \circ ...P_{n_k}$ satisfying $P_{n_r} = 0$ (n_i refers to the degree of the polynomial). P possesses the roots of P_i and the corresponding Galois groups as normal subgroups as the counterpart for the conservation of genes in evolution.
One can distinguish also primitive polynomials as those defining extensions which do not decompose further. Galois groups with prime number of elements corresponds to such extensions. Note that the same extension can appear at several levels in hierarchy and would correspond to a realization of extension at different hierarchy level defining a kind of abstraction level.

(c) Intuitively the measurement cascade should correspond to a cascade proceeding to shorter time and length scales by increasing the resolution and also to a process in which abstraction is gradually concretized.
Could the measurement cascade for a state localized to a given extension of rationals start with the measurement of the root set $X_1 = \{r_{1,1}\}$ of P_{n_1} corresponding to the lowest time resolution. After than P_2 and the root set $X_2 = \{r_{2,i}\}$ would be measured meaning a refined of time resolution replacing $r_{1,i}$ with as subset of X_2 around it.
Here one must be however very cautious: one could also consider a hierarchy of CDs with decreasing size scales as the counterpart of the measurement cascade. I do not understand well enough the scale hierarchy to answer the question whether these two views might relate.

Measurement of time number theoretically

Could the measurement of clock time T as (average) distance between the tips of CD [L96] be understood as number theoretical measurement?

(a) What about the measurement of time as the distance T between tips of CD or more generally as the center of mass value T_0 of T in the case that one has Gaussian wave packets localized around varying T_0? How could one realize the measurement apparatus - the clock - in terms of entanglement?
Suppose that the superposition over CDs with different values of T corresponds at the level of space-time surfaces in M^8 to that for space-time surfaces determined by polynomials P_n with varying degrees and rational coefficients. The measurement fixing the extension and Galois group would not fix P_n since there is a large number of polynomials with

rational coefficients but same Galois group. The measurement fixing the extension leads to a partial (at least) localization in T or T_0 but this is not expected to be enough.

(b) A stronger localization in the state function reduction measuring n would require that T or T_0 correlates with the degree n. How could this be achieved in a natural manner? Intuitively the requirement of some fixed time resolution based on the preferred moments $t = r_n$ interpreted as clock readings has fixed resolution as the average time lapse $\Delta T = \langle \Delta T_{i,i+1} = r_{i+1} - r_i \rangle$ would require $n \propto T$ or $n \propto T_0$. How could this be achieved concretely? Could one specify the zero energy states by giving the time resolution as ΔT and being equivalent to energy resolution. This would also dictate the resolution of the cognitive representation as the set of space-time points in the extension.

9.5 Some questions concerning zero energy ontology

Zero energy ontology (ZEO) [L96] gives rise to quantum measurement theory, which naturally extends to a theory of consciousness. In this article also consciousness aspect is central and my sincere hope is that it would not expel those physicist readers for whom consciousness still remains an unscientific notion.

Zero energy ontology (ZEO) briefly

ZEO provides a new ontology solving the key problem of the standard quantum measurement theory and quantum theory itself. It must be emphasized that ZEO is not a new interpretation created to put under the rug the logical paradox due to the conflict between non-determinism of state function reduction (SFR) and the determinism of unitary time evolution. Also the problem about the scale in which quantum world becomes classical disappers: the Universe is quantal im all scales and ZEO view about quantum jump makes the Universe to look like classical.

(a) At the level of space-time dynamics, the notion of preferred extremal (PE) as a space-time surface is central: PE is an extremal of an action principle, which by general coordinate invariance must be highly unique once its intersection with either boundary of causal CD $= cd \times CP_2$ (cd is the intersection of future and past directed light-cones of M^4) is given. In the ideal situation this implies holography. Space-time surface is an analog of Bohr orbit and classical theory is an exact part of quantum theory.
There is probably a finite and discrete non-determinism analogous to that associated with soap films spanned by a frame: space-time is indeed a minimal surface as also soap films, and the 3-surfaces at its ends at boundaries of CD are part of the frame. Besides space-time surface is an extermal for Kähler action analogous to Maxwell action. The challenge is to interpret this finite non-determinism.

(b) Quantum states, which I call zero energy states, can be interpreted as pairs of analogs of ordinary 3-D quantum states with positive energy. The members of the pair are at the opposite boundaries of CD. The convenient convention used also in quantum field theories (QFTs) is that the conserved quantum numbers at opposite boundaries sum up to zero classically: this brings in nothing new. At quantum level, 4-momenta are conserved only at the limit when CD has infinite size whereas classically the conservation holds true for all CD sizes: this reflects the Uncertainty Principle [L136]. Also in QFTs exact momentum conservation is obtained only at the limit of infinite quantization volume.
At the space-time level, zero energy states can be regarded also as superpositions of deterministic time evolutions: this is central for the interpretation.

(c) SFRs are quantum jumps between zero energy states. SFR does not affect any deterministic time evolution but only replaces their superposition with a new one. This solves the paradox that was one of the key motivations for ZEO.

(d) Zeno effect strongly suggests that there are 2 kinds of quantum measurements assignable to SFRs. For "weak measurements", "small" SFRs (SSFRs), the component of zero energy state at the either boundary of CD, to be called passive boundary (PB), is unaffected. Also the PB is unaffected apart from scaling. At the active boundary (AP) state

changes and AP is scaled up (at least in statistical sense) and due to the scaling shifts to the geometric future.
The unitary time evolution preceding each SSFR corresponds to a scaling of CD (or rather, its M^4 projection cd) rather than time translation as its counterpart in string models. In A unitary evolution B between two SSFRs a superposition of CDs with varying sizes is formed and SFR localizes CD to a fixed size, which means the measurement of geometric time identifiable as the distance between the tips of CD. This geometric time correlates with the subjective time defined by the sequences of SSFRs. Subjective and geometric times are not identical as in standard ontology but only correlated.

(e) "Big" SFRs (BSFRs) are the counterparts of ordinary quantum measurements. In the BSFR the roles of AB and PB of CD change so that the arrow of time changes since CD increases in the opposite direction of time (at least in statistical sense). For an observer with an opposite arrow of time, BSFR looks like an average deterministic time evolution leading to the final state of BSFR as observed experimentally by Minev *et al* [L83] [L83]. This illusion makes BSFR look classical in all scales although the TGD based dynamics is quantal in all scales due to the hierarchy of Planck constants predicted by TGD.
The possibility of time reversal forces a generalization of thermodynamics to allow both arrows of time: this kind of generalization was proposed long ago by Fantappie [J30] with motivation coming from biology. Quite generally, self-organization processes seem to violate the arrow of time. External energy feed explains this partially but BSFR would be an important additional element of self-organization [L91, L130], especially so in living matter.
The assignment of "free will" to BSFR allows us to understand how free will can be consistent with the classical non-determinism of physics which would be exact.

ZEO based quantum measurement theory and therefore also physics naturally extends to a theory of consciousness, and one cannot avoid using this word, which is still a cursed word in the physicalistic camp.

Problems related to the mathematical realization of ZEO

There are several open questions related to ZEO and TGD inspired theory of consciousness and the existing view involves several working hypothesis which should be reduced to deeper principles or shown to be wrong.

At least the following questions related to physical interpretation of ZEO are still waiting for a detailed answer.

(a) Preferred extremal (PE) property of space-time surfaces is central for quantum TGD [L114]. It follows from holography forced by general coordinate invariance (GCI), which however need not be ideal. How uniquely does the PE property of the space-time surface fix the space-time surface inside a given CD? The simplest situation is that the data at the end of the space-time surface at either boundary of the CD,fixes it completely. Space-time surface would be an analog of Bohr orbit.
Full determinism would imply that WCW for CD effectively reduces to the space of 3-surfaces assignable to either end of CD. The dynamics of SSFRs would reduces to that in fermionic degrees of freedom assignable to Boolean cognition since WCW degrees of freedom assignable to sensory perception would be fixed.
However, the dynamics of soap films spanned by frames suggests that this is not the case. The 3-D ends of the space-time surface define a frame and also dynamically generated portions of frame are allowed by the variational principle defined by the sum of a volume term and Kähler action as an analog of Maxwell action. The coefficient of the volume term has an interpretation in terms of a length scale dependent cosmological constant Λ. Outside the frame space-time surface would be at least for a very large portion of extremals an analog of complex surface and therefore a minimal surface [L141] and also an extremal of Kähler action. At the frames only the equations for the entire action (sum of volume term and Kähler action) would be satisfied. The divergences of the conserved isometry currents for the volume term and Kähler action would have delta function

type singularities but they would cancel each other. The portions of the frame could be analogous to singularities of analytic functions such as cuts and poles.

(b) Number theoretic universality [L60, L59] in turn suggests that the inherent non-determinism of p-adic differential equations [K70] [L96] proposed to be a correlate of imagination could also relate to this non-determinism. How do the non-determinism of space-time surface, p-adic non-determinism, and non-determinism of the state function reduction relate to each other: could they be even one and the same thing?

ZEO based quantum measurement theory defines a theory of consciousness. How unique is the interpretation of zero energy ontology (ZEO) [L96]? Here 3 options suggest themselves corresponding to "western" and "eastern" world views and their hybrid.

(a) For the western option, the space-time surface continues outside any CD as external world, in particular sub-CD and sub-CD is a correlate for the perceptive field of self.

(b) For the eastern option, space-time ends at the boundary of any CD and sub-CD is not a correlate for the perceptive field of self and there is no constraint from the external world at boundaries of CD.

(c) For the hybrid of these two options, conscious entity corresponds to a hierarchy of CD for which the highest level corresponds to CD for which space-time does not continue outside the CD. The highest level represents a God-like entity.

Problems related to ZEO based theory of consciousness

The new picture about sub-CDs at WCW level raises questions related to the TGD inspired theory of consciousness. This view involves several ad hoc assumptions related to the notions such as attention, mental image, memory, volition and intentions. Do these assumptions follow from more general assumptions or can some of them be simply wrong?

(a) CD is a correlate for the perceptive field of self. Sub-CDs of CD define perceptive fields of subselves identified as mental images. What is the precise definition of sub-CD? Can one say that a sub-CD is created when a mental image is created. How does this happen? What determines the position and size of the sub-CD?
The sub-CD is defined by the restriction of zero energy state to sub-CDs so that sub-CDs are induced by CD. This condition is analogous to boundary condition in classical physics and freezes WCW degrees of freedom of sub-CD at the passive boundary (PB) but the failure of determinism leaves discrete degrees of freedom at the active boundary (AB) so that the dynamics of SSFRs is restricted to these sub-WCW degrees of freedom and fermionic degrees of freedom.

(b) Where sub-CDs and subselves are located? The natural location for a minimal sub-CD and mental images is around 3-surface at which the classical non-determinism fails: the frames of the soap film in soap film analogy. One can develop a rather detailed picture about frames [L141] based on number theoretic vision realized in terms of $M^8 - H$ duality [L104, L105, L121].

(c) How sub-selves (sub-CDs) are created? Can they disappear? The notion of attention as generation of sub-CD achieved by a location of WCW ("world of classical worlds") spinor field at spacetime surfaces having their intersection with the PB of CD in a fixed set of 3-surfaces defining the sub-WCW is highly suggestive. This also affects the WCW spinor field of CD.
The attention can be directed in several ways. Redirection of attention means a movement of the region defining the content of mental images in the interior of a CD. Entanglement and classical communications would be naturally associated with attention defined in this manner. If minimal subselves are associated with the frames as loci of classical non-determinism, the set of targets of attention is discrete and finite.
This view about attention makes it possible to see also memory, anticipation, and intentions as special cases of attention.

(d) The time evolution of CD itself would correspond to a scaling of CD (rather than translation), which by the failure of strict determinism brings in new discrete degrees of freedom related to the new frames becoming into the daylight as space-time surfaces increase.

In the new picture, the sub-WCW property poses strong restrictions to the earlier picture about the development of sub-CD. The idea about silent wisdom as mental images preserved from the previous life after BSFR is not lost but is considerably modified.
In this picture, the small failure of classical determinism would be an absolutely essential element in that it makes possible a non-trivial theory of consciousness at the level of CD and at space-time level. Otherwise would have only fermionic degrees of freedom forgiven sub-CD. What is intriguing is that everything would be finite. SFRs would involve choices between finitely many alternatives and in this respect the theory would be analogous to the computationalistic approach: in fact, preferred extremals are analogous to computer programs.

9.5.1 Some background

In the sequel, some understanding of the basic ideas and notions of TGD proper [L114] is needed. Also ZEO as the target of critical discussion is briefly summarized.

TGD view briefly

Very concisely, TGD emerges as fusion of special and general relativities and has Poincare invariance of special relativity and General Coordinate Invariance (GCI) and Equivalence Principle (EP) as basic principles. Also the interpretation as a generalization of string models is possible: point-like particles are replaced by 3-surfaces instead of strings and world lines become space-time surfaces.

The notion of induction makes it possible to eliminate classical boson fields as primary dynamical variables and reduce them to the sub-manifold geometry of the space-time surface. For the simplest option, free second quantized quark fields of the embedding space $H = M^4 \times CP_2$ induced to the space-time surface remain as fundamental fermion fields and quarks serve as basic building bricks of both bosons and fermions as elementary particles [L97, L122].

Some understanding of notions such as the "world of classical worlds" (WCW) [K89], preferred extremal (PE) [K14], and various variants of holography [L104, L105] implied by general coordinate invariance (GCI) in TGD framework is assumed. Inclusions of hyperfinite factors of type II_1 (HFFs) [K113, K45] are central elements of quantum TGD proper.

Adelic physics [L59, L60] replacing real number based with number theoretical universal physics based on the hierarchy of adeles defined by extensions of rationals (EQs) and $M^8 - H$ duality (see Appendix 9.5.6) allowing number theoretic and geometric views about physics dual to each other is also assumed as the background.

Hierarchy of Planck constants $h_{eff} = n \times h_0$, with n identified as dimension of EQ, is the basic implication of adelic physics and central for quantum TGD. The phases labelled by h_{eff} behave like dark matter [K34, K35, K36, **?**, K35, K36, K37]. This hierarchy serves as a correlate for quantum criticality in arbitrarily long length scales.

Cognitive representations identified as points of space-time surface for which preferred coordinates of embedding space are in an extension of rationals are also central for the construction of the theory using $M^8 - H$ duality [L104, L105].Galois group of EQ becomes number theoretical symmetry and is central in the description of quantum variants of cognitive representations [L17, L115].

Zero energy ontology (ZEO) [L96] is a key notion of quantum measurement theory. The basic prediction is that time reversal occurs in the ordinary state function reduction (SFR). This has profound implications for the interpretation of the quantum measurement theory [L83].

TGD inspired theory of consciousness can be seen as an extension of quantum measurement theory and relies on Negentropy Maximization Principle (NMP) as a basic dynamical principle [K64] [L130] implying second law for ordinary entanglement entropy.

$M^8 - H$ duality as it is towards the end of 2021

The view of $M^8 - H$ duality (see Appendix 9.5.6) has changed considerably towards the end 2021 [L136] 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 [L136] 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 [L136] 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 [L104, L105]. 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 $X^4 \subset M^8$ [L88]. 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 [L136]. 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 [L121] 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 [L136]. 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.

ZEO

The TGD based view of consciousness relies on ZEO solving the basic paradox of quantum measurement theory. First, a brief summary of the recent view of ZEO [L96] is required. Some aspects of this view will be challenged in the sequel for sub-CDs.

(a) The notion of a causal diamond (CD) (see **Fig. 20**) is a central concept. Its little cousin "cd" can be identified as a union of two half-cones of M^4 glued together along their bottoms (3-D balls). The half-cones are mirror images of each other. CD=$cd \times CP_2$ is the Cartesian product of cd with CP_2 and obtained by replacing the points of cd with CP_2. The notion of CD emerges naturally in the number theoretic vision of TGD (adelic physics [L60])via the $M^8 - H$ duality [L90, L104, L105].

(b) In the ZEO, quantum states are not 3-dimensional if the classical determinism does not fail as it actually does, but superpositions of 4-dimensional deterministic time evolutions connecting ordinary 3-dimensional states. By holography forced by general coordinate invariance, time evolutions are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution.

Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced by a new superposition. The classical determinism of individual

time evolution is not violated. This solves the basic paradox of quantum measurement theory. There are two kinds of SFRs: BSFRs (counterparts of ordinary SFRs) changing the arrow of time (AT) and SSFRs (analogs of "weak" measurements) preserving the arrow of time that give rise to an analog of the Zeno effect (`https://cutt.ly/yl7oIUy`) [L96]. The findings of Minev *et al* [L83] provide strong support for ZEO [L83].

To avoid confusion, one may emphasize some aspects of ZEO.

(a) ZEO does not mean that the physical states identified in standard quantum theory as 3-D time= constant snapshots - and assigned in ZEO to the opposite boundaries of a causal diamond (CD) - would have zero energy. Rather, these 3-D states have the same conserved quantities, such as energy. Conservation laws allow us to adopt the convention that the values of conserved quantities are opposite for these states so that their sum vanishes.
This is not new: in quantum field theories (QFTs), one speaks, instead of incoming and outgoing particles, external particles arriving from the geometric past and future and having opposite signs of energy. That conserved quantities vanish in the *4-D* sense, expresses only the content of conservation laws. A weaker form of this condition [L129] states that the total conserved Poincare charges are opposite only at the limit of infinitely large CD. CD would be an analog of quantization volume in QFTs, whose finiteness implies a small conservation of momentum.

(b) ZEO implies *two* times: subjective time as a sequence of quantum jumps and geometric time as a space-time coordinate: for instance, the proper time of the observer. Since subjective time does not correspond to a real continuum, these times are not identifiable but are strongly correlated. This correlation has led to their identification although they are different.

9.5.2 How uniquely PE property fixes the space-time surface?

How uniquely the PE property fixes the space-time surface if its 3-D intersections with the boundaries of CD are given? This is the key question in this section.

Various variants of holography

General coordinate invariance (GCI) forces holography in the TGD framework. One can however consider several variants of holography [L104, L105, L130].

(a) Holography in the standard sense would fix the space-time surface from the data of its intersection with either boundary of CD or the data associated with the light-like 3-surfaces at which the signature of the induced metric changes.

(b) Strong form of holography (SH) states that 2-D data at the intersections of the light-like 3-surfaces and boundary of CD are enough to determine the space-time surface.

(c) The strongest form of holography inspired by $M^8 - H$ duality [L104, L105, L129] states that space-time region is determined by a rational value coefficients of a real polynomial extended to an octonionic polynomials, whose "root" is the space-time surface in M^8. The n roots of a real polynomial would determine a 4-D region in M^8 and its image in $H = M^4 \times CP_2$ would be interpreted as space-time surface.

(d) There is a variant of holography, which gives up the full determinism of classical field equations and gives rise to what look like classical topological analogs of Feynman diagrams.

   i. Consider first the particle level at the level of H. Particle lines generalized to 4-D orbits of 3-D surfaces representing particles. Particles as 4-D orbits of 3-surfaces contain light-line 3- D orbits of partonic 2-surfaces.

   ii. Partons as building bricks of particles in the information theoretic sense, and correspond to partonic 2-surfaces at which the orbits of partonic 2-surfaces meet. Their orbits are 3-D light-like surfaces at which the signature of the induced metric of the space-time surface changes.

The partonic 2-D surfaces defining topological vertices belong to the 3-D sections of space-time surface with a constant value of M^4 time coordinate t to which one can map the 6-D brane-like entities of M^8 predicted by $M^8 - H$ duality [**?**]

This picture suggests that, besides the data at the boundaries of CD, also the data at the partonic 2-surfaces in the interior of CD are needed. This failure of classical determinism brings in the failure of the strongest form of holography. There would be a large number of PEs connecting the 3-surfaces at the ends of CD and they would correspond to the analogs of Feynman diagrams.
Zero energy state as a scattering amplitude would be a superposition over these diagrams. This superposition would not be however pre-determined as in the path integral but the zero energy state would define the superposition of paths in question.

Is the failure of classical determinism possible?

The possibility of classical non-determinism is suggested by the interpretation of space-time surfaces as generalized Feynman diagrams. These Feynman diagram entities would not however define an analog of path integral in TGD framework. Classical non-determinis would be a space-time correlate for the non-nondetermism at quantum level.

In this framework partonic 2-surfaces or equivalently the 3-D sections of the space-time surfaces with constant value of M^4 time would act as 3-surfaces at which the deterministic time evolution as a minimal surface would fail.

Another option is that light-like 3-surfaces containing the partonic 2-surfaces at very special moments of M^4 time define frames. These special values $t = t_n$ of M^4 time would be associated with 6-D branes predicted by M^8 picture as universal special solutions and their images in H would define "very special moments in the life of self" defined by the sequences of SSFRs defining the self.

(a) The first hint comes from the dynamics of soap films. Soap films are minimal surfaces. The soap films spanned by 1-D frames consist of minimal surfaces glued together at the frames and this dynamics is non-deterministic in the sense that it allows several soap film configurations due to the different branchings at frames. At frames the minimal surface equations fail.

(b) In TGD framework space-time surfaces as PEs are both minimal surfaces and extremals of Kähler action. In this case the 3-surfaces associated with "very special moments of time" $t = t_n$ could define an analog of a dynamically generated frame defining a 4-D soap film. The 3-surfaces at the ends of the CD would be fixed frames like those for soap films. This realizes quantum criticality in the sense that the field equations outside frame do not involve the parameters of the action which sum of volume term and Kähler action. The interpretation as a non-linear analog of massless free field theory outside the frame conforms with the basic spirit of quantum field theory. These solutions of field equations rely on a a generalization of holomorphy to 4-D situation so that field equations reduce to purely algebraic conditions involving only the first derivatives of embedding space coordinates. The analogy is defined by the solution of 2-D Laplacian equation in terms of real or imaginary part of an analytic function.
Field equations consist of two terms, which are divergences for the conserved currents (4-momentum currents plus color currents) defined by the induced metric in the case of volume term. In the interior of the space-time surface these divergences vanish separately for the volume term and Kähler action but not at the frame.

(c) The field equations must hold true also at the 3-D frame but this need not be true for both volume term and Kähler action separately. The coupling parameters of the theory make themselves visible only via the frame. For the volume action the divergences of the conserved currents are orthogonal to the space-time surface. For K "ahler action, the divergences of the conserved currents contain to terms. The first term is proportional to the energy momentum tensor of Kähler action and orthogonal to the space-time surface. Second term is not orthogonal to the space-time surface. For twistor lift the Kähler also has an M^4 part with a similar decomposition.

The sums of the parts of divergences orthogonal to the space-time surface and parallel to it must sum up to zero separately. This gives 8 conditions altogether so that the number of field equations is doubled at the frame.

(d) Could it happen that the divergences of these two isometry currents are singular and proportional to 3-D delta function but that their sum vanishes and conservation laws are respected? The part of the frame in the space-time interior would be dynamically generated whereas the part of the frame at the ends of CD would be fixed.

(e) The restriction to 3-D frames is not the most general option. The delta function singularities could be located also at 2-D partonic 2-surfaces, at light-like 3-surfaces at which the induced metric changes its signature, and at string world sheets which connect these light-like 3-surfaces and have 1-D light-like boundaries at them. The light-like 3-D surfaces would be analogs of the cuts for analytic functions. Partonic 2-surfaces at the ends of light-like 3-surfaces could be analogs for the ends of the cuts. String world sheets could serve as analogs of poles.

(f) The non-determinism associated with the soap films and with frames suggests that there is a large number of 4-D "soap films with a given frame", which is fixed at the boundaries of CD but not in the interior of CD.

9.5.3 Questions related to the theory of consciousness

At the level of TGD inspired theory of consciousness theory, causal diamond (CD) defines a correlate of self or of its perceptive field. CD has sub-CDs which correspond to subselves experienced by self as mental images [L96, L130].

Concerning the evolution of self, the basic notions of "small" state function reduction (SSFR) as an analog of "weak measurement" and "big" SFR (BSFR) as an analog of ordinary SFR.

(a) The first deviation from the standard ontology is that BSFR changes the arrow of time defined by the selection of PB of CD at which 3-D part of zero energy states remains unchaged during SSFRs.

(b) The second deviation is that either boundary of CD and states at it remain unaffected in SSFRs whose sequence defines self as a conscious entity. This is the TGD counterpart for the Zeno effect of ordinary quantum theory in which repeated measurements of the same observable leave the state unaffected.

The details of the evolution of self are not fully understood and the proposed general view can be criticized.

(a) How the constraint that sub-CD serves as a correlate for a classical perceptive field can be taken into account?

(b) What is the precise definition of mental images as subselves? Are they at some special positions inside space-time surface?

(c) What are the precise definitions of memories and conscious memory recall? The same question applies to the notions of intention, anticipation and attention.

(d) Can the mental images be destroyed or do they only experience BSFR and continue to live with an opposite arrow of time and become unconscious to self? If a mental image can completely disappear, what could be the physical mechanism leading to its disappearance?

(e) One can challenge the detailed picture of the notion of time evolution by SSFRs. The assumption about the drift of mental images towards future in the second half-cone of CD is ad hoc. Should it be replaced with a deeper assumption. Could one simply assume that they are stationary.

Three ontological options

The basic problem of ZEO is whether the causal diamond (CD) represents a perceptive field in the sense that the space-time surface continues outside the CD or whether CD is an independent entity in the sense that space-time surfaces do not continue outside CD. Conservation laws do not exclude either option.

ZEO allows 3 ontological options which might be called easter, western, and intermediate views.

Option I: Space-time surfaces are restricted inside CDs. Quantum universe is a collection of CDs containing space-time surfaces, which have ends at the boundaries of CD.

In this framework, space-time in cosmological scales is an idealization and could be perhaps explained in terms of the correlations between CDs. CDs do not form a fractal atlas of something unless one says that the atlas *is* the territory. CD is an independent entity rather than a perceptive field of sub-self.

One can argue that for sub-CDs this picture is problematic since it seems that one loses totally the notion of objective reality as something existing outside CD. There are no sensory perceptions. Could the overlaps with other CDs create the experience about the existence of the external world?

Cosmology would be a mental construct and correspond to a very large CD. One would have a multiverse but only at the level of conscious experience. Option I is consistent with the eastern view that only subjective experience exists but not with the western view.

Option II: Space-time surface continues always outside all CDs and CDs can be interpreted always as perceptive fields. Option II conforms with the westerm option and implies that cosmology is something real.

Option III: Self is a hierarchy of CDs such that for sub-CDs the space-time surfaces continue outside the CD but for the largest CD this would not be the case. Sub-CDs would represent perceptive fields but the largest CD would be a God-like entity experiencing itself as the entire cosmos.

Meditators report altered states of consciousness in which the separation to self and external world ceases and the mind is empty. Also the experience of timelessness is mentioned. Could these states correspond to experiences without mental images (sub-CDs) created by SFRs at this highest level?

Option III is roughly consistent with both western and eastern views about consciousness. If one requires the notion of the external world as objective reality and accepts the proposed explanation of altered states of consciousness, option III remains the only possible option.

A general picture about the dynamics of sub-CDs

The ZEO based view of quantum measurement theory and the theory of consciousness inspired by it have not been precisely formulated for sub-CDs. In particular, the question of how sub-CDs as mental images are created, has remained unanswered.

The following proposal provides such a formulation and is consistent with Options I and III.

(a) CDs form a fractal atlas of conscious maps but the map would be the territory since in general the space-time surfaces need not continue outside the CD. There would be no external particles as 4-D lines for generalized Feynman diagrams outside CD.

(b) Sub-CDs correspond to mental images of CD as a conscious entity. From the point of view of consciousness theory, there are only experiencers (CDs) which can have experiences as mental images (have sub-CDs), be mental images of experiencers (be sub-CDs) and share mental images (intersecting CDs with common sub-CDs).

(c) Consistency conditions for the quantum dynamics of CDs and sub-CDs and for the overlapping CDs give rise to correlations between the regions of the map. The shared regions are geometrically analogs for the intersections of the intersections of a covering of a manifold by open sets.

(d) For sub-CD the interpretation of sub-CD as a perceptive field would be natural.

The first question is what does one really mean with sub-CD at the level of space-time surfaces.

(a) Do the space-time surfaces of sub-CD continue outside sub-CD as space-time surfaces of CD? Does this imply that the quantum dynamics of sub-CDs in ZEO is completely dictated by that of CD? This is certainly not the case. Fermionic zero energy states associated with the sub-CD are possible and are analogous to quantum fluctuations. Note that in the TGD framework all elementary particles can be constructed from fundamental fermions (quarks).

(b) If the PE (PE) property fixes completely the space-time surface, its intersections with the boundary of CD, this seems to be the case. If the classical dynamics is not completely deterministic, as suggested by the analogy with minimal surfaces spanned by frames, the situation changes.
Sub-CD defines a subsystem of CD with boundary conditions at the boundary of CD which do not completely fix the quantum dynamics of sub-CD. Quantum states as WCW spinor fields inside sub-CD could change in SFRs of sub-CD.
The tensor product of sub-CD with CD would not be ordinary tensor product but much more restricted one and Connes tensor product, related to inclusions of HFFs, would be a possible identification. A sub-system would be like an included hyper-finite factor of type II_1 (HFF).

Suppose that the classical dynamics is indeed non-deterministic and sub-CDs are defined in the proposed manner. How the view about WCW spinor fields changes as one restricts the consideration to sub-WCW.

(a) The failure of the classical determinism forces to replace each 3-surface at PB with a discrete tree-like structure consisting of all PEs connecting it to AB. Sub-WCW as the space of PEs is larger than the space of 3-surfaces X^3 at PB. Zero energy states are defined in this sub-WCW and assign to a given X^3 a wave function in this discrete set allowing interpretation as wave function in a set of paths of the tree.
One cannot avoid the association with cognitive representations of adelic physics involving the number theoretic degrees of freedom characterized by Galois group of the extension of rationals associated with the polynomial defining the space-time region [L49, L115].

(b) The activation of sub-WCW would mean an SFR selecting in WCW of CD such sub-WCW for which the space-time surfaces are such that their ends at sub-CD are fixed. This would correspond to SFR creating a sub-CD and corresponding mental image. This would answer the long standing question whether and how mental images can appear as if from scratch. This SFR would also represent a third kind of SFR having interpretation as a partial localization in WCW associated with CD. This also suggest that mental images could disappear suddenly. This "activation" could be seen as a directed attention.

(c) WCW degrees of freedom at the boundaries of sub-CD are fixed. Also sub-WCW spinor fields make sense. One can allow the tensor product of Fock spaces of many-fermion states associated with the boundaries of CD. One would have a QFT like picture with sub-WCW degrees of freedom fixed at boundaries of sub-CD.

(d) The tensor product of fermionic state spaces at the boundaries of sub-WCW makes sense and one can define zero energy states in the same manner as proposed hitherto. The only difference is that WCW degrees of freedom are frozen at the boundaries of sub-CD. At the level of conscious experience this means that the subself experiences the external world as fixed. This would be by definition the meaning of being subself.
The fermionic Fock state basis has an interpretation as a Boolean algebra so that fermionic zero energy states have an interpretation as Boolean statements of form $A \to B$. This would mean that consciousness of the subself would be Boolean, cognitive consciousness, thinking. This conforms with the Eastern view that ordinary consciousness is essentially thinking and that the higher level of consciousness as that associated with the highest level of the CD hierarchy of self is pure consciousness. Thinking assignable to the fermionic degrees of freedom would be seen as an endless generation of illusions. "Reality" in this interpretation would correspond to WCW degrees of freedom.

What restrictions must one pose on the quantum dynamics of CDs in the case of sub-CDs? Does the subjective evolution of sub-CD states by SSFRs and BSFRs make sense for sub-CDs?

(a) The increase of the size of sub-CD makes sense and the proposed subjective evolution by scalings and SSFRs makes sense. The time evolution is also now induced by the increase of the perceptive field of a subself defined by the WCW associated with increasing sub-CD bringing in new 4-surfaces due to the classical non-determinism.

(b) What about the interaction between CD and sub-CDs. Does this time evolution respect the condition that the space-time surfaces meet the fixed 3-surfaces at boundaries of sub-CD or is it possible that the SSFRs of CD destroy the subself by delocalization so that sub-CD as a mental images must be regenerated by localization in WCW.

(c) Also the interaction between overlapping CDs and the sharing of mental images can be understood in this framework.

9.5.4 Comparison of the revised view of self with the earlier one

The revised view about TGD inspired theory of consciousness relies on the definition of subself at the level of WCW unlike the older view. In the following the new view is compared with the old view.

The view about SSFRs

Earlier picture

The earlier view about SSFRs was inspired by the M^8 picture.

(a) The dynamics was assumed to involve both scaling of CD with respect to either tip of CD. The lower half-cone was only scaled whereas the upper half-cone was also shifted as required by the stationarity of the passive boundary. Dynamics at PB was passive in the sense that only a portion of the space-time surface became visible making also new states visible at it (Zeno effect) in the sequence of SSFRs . The idea about scaling leads to a rather concrete proposal for the S-matrix characterizing the scalings of CD.

(b) The surfaces inside CD (or sub-CD) were assumed to be mirror symmetric with respect to the middle plane of CD. This assumption does not conform with the assumption that these surfaces define a perceptive field in the sense that they are parts of large space-times and continue outside CD.

The old view had several ad hoc features.

(a) The creation of mental images was implicitly assumed without specifying what this could mean mathematically. These mental images were assumed to be created in the upper half-cone just above the $t = T$ mid-plane of CD and shift to the geometric future with the upper half-cone of CD. The asymmetry between upper and half-cone could be seen as reflecting geometrically the future-past asymmetry but was ad hoc.

(b) One can criticize the assumption that the memories about the events of the subjective past are located in the geometric future with respect to the mid-plane of CD.

(c) Whether mental images can disappear or only die and reincarnate by BSFR, was not specified.

New picture

In the new picture the situation is the following.

(a) Also in the new picture, the time evolution by SSFRs would be a sequence of scalings of CD. The assumption about reflection symmetry of space-time surfaces is given up since it is inconsistent with the identification of sub-CD as a perceptive field. Also now the time evolution is passive in the sense that only a new portion of the space-time surface extending outside sub-CD is revealed at each step.

(b) As in the previous picture, new discrete WCW degrees of freedom appear during the sequence of SSFRs and complexity increases. For both options only fermionic degrees of freedom remain if full determinism is assumed and if QCC is required also at the level of SFRs.

(c) In the new view both directed attention, memory, and intention correspond to a generation of sub-CD by a localization in WCW fixing a subset of 3-surfaces at the PB of CD. Redirecting of attention would allow apparent movement of the sub-CD in the interior of CD and as a special case shifting the mental images in the time direction assumed in the earlier picture.

(d) In the new view the loci of mental images are naturally associated with the loci of classical non-determinism that is 3-surfaces at the 4-D minimal surface branches.

(e) $M^8 - H$ duality suggests that the branchings occur at H image points of the M^8 cognitive representation defined by the quark momenta which are algebraic integers for the extension of rationals defined by the polynomial defining $X^4 \subset M^8$. The non-determinism at

$X^4 \subset H$ point set would correspond to non-determinism assignable to a bound state of quarks at corresponding point of M^8.
Note that physical states correspond to total quark momenta which are rational integers, one can speak of Galois confinement meaning that physical states are Galois singlets. This gives an infinite hierarchy of bound states formed by a universal, purely number theoretical mechanism. All bound states could be formed in this manner.
The non-determinism at $X^4 \subset H$ point which corresponds to a subset of points as images of quark momenta composing the bound state would correspond to non-determinism assignable to a bound state of quarks at corresponding point of M^8. There would be a hierarchy of CDs within CDs and hierarchy of mental images corresponding to the hierarchy of bound states.
The bound state momenta are mapped to $X^4 \subset H$ by $M^8 - H$ duality already described. In particular, the positions of quarks contained in 6-branes X^6 with a constant energy $E = E_n$ are mapped to a sequence of points at the boundary of cd of the system by M^8-duality and it can be said to represent the positions of these quarks. These point sets define sequences of "very special moments in the life of self".
The targets of attention would therefore form a discrete set assignable to bound states of quarks and antiquarks. Note however that each 3-surface X^3 in the superposition defining the WCW spinor field at the PB of CD has its own discrete set loci of non-determinism. BSFRs can change the superposition of these 3-surfaces. The selection between branches is possible in BSFR but not in SSFRs.

(f) An attractive idea motivated by ZEP is that volitional action could be interpreted in the new view as an SFR selecting one path at the node of a tree characterizing the non-determinism. Single deterministic time evolution analogous to a computer program would be selected rather than modifying the deterministic time evolution as in standard ontology. In the M^8 picture, the very special moments $t = r_n$ in the life of self correspond to the roots of a real polynomial. What happens when all roots have been experienced? Does NMP force the BSFR to occur since nothing new can be learned?

Comparison of the views about BSFR

Those aspects of BSFR in which old and new views differ are of special interest.

Earlier view

The fact that the notion of sub-CD and mental image were not properly formulated led to several ad hoc assumptions.

(a) The possible failure of a strict determinism was realized. The failure of strict determinism was assigned to "very special moments in the life of self" associated with the images $E = E_n$ planes of $M^4 \subset M^8$ at which the partonic vertices as loci of non-determinism were assigned.

(b) The mental images of previous life near the AB of CD were assumed to be inherited as "silent wisdom". Their contents was from the early period of life with opposite arrow of time and one can of course ask whether they were really "wisdom".

(c) There were also assumptions about the change of the size scale of CD in BSFR. The idea that the reduction of the size scale guarantees that re-incarnate has childhood was considered. This assumption also prevents unlimited increase of the size scale of sub-CD.

New view

The new view makes it possible to develop a more detailed picture of what happens in BSFR.

(a) The WCW localization at the AB of CD selects one of the branches of the space-time surface beginning at the PB. This selection of the branch happens to each 3-surface in the superposition of 3-surfaces at the PB defined by the WCW spinor field before BSFR.

(b) The future directed tree becomes a past directed tree beginning from one particular branch at the AB. The initial and final space-time surface share a common space-time surface connecting the roots of the old and new trees. This is essential for having a non-trivial transition amplitude for BSFR at WCW level.

In the earlier view, the mental images interpreted as memory mental images and located near the boundary of CD were assumed to be inherited as "silent wisdom" by the time-reversed reincarnate. What happens now?

The notion of "silent wisdom" as inherited information still makes sense.

(a) The new space-time surfaces originate from 3-surface which was selected by WCW localization in BSFR. Therefore the new space-time surfaces carry classical information about previous life.

(b) The space-time surfaces originating from the new root are near to the space-time surface connecting the old and new roots. The WCW spinor field before and after BSFR musthave a strong overlap in order to make the transition amplitude large. This implies that information about previous life is transferred to the new life.

(c) The nearness property could imply that they are easily re-created as perceptions by directed attention so that they would indeed be "silent" wisdom. These mental images are from the later part of the life cycle rather than from the early life as in the earlier picture. If aging means getting wisdom, then silent wisdom would be in question.

Does the notion of "silent wisdom" as mental images make sense?

(a) Mental images - this includes both sensory and memory mental images and intentions) are naturally assignable to the loci of classical non-determinism at the images of the planes $E = E_n$ of the branched space-time surfaces associated with the new root ("very special moments in the life of self").
For the special space-time surface connecting the roots of old and new space-time surface, the surfaces $E = E_n$ in M^8 would not change and the mental images would carry information about previous life. Could one talk about potentially conscious "silent wisdom".

(b) What happens to the mental images of self in BSFR? Can they be preserved or do they disappear or do they reincarmate by BSFR? The idea about preservation makes sense only for space-time surfaces connecting the roots.

(c) What can happen to the size scale of CD in BSFR? The extreme option that CD decreases in size by shift of the formerly PB such that the time evolutions are fully determinimistic in the superposition of 3-surfaces. There would be no inherited silent wisdom and the self would start from scratch, live a chilhood. Otherwise these loci would define candidate for inherited silent wistom.

In the earlier picture the mental images corresponding to sub-CD could not disappear although it could die by BSFR and reincarnate with a reversed arrow of time. Can the mental image disappear now? Creation of mental image require metabolic energy feed: this explains 7 ± 2rule for the number of simultaneous mental images. Could this happen when attention is redirected? Therefore one could argue that mental image must totally disappear when the attention is redirected.

On the other hand, time reversed mental image apparently feeds energy to the environment in the original arrow of time, i.e. apparently dissipates. Could this dissipation be interpreted as an energy feed for its time reversal.

Note that the total disappearance of the mental image means delocalization at the level of WCW and seems possible. The new view clearly challenges the idea about the Karma's cycle of self. This cycle appears in many applications of BSFR.

9.5.5 Conclusions

Also the article *Some comments related to Zero Energy Ontology (ZEO)*" [L96] written for few years ago challenged the basic assumptions of ZEO. One tends to forget the unpleasant questions but now it was clear that it is better to face the fear that there might be something badly wrong. ZEO however survived and several ad hoc assumptions were eliminated.

Progress at the level of basic TGD

The basic goal is to improve the understanding about quantum-classical correspondence. The dynamics of soap films serves as an intuitive starting point.

(a) In TGD frame 3-surfaces at the boundaries of CD define the analog of frame for a 4-D soap film as a minimal surface outside frame. This minimal surface would be an analog of a holomorphic minimal surface and simultaneous exremal of Kähler action except at the frame where one would have delta function singularities analogous to sources for massless d'Alembert equation.

(b) There is also a dynamically generated part of the frame since the action contains also Kähler action. The dynamically generated parts of the frame would mean a failure of mimimal surface property at frame and also the failure of complete determinism localized at these frames.

(c) At the frame only the equations for the entire action containing both volume term and Kähler term would be satisfied. This guarantees conservation laws and gives very strong constraints to what can happen at frames.
The frame portions with various dimensions are analogous to the singularities of analytic functions at which the analyticity fails: cuts and poles are replaced with 3-, 2-, and 1-D singularities acting effectively as sources for volume term or equvavelently Kähler term. The sum of volume and Kähler singularities vanish by field equations. This gives rise to the interaction between volume and Kähler term at the loci of non-determinism.

(d) H-picture suggests that the frames as singularities correspond to 1-D core for the deformations of CP_2 type extremals with light-like geodesic as M^4 projection, at partonic 2-surfaces and string world sheets, and at 3-D $t = t_n$ balls of CD as "very special moments in the life of self" which integrate to an analog of catastrophe. T
Deformations of Euclidean CP_2 type extremals, the light-like 3-surfaces as partonic orbits at which the signature of the induced metric changes, string world sheets, and partonic 2-surfaces at $r = t_n$ balls taking the role of vertices give rise to an analog of Feynman (or twistor -) diagram. The external particles arriving the vertex correspond to different roots of the polynomial in M^8 picture co-inciding at the vertex.

The proposed picture at the level of $H = M^4 \times CP_2$ has dual at the level of (complexified) M^8 identifiable as complexified octonions. The parts of frame correspond to loci at which the space-time as a covering space with sheet defined by the roots of a polynomial becomes degenerate, i.e. touch each other.

Concerning the physical interpretation, a crucial step of progress was the interpretation of M^8 as analog of momentum space allowing to interpret $M^8 - H$ duality as an analog of momentum-position duality and of complementarity principle of wave mechanics [L136]. This forced to modify $M^8 - H$ duality in M^4 degrees of freedom to satify the constraints posed by UP.

There is a nice analogy with the catastrophe theory of Thom [A19, A7]. The catastrophe graph for cusp catastrophe serves as an intuitive guide line. embedding space coordinates serve as behaviour variables and space-time coordinates as control variables. One obtains a decomposition of space-time surface to regions of various dimension characterized by the degeneracy of the root.

Progress in the understanding of TGD inspired theory of consciousness

The improved view about ZEO makes it possible to define the basic notions like self, subself, BSFR and SSFR at the level of WCW. Also the WCW correlates for various aspects of consciousness like attention, volition, memory, memory recall, anticipation are proposed. Attention is the basic process: attention creates sub-CD and subself by a localization in WCW and projects WCW spinor field to a subset of WCW. This process is completely analogous to position measurement at the level of H. At the level of M^8 it is analogous to momentum measurement.

One can distinguish between the Boolean aspects of cognition assignable to WCW spinors as fermionic Fock states (WCW spinor field restricted to given 3-surface). Fermionic consciousness is present even in absence of non-determinism. The non-determinism makes possible sensory perceptions and spatial consciousness.

A precise definition of sub-CD as a correlate of perceptive field at WCW level implies that the space-time surfaces associated with sub-CDs continue outside it. This gives powerful

boundary conditions on the dynamics. For the largest CD in the hierarchy of CDs of a given self, this constraint is absent, and it is a God-like entity in ZEO. This leads to a connection between the western and eastern views about consciousness.

A connection with the minimal surface dynamics emerges [L141]. The sub-CDs to which mental image as subselves are assigned would be naturally associated with portions of dynamically generated frames as loci of non-determinism. If one identifies partonic 2-surfaces as vertices, one can interpret the collection of possible space-time surfaces for a fixed 3-surface at PB as a tree. All paths along the tree are possible time-evolutions of subself. The dynamics of consciousness for fixed 3-surface at PB becomes discrete and provides discrete correlate for a volitional action as selection of a path or a subset of paths in the tree. The reduction of dynamics of mental imagines to discrete dynamics would mean a huge simplification and conforms with the discreteness of cognitive representations.

Challenges

There are many challenges to be faced. The discrete dynamics of sub-self consciousness certainly correlates with the notion of cognitive representation based on adelic physics [L59, L60] and implying a discretization at both space-time level and WCW level. The Galois group for the extension of rationals acting on the roots of the polynomial plays a key role in this dynamics [L115, L121].

One teaser question remains. Localization requires energy quite generally and this conforms with the fact that mental images demand metabolic energy feed. It is possible to redirect attention and it remains unclear whether the mental image disappears totally or suffers BSFR.

This relates directly to the question whether consciousness continues after the physical death. If mental images (and corresponding sub-CDs) can disappear, the same can happen to us since we are mental images of some higher level self. If this cannot happen, BSFR means death and reincarnation with an opposite arrow of time in a completely universal sense. For instance, sleep period could correspond to a kind of death at some level of the personal self hierarchy generalizing the Id-ego-superego hierarchy of Freud. This would explain why we have no memories of the sleep period.

9.5.6 Appendix: M^8- and H views about classical non-determinism and particle reactions

M^8 picture and $M^8 - H$ duality

In M^8 picture, space-time surfaces correspond to real projections of 4-D complex "roots" of octonionic polynomials obtained from real polynomials with rational coefficients by algebraic continuation, i.e. by replacing real coordinate by complexified octonion coordinate [L53, L54, L55] [L104, L105]. The interested reader finds a rather detailed summary of $M^8 - H$ duality in Appendix 9.5.6.

$M^8 - H$ duality maps the point of $M^4 \times E^4$ to a point of $M^4 \times CP_2$ such that the point of $M^4 \subset M^4 \times E^4$ is mapped to some point of $M^4 \subset M^4 \times CP_2$. $M^8 - H$ duality is not a local map. Rather, the normal space of a $x \in X^4 \subset M^8$ goes to a point of CP_2 characterizing its quaternionic normal space.

(a) To be a 4-D "root" in the complex sense means that the real part of a complexified octonionic polynomial determining the space-time surfaces vanishes. The number theoretic content of this condition is that the normal space of the space-time surface is quaternionic and therefore associative. The second option would be that the tangent space is associative but this gives only M^4 as a solution.

(b) At a given point there are n roots and some of them can coincide in some regions of the space-time surface. These regions correspond to the branchings of the space-time surface at which particle-like entities identified as space-time surfaces meet and interact.
The quaternionic normal plane at this intersection is not unique so that several CP_2 points of $X^4 \subset H$ correspond to a single point of $X^4 \subset M^8$. The extreme situation is

encountered in a point-like singularity when the normal plane at a given point of M^4 is a sub-manifold of CP_2.
The interpretation is as particle vertices. The intuitive expectation is that they correspond to partonic 2-surfaces and perhaps also string world sheets. These surfaces are mapped to those in $M^4 \times CP_2$ by $M^8 - H$ correspondence.

(c) Also 6-D brane like entities are predicted as universal "roots" they correspond to 6-spheres in M^8 with M^4 projection which is a 3-ball with constant value $E = E_n$ of energy as counterpart of the Minkowski time coordinate such that E_n is the root of the real polynomial defining the octonionic polynomial. The momenta $(E_n, p = 0)$ are mapped to points $t_n = (\hbar_{eff}/E_n, 0)$ and define "very special moments of time in the life of self".
The points with $p \neq 0$, in particular the points corresponding to quark momentum, however correspond to $t < t_n$ at the boundary of cd with size $L(p) = \hbar_{ef}/\sqrt{E_n^2 - p^2}$. To these moments the failure of classical determinism giving rise to one particular kind of quantum non-determinism is concentrated. Note that points of double hyperboloid of M^4 with opposite energies are mapped to opposite boundaries of cd.

(d) The intersections of 4-D "roots" with 6-D brane-like entities are 2-D and it might be possible to interpret them as analogs of either partonic 2-surfaces or string world sheets at which several roots become degenerate of octonionic polynomial co-incide. Outside the singularity, the roots do not coincide and define separate space-time sheets and it is natural to interpret them as external particles of a particle reaction.

(e) At the light-like orbits of partonic 2-surfaces the induced metric for the H-image of the space-time surface becomes degenerate since its signature changes. Could one say that the Minkowskian and Euclidean roots coincide at the partonic orbits?
One can also wonder what the M^8 interpretation of wormhole contacts having two throats could be. Do the two throats correspond to two coincing roots at the level of M^8 having different normal spaces and mapped to separate 2-surfaces in H?

Catastrophe theoretic analogy

Consider the analogy with the catastrophe theory of Thom [A19] in more detail.

(a) Catastrophe map is the graph of solutions for the vanishing of the gradient of a potential function as a function of control parameters. One considers only real roots as function of variable control parameters and the number of real roots varies as a function of parameters and one obtains lower-dimensional regions at which the number of roots to catastrophe polynomial changes as roots become degenerate [A19, A7]. Cusp catastrophe serves as the school example.

(b) In the recent case, space-time surfaces correspond to roots of complexified octonionic polynomials and the coefficients of the polynomial appear as control parameters. Also complex roots are allowed and real 4-D space-time surface is obtained as a real projection and mapped to H by $M^8 - H$ duality and conjectured to correspond to a preferred extremal of an action determined by the twistor lift of TGD.

(c) The basic motivations for this assumption are quantum criticality requiring preferred extremal property, which requires at the level of H the independence of the dynamics on coupling parameters of the twistor lift of Kähler action outside the loci of non-determinism demanded by M^8 level.

Connection between singularities and preferred extremals of various types

The above picture suggests the characterization of the space-time surfaces in terms of their singularities as surfaces of M^8.

At the level of H one can consider 4 kinds of very simple preferred extremals, which give rise to prototype singularities.

(a) Einsteinian spacetime $X^4 \subset M^8$ with a 4-D M^4 projection and a unique normal space as a point of CP_2. $X^4 = M^4$ defines a prototype.

(b) Cosmic string extremal $X^2 \times Y^2$ with Y^2 a complex surface in CP_2 and defining a set of normal spaces assignable to a point of X^2. $M^2 \times S^2$, S^2 a geodesic sphere defines a proto type. S^2 can be either homological trivial or non-trivial.

(c) $X^3 \times S^1 \subset M^4 \times CP_2$, where S^1 is a geodesic circle of CP_2, is a candidate for a preferred extremal and singular surface. Both $M^3 \times S^1$ and $E^3 \times S^1$ are minimal surfaces and vacuum extremals of Kähler action.
For the Euclidean signature, X^3 could be space-like and define a 3-ball compactifying to S^3 as a sub-manifold of the S^6 brane. The very special moments t_n would be singular in the sense that the normal space at a given point of $X^3 \subset M^4 \subset M^8$ would not be unique and would give rise S^1 singularity.

(d) CP_2 type extremal with light-like geodesic as $M^4 \subset H$ projection and corresponding to a light-like geodesic in M^8 with normal spaces forming a 3-D surface in CP_2. Also $M^1 \times Y^3 \subset M^4 \times CP_2$ can be considered but is probably not a preferred extremal.

The intuitive picture is that these 4 types of preferred extremals correspond to singularities of the normal space of $X^4 \subset M^8$ of dimension $d = 0, 1, 2, 4$ and codimension $d_c = 4 - d$.

Analogy with knot theory

In knot theory a knot in 3-D space is projected to 2-plane where one obtains a diagram containing crossings. Knot invariants can be constructed in terms of this diagram. A knot theory inspired intuition is that space-time surfaces near to these special cases are projected to these special surfaces to get the toy model.

(a) Canonically embedded $M^4 \subset M^8$ (or $M^4 \subset M^4 \times CP_2$) is an analog of the plane to which the knot is projected. One can project the space-time regions with 4-D $M4$ projection to M^4. In particular, those with a Minkowskian signature of the induced metric.

(b) The M^4 projection of CP_2 type extremal is 1-D light-like geodesic. One must project the deformations of CP_2 type extermals to CP_2 type extremal at the level of H. At the level of H, CP_2 type extremal could correspond to a light-like geodesic of M^8 such that each point of the geodesic is singular point such that the union of quaternionic normal spaces defines a 3-D quaternionic surface in CP_2.
A puncture in E^3 as an infinitesimal hole serves as an analogy. At the puncture, one can say that all normal spaces labelled by points of S^2 are realized.
At the given point of the light-like geodesic, the quaternionic normal space of point is not unique but a 3-D union of normal spaces and defines a 3-D subset CP_2.

(c) For the $X^2 \times Y^2 \subset M^4 \times CP_2$ type cosmic string extremals and their small deformations, one must project to $M^2 \times S^2 \subset CP_2$. For a point of X^2 the normal spaces define $Y^2 \subset CP_2$ so that the singularity is milder.
For $X^3 \times S^1 \subset M^4 \times CP_2$ the normal spaces at a point of X^3 would define $S^1 \subset CP_2$. If X^3 is Euclidean, these 3-D singularities could correspond to the $t = t_n$ planes associated with the branes. The small deformations of these surfaces would project to $M^3 \times S^1$. This picture would integrate all 3 kinds of singularities and various types of preferred extremals to a single unified picture.

A toy model for the singularities

The following toy model for the singularities in the case of CP_2 type extremals generalizes also to other singularities.

(a) A rather general class of CP_2 type extremals can be represented as a map $M^4 \to CP_2$ given by

$$m^k = p^k f(r) \ ,$$

where p^k is light-like momentum and r is radial $U(2)$ invariant CP_2 coordinate labelling 3-spheres of CP_2 such that $r = \infty$ gives homologically non-trivial geodesic 2-sphere instead of 3-sphere.

If $f(r)$ approaches constant value for $r \to \infty$, one can say that M^4 time stops at this limit, and one obtains a homologically non-trivial geodesic sphere instead of 3-D surface identifiable as an intersection with 6-D brane. Various external particles of the vertex would correspond to $m^k = p_k f_i(r)$ such that their values at $r = \infty$ co-incide.
It is not possible to obtainh omologically trivial 2-sphere in this manner.

(b) Outside the vertex, the CP_2 type space-time sheets have distinct light-like geodesics as M^4 projections and they can be continued to distinct regions of M^4 in the toy model.
The analog of the knot diagram would be a set of M^4:s with different constant values of CP_2 coordinates. The CP_2 type extremals would be glued along light-like geodesics to various M^4s.
The CP_2 points of M^4:s meeting at the same geodesic sphere must belong to the same geodesic sphere S^2. The S^2:s associated with different vertices are different. Note that any two geodesic spheres must have common points.

(c) In the toy model for the string world sheets $X^2 \times Y^2$ would be projected to a piece of $M^2 \times S^2$ connecting two partonic vertices with the same S^2. S^2:s would be at the ends of the string, whose orbit is a piece of M^2.
$B^3 \times S^1$ could be interpreted as a subset of 6-D brane with B^3 identified as the $t = t_n$ cross section of M^4 light-cone.

This picture would suggest that the singularities could be indeed located to $t = t_n$ planes and integrated together to form a rough analog of catastrophe map.

Some examples of minimal surfaces with 1-D CP_2 projection

This subsection is not directly relevant to the basic topic and is added to give ideas about the possible role of volume term.

The original proposal was that preferred extremals are extremals of Kähler action but the twistor lift introduced the volume term as an additional term. This removed the huge vacuum degeneracy of Kähler action meaning that any 4-surface for which CP_2 projection was so called Lagrange manifold with the property that induced Kähler form vanishes, was a solution of field equations. For these surface induced Kähler potential is pure gauge.

The addition of the volume term removes this degeneracy and only minimal surfaces of this kind are possible as extremals. It is however not clear whether they are preferred extremals (are they analogs of complex surfaces?).

These solutions have not been studied previously [K14]. Space-time surfaces representing a warped embedding of M^4 with a flat metric represent the simplest example.

(a) Denoting the angle coordinate of the geodesic sphere S^1 byΦ and the metric of S^1 by $ds^2 = -R^2 d\Phi^2$ the ansatz reads in linear Minkowski coordinates as $\Phi = k \cdot m$, where k is analog of four-momentum. The induced metric is flat and the second fundamental form vanishes by the linearity of Φ in m so that the field equations are satisfied.
Boundary conditions require the vanishing of the normal components of momentum currents and give $(\eta^{\alpha\beta} - R^2 p^\alpha p^\beta) n_\beta = 0$ .This condition cannot be satisfied so that these solutions should have infinite size, which looks unphysical.
The presence of the volume term in the action implies that the induced metric appears in the boundary conditions and this represents a problem quite generally. The only way to overcome the problem is that there are no boundaries. The many-sheetedness indeed makes this possible.
The warped extremals could represent a reasonable approximation of the space-time surface in the regions which are almost empty.

(b) The light velocity defined in terms of time taken to get from the M^4 position A to B, is reduced to $c_1 = \sqrt{1 - |k \cdot k|}$. If k is light-like this does not happen.
Although the analog of gravitational force is vanishing in warped metric, the deviation the flat metric from M^4 metric given by $|k \cdot k|$ in flat case could it be interpreted as gravitational potential and the gravitational potential energy of test mass would be given by by $E_{gr} = -m|k \cdot k|$.
Could Nature provide a kind of cognitive representation or toy model of a gravitational field as a piecewise constant function in terms of CDs with which warped vacuum

extremals would be associated? The representation would contain length scale dependent Λ as second parameter assigning momentum 4-momentum proportional to $\Lambda\ p^k$ to the CD. The volume energy would include its gravitational potential energy represented in terms of warping?

For warped solutions the space-time light cone - to be distinguished from its embedding space counterpart - would be defined by $c_1^2t^2 - r^2 = 0$ and space-time CD would be modified accordingly.

Only single extremal - canonically embedded M^4 - remains from the spectrum of cosmological vacuum extremals for Kähler action having 1-D CP_2 projection and defined by $\Phi = f(a)$, where f is an arbitrary function of light-cone proper time coordinate $a = \sqrt{t^2 - r_M^2}$.

At QFT-GRT limit, the many-sheeted space-time is approximated with Einsteinian cosmology with the deviation of the induced metric from M^4 metric defined by the sum of the corresponding deviations for the sheets. Since the value of Λ becomes large in short p-adic length scales, a cosmology resembling GRT type cosmology could emerge and Einstein's equations would be a remnant of Poincare symmetry.

The induced metric for the solutions has very little to do with the metric appearing at the Einsteininian limit. The models of cosmology as space-time surfaces based on Kähler action with vanishing Λ could however make sense in very long scales for which Λ approaches zero.

For string dominated cosmology, the comoving mass is proportional to a [K95, K14, K62]. One has a silent whisper amplified to a Big bang in GRT sense. Also critical cosmology [K14] as an analog of inflationary cosmology for which curvature scalar as dimensional quantity vanishes can be regarded as a silent whisper amplified to a Big Bang and also it becomes Euclidean for a critical value $a = a_0$ of cosmic time.

9.6 What could 2-D minimal surfaces teach about TGD?

In the quantum TGD based on zero energy ontology (ZEO) space-time surfaces within causal diamonds (CDs) are fundamental objects [L96, L132]. $M^8 - H$ duality plays a central role: the earlier views can be found in [L53, L54, L55] and the recent view in [L104, L105, L129] differing in some aspects from the earlier view. $M^8 - H$ duality means that one can interpret the space-time surfaces in two ways: either as an algebraic surfaces in complexified M^8 or as minimal surfaces in $H = M^4 \times CP_2$ [L132]. $M^8 - H$ duality maps these surfaces to each other.

The twistor lift of TGD is another key element [L61, L80]. It replaces space-time surfaces with their 6-D twistor spaces represented as 6-D surfaces in the product of twistor spaces assignable to M^4 and CP_2 and having an induced twistor structure. This implies dimensional reduction of a 6-D Kähler action to a sum of a 4-D Kähler action and volume term having interpretation in terms of cosmological constant Λ. Kähler structure exists only for the twistor spaces of M^4 and CP_2 [A12] so that the theory is unique.

Each extension of rationals (EQ) corresponds to a different value $\Lambda > 0$. For $\Lambda = 0$, the finite-D extension of rationals determined by real polynomials would be replaced with real analytic functions or subset of them.

Whether $\Lambda = 0$ can be accepted physically, will be one of the key topics of this article. At the level of adelic theory of cognition [L59, L58] this question boils down to the question whether cognition is always finite and related to finite-D extensions of rationals of whether also infinite-D extensions and transcendence can be allowed.

9.6.1 Basic notions

$M^8 - H$ duality and twistor lift of TGD are the basic notions relevant for what follows and its is appropriate to discuss them briefly.

Space-time surfaces at the level of M^8

The recent view of $M^8 - H$ duality [L104, L105, L129] deserves a brief summary.

At M^8 level, space-time surfaces can be regarded as algebraic 4-surfaces in complexified M^8 having interpretation as complexified octonions. The dynamical principle states that the normal space of the space-time surface at each point is associative and therefore quaternionic. The space-time surfaces are determined by the condition that the real part of an octonionic polynomial obtained as an algebraic continuation of a real polynomial with rational coefficients vanishes.

This gives a complex surface which is minimal surface from which one takes a real part by projecting to real part of complexified M^8: it is not clear whether it is minimal surface of M^8. Minimal surface property is the geometric analog of a massless d'Alembert equation [L36, L89].

Also real analytic functions can be considered [L104, L105] but this leads to infinite-D extensions of rationals in the adelization requiring that also the p-adic counterparts of the space-time surfaces exist. Whether this phase which would correspond to $\Lambda = 0$, can be accepted physically, will be one of the key topics in the sequel.

The conditions defining the space-time surfaces are exactly solvable and the conjecture is that these surfaces are minimal surfaces by their holomorphy (the induced metric of the space-time surface does not however play any role and its role is taken by the complexification number theoretic octonion norm which is real valued for the real projections) [L104, L105, L129].

Space-time surfaces at the level of $H = M^4 \times CP_2$

At the level of $H = M^4 \times CP_2$, space-time surfaces are preferred extremals (PEs) of a 6-D Kähler action fixed by the twistor lift of TGD [L80]. The existence of the twistor lift makes TGD unique since only the twistor spaces of $T(M^4)$ and $T(CP_2)$ have the needed Kähler structure [A12]. The 6-D twistor space $T(X^4)$ of the space-time surface X^4 is represented as a 6-surface X^6 in $T(M^4) \times T(CP_2)$. $T(X^4)$ has S^2 as fiber and X^4 as base. The twistor structure of $T(X^4)$ is induced from the product of twistor structures of $T(M^4)$ and $T(CP_2)$. The S^2 bundle structure of X^6 requires dimensional reduction and dimensionally reduced 6-D Kähler action consists of a volume term having an interpretation in terms of length scale dependent cosmological constant Λ and 4-D Kähler action.

Physically "preferred" means holography: to a given 3-surface at the either boundary of CD one can assign a unique space-time surface as an analog of Bohr orbit. This assumption is very probably too strong: the number of Bohr orbits is finite and the dynamically determined frames of the space-time surface would characterize the non-determinism [L132]. "Preferred" has several mathematical meanings, which are conjectured to be equivalent.

One of those meanings is that space-time surfaces simultaneous extremals of both volume term and Kähler action and field equations reduce almost everywhere to the analogs of the conditions satisfied by complex surfaces of complex manifolds. Note that the field equations express local conservation laws for the isometries of $H = M^4 \times CP_2$ and are in this sense hydrodynamic.

The field equations for preferred extremals do not depend on coupling parameters. This expresses quantum criticality and reduces the number of solutions dramatically as required by the fact that at the level the field equations are algebraic rather than differential equations.

Space-time surfaces are therefore minimal surfaces everywhere except at singularities, which are lower-dimensional surfaces. At singularities they are satisfied only for the entire action. The divergences of the isometry currents for the volume term and Kähler action would have delta function singularities, which must cancel each other to guarantee conservation laws.

The singular surfaces can be wormhole throats as boundaries of CP_2 type extremals at which the signature of the induced metric changes, partonic 2-surfaces acting as analogs of vertices at which light-like partonic orbits representing the lines of generalized Feynman (or twistor) diagram meet, and string world sheets having light-like boundaries at partonic orbits.

Also 3-D singularities are predicted and could be associated to time= constant hyperplanes of M^4, which in M^8 picture are associated with the roots of the polynomials determining space-time region: I have christened these roots "very special moments in the life of self" [L88]. The roots define 6-spheres as universal special solutions and they intersect future light-cone along $t = r_n$ hyper-plane. It is possible to glue different solutions together along these planes so that they can serve as loci of classical non-determinism.

The singular surfaces are analogous to the frames of soap films [L132]: part of them are fixed and at the boundaries of CD and part of them are dynamically generated. Classical conservation laws for the isometry currents expressing field equations pose strong conditions on what can happen in vertices.

$M^8 - H$ correspondence for the singularities

By $M^8 - H$ correspondence, the singular surfaces of $X^4 \subset H$ correspond to the singularities of the pre-image at the level of M^8. For the singularities $X^4 \subset M^8$ the quaternionic normal space of X^4 is not unique at points of a $d < 4$ dimensional surface but is replaced with a union of quaternionic normal spaces labelled by the points of sub-manifold of CP_2 for which the dimension is $d_c = 4 - d$. At the level of H, the singular points blow-up to d_c-dimensional surfaces. What happens for the normal space at a puncture of 3-space serves as a good analog.

In particular, the deformation of a CP_2 type extremal as a singularity corresponds to an image of a 1-D singularity with $(d = 1, d_c = 3)$ and $d_c = 3$-dimensional blow up. The properties of CP_2 type extremals suggest the 1-D curve is light-like curve for mere Kähler action and light-like geodesic for the Kähler action plus volume term.

These situations correspond to $\Lambda = 0$ and $\Lambda > 0$, where Λ is length scale dependent cosmological constant as coefficient of the volume term of action.

Membrane like structures as particularly interesting singularities

Membrane-like structures appear in all length scales from soap bubbles to large cosmic voids and it would be nice if they were fundamental objects in the TGD Universe. The Fermi bubble in the galactic center is an especially interesting membrane-like structure also from the TGD point of view as also the membrane- like structure presumably defining the analog of horizon for the TGD counterpart of a blackhole. Cell membrane is an example of a biological structure of this kind. I have however failed to identify candidates for the membrane-like structures.

An especially interesting singularity would be a static 3-D singularity $M^1 \times X^2$ with a geodesic circle $S^1 \subset CP_2$ as a local blow-up.

(a) The simplest guess is a bubble-like structure as a product $M^1 \times S^2 \times S^1 \subset M^4 \times CP_2$. The problem is that a soap bubble is not a minimal surface: a pressure difference between interior and exterior of the bubble is required so that the trace of the second fundamental form is constant. Quite generally, closed 2-D surfaces cannot be minimal surfaces in a flat 3-space since the vanishing curvature of the minimal surface forces the local saddle structure.

(b) A correlation between M^4 and CP_2 degrees of freedom is required. In order to obtain a minimal surface, one must achieve a situation in which the S^2 part of the second fundamental form contains a contribution from a geodesic circle $S^1 \subset CP_2$ so that its trace vanishes. A simple example would correspond to a soap bubble-like minimal surface with M^4 projection $M^1 \times X^2$, which has having geodesic circle S^1 as a local CP_2 projection, which depends on the point of $M^1 \times X^2$.

(c) The simplest candidate for the minimal surface $M^1 \times S^2 \subset M^4$. One could assign a geodesic circle $S^1 \subset CP_2$ to each point of S^2 in such a way that the orientation of $S^1 \subset CP_2$ depends on the point of S^2.

(d) A natural simplifying assumption is that one has $S^1 \subset S^2_1 \subset CP_2$, where S^2_1 is a geodesic sphere of CP_2 which can be either homologically trivial or non-trivial. One would have a map $S^2 \to S^2_1$ such that the image point of point of S^2 defines the position of the North pole of S^2_1 defining the corresponding geodesic circle as the equatorial circle.
The maps $S^2 \to S^2_1$ are characterized by a winding number. The map could also depend on the time coordinate for M^1 so that the circle S^1 associated with a given point of S^1 would rotate in S^2_1. North pole of S^2_1 defining the corresponding geodesic circle as an equatorial circle. These maps are characterized by a winding number. The map could

also depend on the time coordinate for M^1 so that the circle S^1 associated with a given point of S^1 would rotate in S^2_1.
The minimal surface property might be realized for maximally symmetric maps. Isometric identification using map with winding number $n = \pm 1$ is certainly the simplest imaginable possibility.

Large voids of size scale or order 10^8 light years forming honeycomb like structures are rather mysterious objects, or rather non-objects. The GRT based proposal is that the formation of gravitational bound states leads to these kinds of structures in general relativity but I do now know how convincing these arguments really are.

One should answer two questions: what are these voids and why do they form these lattice-like structures?

One explanation of large voids is based on the TGD based view about space-time as a 4-surface in $H = M^4 \times CP_2$.

(a) Space-time surfaces have M^4 projection, which is 4-D for what I call Einsteinian space-times. At this limit general relativity is expected to be a good approximation for the field theory limit of TGD.
However, the M^4 projection can be also 3-D , 2-D or 1-D. In these cases one has what looks like a membrane, string, or point-like particle. All these options are realized. The simplest membranes would look like $M^1 \times S^2 \times S^1$, S^1 a geodesic circle of CP_2, which depends on a point of $M^1 \times S^2$ defining the M^4 projection. Only this assumption allows us to have a minimal surface. Varying S^1 creates the analog of pressure difference making soap films possible. I discovered this quite recently although the existence of membrane like entities was almost obvious from the beginning.
Small perturbations tend to thicken the dimension of M^4 projection to 4 but the deformed objects are in an excellent approximation still 3-D, 2-D or 1-D.

(b) Large voids could be really voids in a good idealization! Even 4-D space-time would be absent! The void would be the true vacuum. It should be noticed that matter as smaller objects, say cosmic strings thickened to flux tubes, would in turn have galaxies as tangles, which in turn would have stars as tangles. The TGD counterparts of blackholes would be dense flux tube spaghettis filling the entire volume.

(c) What is remarkable that membranes are everywhere: large voids, blackhole horizons, Fermi bubbles, cell membranes, soap bubbles, bubbles in water, shock wave fronts, etc....

What could then give rise to the lattice like structures formed from voids? Here TGD suggests a rather obvious solution.

(a) The lattices could correspond to tessellations of the 3-D hyperbolic space H^3 for which cosmic time coordinate identified as light-cone proper time is constant. H^3 allows an infinite number of tessellations whereas Euclidean 3-space allows a relatively small number of lattices.
There is even empirical evidence for these tessellations. Along the same line of sight there are several sources of light and the redshifts are quantized. One speaks of God's fingers [E6] [K95]. This is what any tessellation of cosmic voids would predict: cosmic redshift would define effective distance. Of course also tessellations in smaller scales can be considered.

(b) Also ordinary atomic lattices could involve this kind of tessellations with atomic nuclei at the centers of the unit cells as voids. The space between nucleus and atom would literally be empty, even 4-D space-time would be absent!

(c) Also the TGD inspired model for genetic code [L128] involves a particular tessellation of H^3 realized at the magnetic body (MB) of a biological system and realizing genetic code. This leads to the conjecture that genetic code is universal and does not characterize only living matter. It would be induced to the space-time surface in the sense that part of tessellation would define a tessellation at the space-time surface. At the level of dark matter at MB, 1-D DNA could also have 2-D and even 3-D analogs, even in ordinary living matter!

9.6.2 Key questions

The basic question to be discussed in the following is what the general ideas about 2-D minimal surfaces can teach about minimal surfaces in M^8 and H, and more generally, about quantum TGD.

Uncertainty Principle and $M^8 - H$ duality

The interpretation of M^8 as analog of momentum space [L104, L105] meant a breakthrough in the understanding of $M^8 - H$ duality but created also a problem. How can one guarantee that $M^8 - H$ duality is consistent with Uncertainty Principle (UP)? The surfaces to which one can assign well defined momentum in M^8 should correspond to the analogs of plane waves in H and geometrically to periodic surfaces.

The fact that at the level of M^8 the surfaces are algebraic surfaces defined by polynomials with rational coefficients poses therefore a problem. Periodicity requires trigonometric functions. The introduction of real anlytic functions with rational Taylor coeffients would force the introduction of infinite-D extensions of rationals and make this possible. This is however in conflict with the idea about the finiteness of cognition forming the basic principle of adelic physics [L59, L60].

Is the category of polymials enough?

Is it possible to have periodic minimal surfaces at the level of H or at the level of both M^8 and H without leaving the category polynomials?

(a) Could the non-local character of the $M^8 - H$ duality in CP_2 degrees freedom miraculously give rise to periodic functions at the level of H? Or should one perhaps modify $M^8 - H$ duality itself to achieve this [L129].

(b) Periodic frames assignable to light-like curves in M^8 as light-like curves would allow to achieve periodicity in the same manner as for helicoid but this requires the extension of the category of real polynomials to real analytic functions in M^8. One could even give up the assumption about a Taylor expansion with rational coefficients and assume that the coefficients belong to some possibly transcendental extension of rationals. This option would make sense in $\Lambda = 0$ phase.

(c) Or could geometry come in rescue of algebra? Could one construct periodic surfaces both at the level of M^8 and H purely geometrically by gluing minimal surfaces together to form repeating patterns as is done for 2-D minimal surfaces? This option could work in $\Lambda > 0$ phases: smoothness at the junctions would be given up but local conservation laws would hold true for the entire action rather than for volume term and Kähler action separately.

If transcendental extensions are allowed, they would naturally contain some maximal root $e^{1/n}$ and its powers. The induced extension of p-adics is finite-D since e^p is an ordinary p-adic number. Logarithms of $log(k)$, $1 \leq k \leq p$, and their powers are needed to define p-adic logarithm for given p. The outcome is an infinite-D extension. Also π and its powers are expected to belong to the minimal transcendental extension.

It came as a surprise to me that is not known whether e and π are algebraically independent over rationals, that is whether a polynomial equation $P(x, y) = 0$ with rational coefficients is true for $(x, y) = (\pi, e)$ (`https://cutt.ly/xmyL23W`.) This would imply that π belongs to the extension defined by the polynomial $P(y, e)$ in an extension of rationals by e. Same would be true in the corresponding finite-D extensions of p-adic numbers. The algebraic independence of π and e would have rather dramatic implications for the TGD view about cognition. That π and e are algebraically independent follows from a more general conjecture by Schanuel and `https://cutt.ly/ImyL1YJ`).

Is also $\Lambda > 0$ phase physically acceptable?

Can one allow also $\Lambda = 0$ phase for the action. In this case the action reduces to mere Kähler action defined by M^4 and CP_2 Kähler forms analogous to self-dual covariantly constant $U(1)$

gauge fields? Could one see $\Lambda = 0$ phase as an analog of Higgs=0 phase?

In this phase the category of rational functions would expand to a category of real analytic functions and infinite extensions of rationals containing transcendental numbers would be unavoidable and allow light-like curves as frames instead of piecewise light-like geodesics.

One could argue that since the evolution of mathematical consciousness has led to the notion transcendentals and transcendental functions, they must be realized also at the level of space-time surfaces.

One can invent objections against the $\Lambda = 0$ phase for which Kähler action has only CP_2 part and serving at the same time as arguments for the necessity of M^4 part.

(a) For a mere CP_2 Kähler action, the CP_2 type extremals representing building bricks of elementary particles become vacuum extremals and are lost from the spectrum. However, also the M^4 part of Kähler action predicted by the twistor lift gives rise to Chern-Simons (C-S) term assignable to the light-like 3-surface X^3_L as the orbit of partonic 2-surface and one can assign a momentum to X^3_L. The boundary conditions guaranteeing momentum conservation make possible momentum exchange between interior and X^3_L.

(b) CP_2 Kähler action has a huge vacuum degeneracy since space-time surfaces with 2-D Lagrangian manifold as a CP_2 projection are vacuum extremals. $\Lambda > 0$ eliminates most of these extremals. Also the M^4 part of Kähler action, which vanishes for canonically imbedded M^4, implies that most vacuum extremals of CP_2 Kähler action cease to be extremals even for $\Lambda = 0$.

While writing the first version of this article I had not realized that what the correct form for the Kähler property in M^4 case is.

(a) Suppose for definiteness the simplest option that the M^4 Kähler form are associated with the decomposition $M^4 = M^2 \times E^2$. A more general decomposition corresponds to Hamilton-Jacobi structure in which the distributions for $M^2(x)$ and $E^2(x)$ orthogonal to each other are integrable and define slicings of M^4 [L136].

(b) The naive guess was that $J^2 = -g$ condition must be satisfied. This implies that the M^2 part of Kähler form of $M^4 = M^2 \times E^2$ decomposition has an electric part, which is imaginary so that the energy density is of form $-E^2 + B^2$ ($= 0$ for M^4). For instance, solutions of $M^2 \times Y^2$, where Y^2 is any Lagrangian manifold of CP_2 would have negative energy for $\Lambda = 0$. Even worse, Kähler gauge potential would be imaginary and the modified Dirac equation would be non-hermitian.

(c) The problem disappears by noticing that the M^2 by its signature has hypercomplex rather than complex structure, which means that the counterpart of the imaginary unit satisfies $e^2 = 1$ rather than $i^2 = -1$. This allows a real Kähler electric field and the situation is the same as in Maxwell's theory.

9.6.3 About 2-D minimal surfaces

A brief summary about 2-D minimal surfaces and questions raised by them in TGD framework is in order. One can classify minimal surfaces to those without frame and with frame.

Some examples of 2-D minimal surfaces

The following examples about minimal surfaces are collected from the general Wikipedia article about minimal surface `https://cutt.ly/Hn673ry`) and various other Wikipedia articles. This article gives also references to articles (for instance the article "The classical theory of minimal surfaces" of Meeks and Perez [A24]) and textbooks discussing minimal surfaces , see for instance [A18]. Also links to online sources are given. "Touching Soap Films - An introduction to minimal surfaces" `https://cutt.ly/dmwMnJ7`) serves as a general introduction to minimal surfaces). There is also a gallery of periodic minimal surfaces (`https://cutt.ly/RmwMQ49`), which is of special interest from the TGD point of view.

1. Minimal surfaces without frame

In E^3 frameless minimal surfaces have an infinite size and are often glued from pieces, which asymptotically approach a flat plane.

Catenoid (https://cutt.ly/in675Z6) is obtained by a rotation of a catenoid, which is the form of the chain spanned between poles of equal height in the gravitational field of Earth. Catenoid has two planes as asymptotics and is obtained from torus by adding two punctures. Costa's minimal surface (https://cutt.ly/in65wyP) is obtained from torus by adding a single puncture and its second end looks like a catenoid.

Frameless minimal surfaces in E^3 allow also lattice-like structures. Schwarz minimal surface (https://cutt.ly/dn65rJm) is an example about minimal giving rise to 3-D lattice like structure. These surfaces have minimal genus $g = 3$.

In compact spaces closed minimal surfaces are possible and some quite surprising results hold true, see the popular article "*Math Duo Maps the Infinite Terrain of Minimal Surfaces*" (http://tinyurl.com/yyetb7c7). These surfaces have area proportional to volume of the embedding space and the explanation is that these surfaces fill the volume densely [A13, A16].

2. Minimal surfaces with lattice like structure

There exists also minimal surfaces with lattice-like structure.

(a) Riemann described a one parameter of minimal surfaces with a 1-D lattice structure consisting of shelfs connected by catenoids (https://cutt.ly/Pn65y3f).

(b) Scherk surfaces (https://cutt.ly/3n65oeB) are singly or doubly periodic. Scwartz surfaces (https://cutt.ly/un65pCK) are triply periodic structures defining 3-D lattices and have minimal genus $g = 3$. This kind of surfaces have been used to model condensed matter lattices. These surfaces have also hyperbolic counterparts.

3. Minimal surfaces spanned by frames

Minimal surfaces with frames allow to models soap films and are obtained as a solution of the Plateau's problem (https://cutt.ly/7n65fgT).

(a) Helicoid (https://cutt.ly/Wn65jgT) represents a basic example of a simply periodic framed surface. Also helicoid involves transcendental functions. A portion of helicoid is locally isometric to catenoid.

(b) Arbitrary curves can serve as frames with some mild restrictions. The minimal surface need not be unique. A given 2-D minimal surface is obtained in topological sense from a compact manifold by adding a puncture to represent boundaries defined by frames or the boundaries at infinity.

Some comments on 2-D minimal surfaces in relation to TGD

The study of the general properties of 2-D minimal surfaces from the TGD perspective suggest a generalization to the TGD framework and also makes possible a wider perspective about TGD itself.

1. Frameless minimal surfaces in TGD framework

Frameless minimal surfaces in E^3 have infinite sizes since they are locally saddle like. In TGD framework, the most interesting space-time surface are expected to be framed. Despite this frameless minimal surfaces are of interest.

(a) In the TGD framework the minimal surfaces could extend to infinity in time-direction and remain finite in spatial directions. The asymptotically flat 2-plane could in TGD correspond to the simplest extremals of action: M^4 and "massless extremals" (MEs); surfaces $X^2 \times Y^2$ with X^2 a string world sheet and Y^2 complex manifold of CP_2; and CP_2 type extremals with 1-D light-like curve as CP_2 projection.
Conservation laws do not allow M^4 even in principle unless the total angular momentum and color charges vanish. Various singularities could deform flat M^4 in close analogy with point and line charges.

(b) In curved compact spaces also closed minimal surfaces are possible [A13, A16] (`http://tinyurl.com/yyetb7c7`). One can wonder whether CP_2 as a curved space might allow a volume-filling closed 2-D or 3-D minimal surfaces besides complex surfaces and minimal Lagrangian manifolds [L89]. For $\Lambda > 0$, only complex surfaces defined by polynomials in M^8 appear in PEs. It is difficult to see how this kind of exotic structure could define a physically interesting partonic 2-surface although formally one could consider a product of string world sheet and this kind of 2-surface.

2. Minimal surfaces with lattice structure

2-D minimal surfaces in E^3 allow lattice-like structures with dimensions 1, 2 and even 3. They are are interesting also in TGD framework.

(a) Scwartz surface (`https://cutt.ly/un65pCK`), call it S, allows in the TGD framework a variant of form $M^1 \times S \times S^1$, where S^1 is a geodesic sphere. Same applies to all 2-D minimal surfaces allowing a lattice structure and could be in a central role in condensed matter physics according to TGD. Also hyperbolic variants of a lattice like structure expected to relate to the tessellations of hyperbolic 3-space can be considered and could play important role at the level of magnetic bodies (MBs) as indeed suggested [L128].

(b) If $\Lambda = 0$ phase is physically acceptable, it would make possible light-like curves as frames and also lattice-like minimal surfaces with periodicity forced by that of the light-like curve assignable to to CP_2 type extremal as M^8 pre-image.
Note that $\Lambda = 0$ phase relates to $\Lambda > 0$ phase by the breaking of conformal symmetry transforming light-like curves to light-like geodesics. The interpretation of $\Lambda = 0$ phase in terms of the emergence of continuous string world sheet degrees of freedom is attractive. Another interpretation would be based on the hierarchy of Jones inclusions of hyperfinite factors of type II_1 (HFFs). $\Lambda > 0$ phase would define the reduced configuration space ("world of calassical worlds" (WCW)) in finite measurement resolution defined by the included HFF representing measurement resolution and $\Lambda = 0$ phase as the factor without this reduction. The approximation of real analytic functions by polynomials of a given degree would define the inclusion. This sequence of approximations would be realized as genuine physical systems ,rather than only approximate descriptions of them.

(c) For $\Lambda > 0$ allowing only polynomial function, periodic smooth minimal surfaces in M^8. The construction of Schwartz surface suggests how one can circumvent this difficulty.
Schwartz surface defines a 3-D lattice obtained by gluing together analogs of unit cells. If a region of a minimal surface intersects orthogonally a plane, the gluing of this surface together with its mirror image gives rise to a larger minimal surface and one can construct an entire lattice-like system in this way. These surfaces are not smooth at the junctions. In the TGD framework, one would construct lattice in time direction and the gluing would occur at edges defined by 3-D $t = r_n$ planes ("very special moments in the life of self" [L88]). Local conservation laws as limits of field equations are enough and derivatives can be discontinuous at $t = r_n$ planes. The expected non-uniqueness of the gluing procedure would mean a partial failure of the strict classical determinism having a crucial role in the understanding of cognition in ZEO. This is discussed in [L132].
M^8-picture suggests a very concrete geometric recipe for constructing minimal surfaces periodic in time direction and this would make it possible to realize UP for $M^8 - H$ duality.

The general vision would be that $\Lambda > 0$ phases the periodic minimal surfaces can be constructed as piecewise smooth lattice-like structures in the category of real polynomials by using the gluing procedure whereas in $\Lambda = 0$ phase they correspond to smooth surfaces in the category of real analytic functions.

3. Minimal surfaces spanned by frames

Minimal surfaces spanned by frames are of special interest from TGD point of view.

(a) In the TGD framework. Minimal surfaces are spanned by fixed frames at the boundary of CD and by dynamically generated frames in the interior of CD. The dynamically generated frames break strict determinism, which means that space-time surfaces as

analogs of Bohr orbits becomes non-unique [L132] and holography (for its various forms see [L104, L105]) forced by the General Coordinate Invariance is not completely unique.

(b) CP_2 type extremal in H would correspond to 1-D singularity in M^8 analogous to a frame assigned 2-D minimal surfaces. The physical picture suggests that this curve is a light-like curve for the Kähler action ($\Lambda = 0$) and a light-like geodesic for action involving also volume term ($\Lambda > 0$). In the first case the periodicity of the light-like curve could give rise to periodic minimal surfaces as generalization of helicoid. In the second case discretized variants could replace these curves.

(c) For the minimal surfaces discussed above, polynomials are not enough for their construction and the examples involve transcendental functions like trigonometric, exponential and logarithmic functions in their definition.
The same is expected to be true also in TGD. Should one leave the category of polynomials and allow all real analytic functions with rational Taylor coefficients? Or should one assume also the $\Lambda = 0$ phase making possible real analytic functions?
As far as cognitive representations are involved, this would mean that cognition becomes infinite since the extensions of p-adic become infinite. Could $\Lambda = 0$ phase be associated with an expansion of consciousness, kind of enlightment, and relate to mathematical consciousness?

9.6.4 Periodic minimal surfaces with periodicity in time direction

There are several motivations for the periodic minimal surfaces.

Consistency of $M^8 - H$ duality with Uncertainty Principle

Consistency of $M^8 - H$ duality with UP is one motivation.

(a) M^8 is interpreted as an analog of momentum space. $M^8 - H$ correspondence must be consistent with UP. If $M^8 - H$ correspondence in M^4 degrees of freedom involves inversion of form $m^k \to \hbar_{eff} m^k/m^2$. [L104, L105, L129]. This solves the problem only partially. $M^8 - H$ correspondence should realize also the idea about plane wave as space-time counterpart of point in momentum space.
The first guess [L129] would be that the $X^4 \subset CD \subset M^8$ is mapped to a union of translates of images of CD by inverse of P^k, where is the total momentum assignable to CD. What I saw as a problem, was that this gives a lattice-like many-particle state rather than a single particle state as a counterpart of a plane wave.
If the momentum is space-like, this is indeed the case. Therefore I proposed that the image is a quantum superposition of translates rather than their union and represents an analog of plane wave. I failed to realize that this is not the case for time-like momentum since periodicity in time direction does not mean lattice as many-particle state.
A geometric correspondence for time-like momenta is possible after all! The problem is a concrete realization of this correspondence and here the geometric construction gluing together the analogs of unit cells to form a periodic structure in time direction suggests itself.

(b) Quite concretely, one could take part of $X^4 \subset CD \subset M^8$ defining particle and construct a periodic surface with a period determined by the total time-like momentum assignable to this part of X^4. X^4 has a slicing by planes $e = e_n$ [L88] assignable to 6-branes with topology of S^6 defining universal special solutions of algebraic equations. Here e_n is a root of the real polynomial defining X^4.
One could take a piece $[e_1, ..., e_k]$ of $X^4 \subset CD$ and glue it to its time reversal in M^8 to get a basic unit cell and fuse these unit cells together to obtain a periodic structure.
The differences $e_i - e_j$, which for M^8 correspond to energy differences, are mapped by inversion to time differences $t_i - t_j$ in H. The order of magnitude for the p-adic length scale assignable to CD in question is the same as for the largest difference for the roots as conjectured on basis of the conjecture that the p-adic length scale correspond to a ramified prime of the extension dividing $|t_i - t_j|^2$ for some pair (i, j). The p-adic prime

for CD need not however be a ramified prime and one can develop an argument for how it emerges [L132].

(c) Rather remarkably, one can glue together portions $[t_1, ..t_r]$ and the mirror image of $[t_k, t_r]$, for any k. All possible sequences of this kind are possible! This suggests an analogy to logical reasoning: $[t_n, t_{n+1}]$ would represent a basic step $t_n \to t_{n+1}$ in the reasoning and one could combine these steps. Could this process serve as the geometric correlate for logical thought or as engineeering at the level of fundamenta interactions?
The physicalists refusing to accept non-determinism at the fundamental level fail to realize that our technology relies on a fusion of deterministic processes and is therefore not consistent with strict determinism. Also computer programs consist of deterministic pieces.

(d) There is still one open question. Does the construction of the time lattices occur only at the level of H or both at the level of M^8 and H? One can argue that the realization of the analog of inverse Fourier transform forces the construction at both sides.

Bohr orbitology for particles in terms of minimal surfaces

In TGD, space-time surfaces correspond to analogs of Bohr orbits. One should also have classical space-time analogs for ordinary bound states as Bohr orbits for particles. Atoms represent the basic example. In TGD Universe, Bohr model should be much more than mere semiclassical model. Also the geodesic orbits of particles in gravitational fields should have minimal surface analogs.

The Bohr orbits should be representable as parts of minimal surfaces identifiable as deformed CP_2 type extremals. There are two options to consider corresponding to $\Lambda = 0$ phase and to $\Lambda > 0$ phases.

1. $\Lambda = 0$ *phase*

$\Lambda = 0$ phase corresponds to a long length scale limit but general consideratons encourage its inclusion as a genuine phase. Its relation to $\Lambda > 0$ phases would be like the relation of real numbers to extensions of rationals and transcendental functions to polynomials.

(a) For $\Lambda = 0$, CP_2 type extremals are vacuum extremals and correspond to 1-D singularities, which are light-like curves in M^8 blown up to orbits of wormhole contacts in H.
Light-like curve as an M^4 projection of Bohr orbit of this kind can give rise to "zitterbewegung" as a helical motion with average cm velocity $v < c$. The proposal for the TGD based geometric description of Higgs mechanism realizes this zitterbewegung of CP_2 type extremals for Kähler action. This makes it possible to assign to any particle orbit - be it Bohr orbit in an atom or a geodesic path in a gravitational field, an average of a light-like curve.

(b) Light-likeness gives rise to Virasoro conditions emerging in the bosonic string theories. This served as a stimulus leading to the assignment of extended Kac-Moody symmetries to the light-like partonic orbits X^3 . The isometries of H define the extended Kac-Moody group. The generators of the Kac-Moody algebra depend on the complex coordinate z of the partonic 2-surface and on the light-like radial coordinate of X^3. Super-symplectic symmetries assigned to the light-like $\delta M^4_{\pm} \times CP_2$ and identified as isometries of WCW have an analogous structure [K89] [L114].
The light-like orbits of the partonic 2-surfaces in H are connected by string world sheets. The interpretation could be that in $\Lambda = 0$ phase strings emerge as additional degrees of freedom.

(c) For CP_2 part of Kähler action $\Lambda = 0$ CP_2 type extremals are vacua (this need not be the case for the deformations). The C-S term for CP_2 Kähler action carries no momentum and cannot contribute to momentum and cannot realize momentum conservation for deformed CP_2 type extremals.
However, the C-S term for the M^4 part of Kähler action defines the partonic orbits as dynamical entities. If the projection of the deformation of CP_2 type extremal at the wormhole throat has M^4 projection with dimension $D = 3$, M^4 C-S term gives rise

to non-vanishing momentum currents and the smooth light-orbit is consistent with the momentum conservation if boundary conditions are realized. What is remarkable that M^4 C-S term also gives rise to small CP breaking, whose origin is not understood in the standard model. The tiny C-S breaking term would be paramount for the existence of elementary particles!

The implications of this picture are rather profound. It could be possible to assign to any physical system rather detailed view about the minimal surfaces involved both at the level of H and M^8.

Could tachyonic states appear as parts of non-tachyonic states somewhat like tachyonic virtual particles appear in Feynman graphs?

(a) The possibly existing periodic minimal surfaces with tachyonic total momenta would have an interpretation as lattice-like many-particle states. This excludes them as unphysical. In fact, one cannot construct tachyonic periodic minimal surfaces in the proposed way since the planes $t = t_n$ have time-like normal.

(b) M^8 picture allows to interpret tachyonicity as a trick. In the M^8 picture the choice of $M^4 \subset M^8$ is in principle free. The mass squared of the particle depends on this choice since M^4 momentum is a projection of M^8 momentum to $M^4 \subset M^8$. For eigenstates of M^4 mass, one can rotate $M^4 \subset M^8$ in such a way that the mass squared vanishes. For a superposition of states with different mass squared possible in ZEO this is not possible but one can choose M^4 so that mass squared is minimized. This gives rise to p-adic thermodynamics as a description for the mixing with heavier states.
One could understand the tachyonic ground state as an effective description for the choice of M^4 in this manner.

2. $\Lambda > 0$ phase

For $\Lambda > 0$ only light-like geodesics are possible and this forces a modification of the above picture by replacing light-like curves with piece-wise light-like geodesics.

(a) A discrete variant of zitterbewegung consisting of pieces of light-like geodesics is suggestive. The dynamics in stringy degrees of freedom would be almost frozen and completely dictated by the ends of the string. Discretized version of smooth dynamics would be in question. This kind of phenomenological model for hadronic strings has been proposed.

(b) The change of the direction of the partonic orbit takes place in a vertex. In M^8 picture it is associated with a partonic 2-surface associated with a $t = r_n$ hyperplane at which several CP_2 type extremals meet at the level of H. These reactions could be seen as ordinary particle reactions.

(c) Another way to change the direction would be based on the interaction of parton with the interior degrees of freedom so that conservation laws are not lost. The interaction between the 3-D orbit of wormhole throat and interior is defined by the condition that normal components of the isometry currents of the total Kähler action are equal to the divergences of C-S currents the partonic orbit. For the M^4 part of C-S action only momentum currents are non-vanishing whereas for CP_2 only color currents are non-vanishing.
At the turning points the normal current of the entire Kähler action - and the divergence of the isometry current for C-S part CP_2 type extremal must become non-vanishing and divergent but cancel each other. Local conservation laws hold true and one can speak of a momentum exchange between interior and wormhole throat. This picture applies also to color currents.

3. A connection with Higgs mechanism

The fact that zitterbewegung makes the particle effectively massive in long enough scales, suggests an analogy with the massivation by the Higgs mechanism.

(a) The interactions between partonic orbits and the interior of the space-time surface are analogous to the interactions of particles with a Higgs field leading to the massivation as the Higgs field develops a vacuum expectation value.

(b) M^4 Kähler form represents a constant self-dual Abelian gauge field. Although this field is not a scalar field, it is analogous to the vacuum expectation value of the Higgs field as far as its effects are considered.

4. A connection twistor diagrams and generalization of cognitive representations

Also a connection with twistor diagrams is suggestive. The light-like geodesic lines appearing as 1-D singularities in M^8 would correspond to light-like differences of the time-like momenta assignable to vertices. In H they are assignable with partonic 2-surfaces identifiable as boundaries of 3-D blow ups of 1-D singularities in M^8. In M^8, the graphs containing time-like momenta connected by singular lines would define analogs of twistor diagrams. Also at the level of H the lines connecting partonic 2-surfaces would be light-like as also the distances between them since the inversion map preserves light-likeness of the tangent curves.

This would pose additional conditions on cognitive representations.

(a) The original proposal [**?**]as that cognitive representation consists of points of X^4 for which M^8 coordinates belong to the EQ associated with the polynomial considered. The expectation was that one has a generic situation so that this set is automatically finite. The explicit solution of the polynomial equations however led to a surprising finding was that the number of these points was a dense set for the space-time surfaces satisfying co-associativity conditions [L104, L105]. The second surprise was that co-associativity (associativity of normal space) is the only possible option.

(b) The additional conditions guaranteeing that the cognitive representation consists of a finite number of objects, generalize it from a discrete set of points to a union of singularities with co-dimension $d_c = 4 - d$, $d = 1, 2, 3$.
The vertices would be connected by $d = 1$ light-like singularities and belong to 2-D partonic 2-surfaces as $d = 2$ singularities at $t = r_n$ surfaces in turn defining $d = 3$ singularities. Also 2-D string world sheets having $d = 1$ singularities as boundaries would be included.

(c) This would also generalize twistor diagrams as a frame holographically coding for the space-time surface as an analog of Bohr orbit. At the M^8 level, the definition of the parts of this structure would involve only parameters with values in EQ (say the end points of a light-like geodesic defining it).

Periodic self-organization patterns, minimal surfaces, and time crystals

Periodic self-organization patterns which die and are reborn appear in biology. Even after images, which die and reincarnate, form this kind of periodic pattern. Presumably these patterns would relate to the magnetic body (MB), which carries dark matter in the TGD sense and controls the biological body (BB) consisting of ordinary matter. The periodic patterns of MB represented as minimal surface would induce corresponding biological patterns.

The notion of time crystal [B10] (`https://cutt.ly/2n65x0k`) as a temporal analog of ordinary crystals in the sense that there is temporal periodicity, was proposed by Frank Wilczeck in 2012. Experimental realization was demonstrated in 2016-2017 [D12] but not in the way theorized by Wilczek. Soon also a no-go theorem against the original form of the time crystal emerged [B17] and motivated generalizations of the Wilzeck's proposal.

Temporal lattice-like structures defined by minimal surfaces would be obvious candidates for the space-time correlates of time crystals.

(a) One must first specify what one means with time crystals. If the time crystal is a system in thermo-dynamic equilibrium, the basic thermodynamics denies periodic thermal equilibrium. A thermodynamical non-equilibrium state must be in question and for the experimentally realized time crystals periodic energy feed is necessary.
Electrons constrained on a ring in an external magnetic field with fractional flux posed to an energy feed form a time crystal in the sense that due to the repulsive Coulomb interaction electrons form a crystal-like structure which rotates. This example serves as an illustration of what time crystal is.

(b) Breaking of a discrete time translation symmetry of the energy feed takes place and the period of the time crystal is a multiple of the period of the energy feed. The periodic energy feed guarantees that the system never reaches thermal equilibrium. According to the Wikipedia article, there is no energy associated with the oscillation of the system. In rotating coordinates the state becomes time-independent as is clear from the example. What comes to mind is a dynamical generation of Galilean invariance applied to an angle variable instead of linear spatial coordinate.

(c) Also the existence of isolated time crystals has been proposed assuming unusual long range interactions but have not been realized in laboratory.

Time crystals are highly interesting from the TGD perspective.

(a) The periodic minimal surfaces constructed by gluing together unit cells would be time crystals in geometric sense (no thermodynamics) and would provide geometric correlates for plane waves as momentum eigenstates and for periodic self-organization patterns induced by the periodic minimal surfaces realized at the level of the magnetic body. It is difficult to avoid the idea that geometric analogs of time crystals are in question.

(b) The hierarchy of effective Planck constants $h_{eff} = nh_0$ is realized at the level of MB. To preserve the values of h_{eff} energy feed is needed since h_{eff} tends to be reduced spontaneously. Therefore energy feed would be necessary for this kind of time crystals. In living systems, the energy feed has an interpretation as a metabolic energy feed.
The breaking of the discrete time translation symmetry could mean that the period at MB becomes a multiple of the period of the energy feed. The periodic minimal surfaces related to ordinary matter and dark matter interact and this requires con-measurability of the periods to achieve resonance.

(c) Zero energy ontology (ZEO) predicts that ordinary ("big") state function reduction (BSFR) involves time reversal [L96, L132]. The experiments of Minev *et al* [L83] [L83] give impressive experimental support for the notion in atomic scales, and that SFR looks completely classical deterministic smooth time evolution for the observer with opposite arrow of time. Macroscopic quantum jump can occur in all scales but ZEO together with h_{eff} hierarchy takes care that the world looks classical! The endless debate about the scale in which quantum world becomes classical would be solely due to complete misunderstanding of the notion of time.

(d) Time reversed dissipation looks like self-organization from the point of view of the external observer. A sub-system with non-standard arrow of time apparently extracts energy from the environment [L91]. Could this mechanism make possible systems in which periodic oscillations take place almost without external energy feed?

Could periodic minimal surfaces provide a model for this kind of system?

(a) Suppose that one has a basic unit consisting of the piece $[t_1, .., t_k]$ and its time reversal glued together. One can form a sequence of these units.
Could the members of these pairs be in states, which are time reversals of each other? The first unit would be in a self-organizing phase and the second unit in a dissipative phase. During the self-organizing period the system would extract part of the dissipated energy from the environment. This kind of state would be "breathing" [L193].
There is certainly a loss of energy from the system so that a metabolic energy feed is required but it could be small. Could living systems be systems of this kind?

(b) One can consider also more general non-periodic minimal surfaces constructed from basic building bricks fitting together like legos or pieces of a puzzle. These minimal surfaces could serve as models for thinking and language and behaviors consisting of fixed temporal patterns.

9.7 Double slit experiment in time domain from the TGD perspective

The temporal analog of the double slit experiment carried out by a research team led by Riccardo Sapienza [D11] has gained a lot of attention. The experiment is a generalization

of the regular double slit experiment to the time domain (rebrand.ly/tmbz3gu).

I am grateful to Tuomas Sorakivi for turning my attention to a Youtube video "Light Can Interfere in Time as well as Space" by Ben Milles (rebrand.ly/zz3jq2a). The discussions in our Zoom group about the experiment inspired this article and led to an idea that the testing of the basic predictions of zero energy ontology might be possible.

There are also popular articles about the experiment in Live Science (rebrand.ly/o0ojyya) and in Quantum Insider (rebrand.ly/y3k24gl).

The following is the abstract of the research article [D11]:

"Double-slit experiments—where a wave is transmitted through a thin double aperture in space—have confirmed the wave–particle duality of quantum objects, such as single photons, electrons, neutrons, atoms and large molecules. Yet, the temporal counterpart of Young's double-slit experiment—a wave interacting with a double temporal modulation of an interface—remains elusive. Here we report such a time-domain version of the classic Young's double-slit experiment: a beam of light twice gated in time produces an interference in the frequency spectrum.

The 'time slits', narrow enough to produce diffraction at optical frequencies, are generated from the optical excitation of a thin film of indium tin oxide near its epsilon-near-zero point. The separation between time slits determines the period of oscillations in the frequency spectrum, whereas the decay of fringe visibility in frequency reveals the shape of the time slits.

Surprisingly, many more oscillations are visible than expected from existing theory, implying a rise time that approaches an optical cycle. This result enables the further exploration of time-varying physics, towards the spectral synthesis of waves and applications such as signal processing and neuromorphic computation."

The temporal analog of double slit experiments are expected to have many technological applications:

"The observation of temporal Young's double-slit diffraction paves the way for the optical realizations of time-varying metamaterials, promising enhanced wave functionalities such as non-reciprocity, new forms of gain, time reversal and optical Floquet topology. The visibility of oscillations can be used to measure the phase coherence of the wave interacting with it, similar to wave–matter interferometers. Double-slit time diffraction could be extended to other wave domains, for example, matter waves, optomechanics and acoustics, electronics and spintronics, with applications for pulse shaping, signal processing and neuromorphic computation."

Double slit experiment in spatial domain

One can look at the description of the situation in Maxwell's classical theory first. One has two slits at the first screen characterized by their distance and their widths. They parameterize the diffraction pattern at the second screen. The beam can be assumed to be monochromatic and normal to the screen.

Formally one can say that the transparency of the screen containing the slits is varying. It vanishes outside the slits and is maximal at the slits. The transparency of the screen depends on position. The modelling based on Maxwell's equations assumes incoming beam of light, say plane wave in definite direction and presence of the first screen described in terms of transparency. One can solve Maxwell's equations and predict the diffraction pattern.

One can study the spatial interference pattern at the second screen or equivalently, its Fourier transform with respect to a coordinate parallel to the screen and in the direction vertical to the parallel slits. One obtains a diffraction pattern also in the space of wave vectors (photon momenta in the quantum situation). The dominating peak is associated with the wave vector associated with the incoming beam.

In the diffraction, the normal component of the wave vector is conserved but the tangential component can change. This gives rise to dispersion with respect to the tangential component of the wave vector. At single photon level one can say that the slit scatters the incoming photons to various directions.

Hitherto everything has been purely classical. What makes the phenomenon so remarkable is that the double slit diffraction patterns appear also when single photons are used. This takes place also for other particles. The classical view of a particle would predict two peaks behind the slits.

9.7.1 Double slit experiment in time domain

What happens in the temporal double slit experiment is very similar to what happens in the regular case. One cannot directly measure the temporal patterns of the reflected wave. One can however measure the intensity as a function of frequency characterized by the Fourier transform of the reflected electromagnetic field. If one is also able to determine the phases of the Fourier components theoretically, one could also estimate the fields at the level of space-time, even those before the first pump pulse.

The frequency distribution is qualitatively similar to that for the wave vector distribution in the regular double slit experiment. Slit becomes pulse, slit width becomes the duration of pulse, and the distance between slits becomes the interval between pulses.

The effect is stronger than expected for short pulse durations approaching the optical cycle $T = 1/f$ where f is the frequency of the incoming laser beams. The proposal is that what matters is the time scale τ for the change from transparency to reflectivity lasting as the duration of the pulse. One has $\tau = 2.3$ fs is roughly one half of the period $T = 1/f = 4.4$ fs of the period of incoming laser beam. The duration between pulses is .8 ps.

During period τ the dispersion of the chromatic beam to frequencies around the peak frequency would take place and could be understood mathematically as following from the time dependence of the refractive index (or reflection coefficient).

The frequency dispersion occurs already for a single pulse and gives rise to a single maximum as in the case of the ordinary single slit experiment. For two pulses a diffraction pattern in the frequency domain resembling that of the double slit experiment is observed. The shorter the duration of the pulse is and the shorter the time interval between slits is, the more pronounced the diffraction pattern is.

Maxwell's equations in the presence of the screen with time dependent refractive index describes the situation classically in the first approximation. Time dependent refractive index characterizes the screen. Refractive index does not change during the period between pump pulses but changes during the period τ to a constant value preserved during the pump pulse and after that returns to its original value. The interpretation would be that pump pulse feeds to the system energy needed to keep the value of the refractive index constant allowing reflection. One can say that during the pulse the system is not closed.

In the Maxwellian view, the reflected fields propagate with a light velocity. This gives rise to classical causality. The temporal field pattern of the reflected wave deducible by the inverse Fourier transform from its frequency pattern should vanish before the first pulse. But is this really the case? Time reversal is mentioned in the abstract of the article: is there evidence that this is actually not the case?

9.7.2 TGD view of the double-slit experiment in temporal domain

Consider next the TGD [L136] based quantum view of the situation.

Basic incredients

There are several new ingredients involved.

(a) TGD leads to a new view of space-time [L180]. Point-like particles are replaced by 3-surfaces in $H = M^4 \times CP_2$ and their orbits determine space-time regions. The regions of space-time surface obey almost deterministic holography, being analogous to Bohr orbits.

(b) Holography forces zero energy ontology (ZEO) [L96, L76, L144, L132] replacing the standard ontology of quantum theory and solving the basic paradox of the quantum measurement theory. ZEO also leads to a new view of what occurs in state function reductions (SFRs).

(c) Number theoretic view of TGD predicts a hierarchy of effective Planck constants $h_{eff} = nh_0$ [K34, K35, K36, **?**, K35, K36, K37] characterizing phases of ordinary matter behaving in many respects like dark matter. They allow long length scale quantum coherence. In the recent case, laser beams could have $h_{eff} > h$.

(d) Momentum position duality is generalized to $M^8 - H$ duality [L104, L105, L178], which states that the M^8 picture providing algebraic and number theoretic view of physics is complementary to the geometric view of physics.

This framework could allow totally new insights of the double slit experiment in the time domain.

ZEO briefly

I have explained ZEO so many times that I will give only a very brief sketch.

(a) In ZEO, quantum states are superpositions of classical time evolutions obeying almost, but not quite(!) exact holography [L179, L180, L168]. These time evolutions correspond to space-time surfaces analogous to Bohr orbits. These space-time surfaces are within a causal diamond (CD) and zero energy states are pairs of 3-D states as analogs of ordinary 3-D quantum states at the opposite boundaries of the CD identifiable as superpositions of 3-surfaces.

(b) There are two kinds of state function reductions (SFRs) [K117] [L96, L132, L76]. "Small" SFRs (SSFRs) preserve the arrow of time, and their sequence is the counterpart for repeated quantum measurements which do not affect the system at all (Zeno effect). SSFRs do not affect the passive boundary nor 3-D states at it. SSFRs affect the states at the active boundary of CD and in a statistical sense shift it farther away from the passive boundary. This shifting corresponds to the increase of the geometric time identified as the distance between the tips of CD. Geometric time therefore correlates with the subjective time identified as the sequence of SSFRs.

(c) In "big" SFRs (BSFRs), which are counterparts of ordinary SFRs the arrow of time changes and the roles of active and passive boundaries of CD are changed. SSFRs correspond to a sequence of measurements of fixed observables. The states at the passive boundary are eigenstates for a subset of these observables and are not affected in SSFRs. When the set of measured observables changes by external perturbation, BSFR must occur and change the arrow of time temporarily. Quantum tunnelling would correspond to a temporary change of the arrow of time caused by two BSFRs.

Could ZEO make it possible to say something interesting about the time slit experiments?

(a) In Maxwellian view the reflected fields propagate with light velocity. This gives rise to classical causality. In the Maxwellian picture, the temporal field pattern of the reflected wave, possibly deducible by inverse Fourier transform from its Fourier transform, should vanish before the first pulse. Is this really the case? Can this be tested? Time reversal is mentioned in the abstract of the article, is there evidence for the occurrence of a temporary time reversal.

(b) Could the pump pulse induce BSFR and a temporary time reversal? The end of the pulse would induce a second BSFR and bring back the original arrow of time. Since SFRs replace the superposition of classical space-time surfaces (classical time evolutions and therefore field patterns) with a new one, the pair of BSFRs would change the classical field patterns also in the geometric past.

Could the classical field patterns be deduced from the frequency spectrum of reflected waves? If it is possible to estimate the phases of the Fourier components theoretically, it is in principle to estimate the classical spatiotemporal field patterns in the geometric past.

If they violate classical causality, i.e. are non-vanishing before the first pump pulse, one can conclude that the experiment provides a strong support for ZEO. Quite generally, one might someday be able to measure what happens to the geometric past in BSFR pairs.

Can one determine the classical fields in the geometric by measuring the Fourier transform?

In principle, there are good hopes that in the TGD Universe it might be possible to deduce from the frequency spectrum of the reflected light the spatiotemporal behavior of

the reflected wave in the geometric past and therefore test ZEO. There are several reasons for why this should be the case.

(a) Classical fields are geometrized in TGD. For a single space-time surface the classical fields are determined completely by the surface itself as induced fields. This simplifies dramatically the mathematical picture.

(b) Topological quantization means that Maxwellian classical fields decompose to topological field quanta, which or at least their M^4 projections have a finite size. One obtains a variety of field quanta. Massless extremals (MEs) are highly analogous to laser beams and represent precisely targeted propagation in which the pulses consisting of Fourier components with only a single direction of wave vector in the direction of ME preserve their shape.
The pulse beam, incoming laser beam and reflected light beam(s) could be modelled in terms of MEs. The reflected beam could correspond to a ME representing a superposition of analogs of parallel plane waves with different frequencies. Monochromatic ME becomes multichromatic ME in the reflection. One could say that the frequency dispersion represents new physics predicted by TGD.

(c) Holography makes it possible to deduce a given space-time surface from a 3-D holographic data, basically a set of 3-surfaces. There is no need to know the 4-D tangent spaces at the 3-surfaces.
There is however a small violation of determinism for the holography, which in fact forces ZEO. At the space-time level this corresponds to the fact that space-time surfaces as minimal surfaces are not completely fixed by holographic data, which is analogous to frames spanning soap films.

(d) Complexified M^8 is an analog of 8-D momentum space and a given 4-surface in M^8 is determined by roots of a polynomials, which correspond to mass shells $H^3 \subset M^4 \subset M^8 = M^4 \times E^4$. The 4-surface $Y^4 \subset M^8$ must go through 3-surfaces at these mass shells defining the holographic data.
The condition that the normal space of 4-surface $Y^4 \subset M^8$ going through these mass shells is associative allows us to realize M^8 holography almost uniquely.

(e) One can also apply $M^8 - H$ duality, which is analogous to momentum position duality of wave mechanics. $M^8 - H$ duality maps $Y^4 \subset M^8$ to a space-time surface $X^4 \subset H = M^4 \times CP_2$ and induces holography at the level of H. For space-time surfaces, holography means a generalization of holomorphy from 2-D to a 4-D situation.
In particular, mass shells are mapped by the inversion mapping M^4 momentum value at mass shell to a light-cone proper time $a = constant$ hyperboloid in $M^4 \subset H$. The momentum components are in general algebraic integers and therefore complex. Therefore one must take the real part of the image by inversion. One has $p^k \to Re[h_{eff} p^k/p_l p^l]$ [L178].
This works when mass squared $p^l k p_l = m^2$ is nonvanishing. Photons are however massless. In this case the inversion is ill-defined. In the massless case polynomials determine energy shells in M^4. In this case, the associative holography is based on energy shells. The inversion must map light-cones boundaries to light-cone boundaries. Complex algebraic integer valued energy E is mapped to $t = Re[h_{eff}/E]$.

(f) 3-D holographic data at the mass shells in H^3, and in the special case at light-cone boundaries for massless photons, codes for the frequency spectrum and this in principle determines the classical fields in X^4 by $M^8 - H$ duality.
Associative holography and $M^8 - H$ duality would make it possible to calculate the classical fields in the geometric past before the first pump pulse and test ZEO by comparing them with those predicted by the classical causality.

(g) Number theoretical view brings in also the notion of finite measurement resolution, necessary for number theoretical universality needed when p-adic physics is introduced as a correlate for cognition. This simplifies further the situation.
Finite measurement resolution requires a number theoretical discretization of mass shells, which is unique. Allowed 4-momenta components, which are algebraic integers for an algebraic extension determined by the polynomial P whose roots define mass shells in

turn determining Y^4. The momentum unit corresponds to the size scale of the causal diamond (CD).

The physical states expressible as bound states of fundamental fermions and antifermions are Galois singlets for which momentum components are ordinary integers.

An interesting possibility is that, in a finite measurement resolution determined by the polynomial P, all space-time surfaces in the superposition defining a given zero energy state have the same number theoretic discretization. Finite measurement resolution would make the quantum states effectively classical apart from the non-determinism associated with the holography!

In principle, this picture would allow us to determine the classical fields in the geometric past from the frequency spectrum and to check whether they are consistent with the classical causality. The appearance of the reflected wave is already before the first pulse could be regarded as an empirical support, if not a proof for the ZEO!

Of course, in reality the space-time of standard model is determined as an approximation by replacing the space-time visualizable as topologically extremely complex many-sheeted structure with its M^4 projection such that the sums of the induced fields at various sheets define standard model gauge fields and gravitational field as the sum of the deviations of the induce metric from the Minkowski metric.

Chapter 10

About the Number Theoretic Aspects of ZEO

10.1 Introduction

The interaction between number theoretic vision, ZEO, and the TGD view DNA enriches all of them. In this article the recent view about quantum measurements is discussed in light of the recent progress in the understanding of the number theoretic aspects of TGD [L104, L105].

10.1.1 $M^8 - H$ duality and classical non-determinism

The progress in the understanding of $M^8 - H$ duality serves as a strong motivation for looking ZEO from the number theoretic perspective.

$M^8 - H$ duality [L104, L105] is a central piece of the number theoretic picture. $M^8 - H$ duality involves the map of a 4-D surface of M^8 to H determininiming holography in terms of the associativity of the normal space of the space-time surface. The realization of holography determine the 4-surface of M^8 by using the 3-D mass shells of $H^3 \subset M^4_c \subset M^8_c$ determined as roots of a polynomial serve as holographic data.

$M^8 - H$ duality is not a mere geometric map. Uncertainty Principle requires that the counterpart of CD in M^8 is mapped to a superposition of CDs as a plane wave for which the role of position coordinate is taken by the center of CD in M^4.

(a) The CDs involved have the same center and the roots correspond to mass shells and their H-images to proper time $a = constant$ hyperboloids of M^4 such that proper time coordinate is essentially $a = h_{eff}/m$ for a Galois singlet with integer value momentum and integer value mass squared using as unit the p-adic length scale defined by the largest ramified prime.
Octonionic associativity condition leads to a selection of a unique origin for the pair of positive and negative energy light-cones in M^8 mapped to pairs of half-cones of CD.

(b) The intuitive picture is that also the Poincare transforms of CDs should be allowed. Is this physically acceptable and how could one realize this?
M^8 corresponds to momentum space so that origin is a special point and coordinates are naturally unique. In M^8 Lorentz transformations are rotations and translations do not act on momenta but multiply Fourier components by phases.
The $M^8 - H$ duality could map the half-light cones of M^8 with opposite sign of energy to the half-cones of CD. $M^8 - H$ duality is essentially an inversion thye level of momentum space. The value of $h_{eff} = nh_0$ in the inversion would be determined by the polynomial P in question as the order of its Galois group.
Any point of $M^4 \subset H$ conserve as the origin defining the point of inversion. All choices are possible. The solution of the problem is a quantum superposition of all possible choices that is a plane wave in M^4 for the center of CD. The momentum would be defined by

the total momentum assignable to either half-cone of the CD. $M^8 - H$ duality would be between states rather than being purely geometric.

Holography applies also to string worlds sheets, which intersect the mass shells at 1-D curves. The reconnections of string world sheets correspond to self-intersections of the space-time surface and occur at discrete points deterministically for space-time surfaces as preferred extremals (PEs). At the intersection points there is nondeterminism since AC+BD can go to AC+BD or AD+BC. The reconnection gives rise to the basic braiding operation of strings as space-like braid strands.

If $M^8 - H$ duality holds true, polynomials determine space-time regions and the Galois groups define fundamental symmetries of physics. The key questions relate to the interpretation of the functional composition of polynomials. Second question is whether one can allow product polynomials.

(a) Product polynomials are allowed and give a direct connection to particle physics and an intuitive picture about free many-particle states. Fundamental particles would correspond to irreducible monic polynomials with a simple Galois group.

(b) The idea that functional decomposition gives many particle states in the usual sense is given up. The functional composition of polynomials would give rise to many-sheeted space-time as a hierarchical structure and connect the number theoretic view concretely with the view involving MBs. Also a connection with the notion of infinite prime emerges.

10.1.2 ZEO based quantum measurement theory from number theoretic perspective

The view about TGD based quantum measurement theory relies on zero energy ontology (ZEO) and its interpretation as consciousness theory involves several ad hoc elements. The notion of state function reduction (SFR) is the key notion. One can distinguish between "big" SFR (BSFR) as counterpart of ordinary SFR and "small" SFR (SSFR) as counterpart of weak measurement. What happens in SSFR and BSFR from a number theoretic point of view, is the key question.

The view about SSFRs is simplified.

(a) SSFR is assumed to occur after BSFR, which leads to a complete localization of the WCW spinor field to a space-time surface represented by fixed polynomial P at the level of M^8: localization would be in the resolution defined by the resolution defined by the cognitive representation defined by the polynomial.
The localization to single P has operational interpretation. One says that the localization occurs to single $P = P_1 \circ ... \circ P$ if the $P = ... \circ P_1 \circ ... \circ P$ if only the mass shells correspond to the roots of polynomials P_1 contain quarks. The higher mass shells are not activated. Note that the states of quarks considered are associated with either half-cone. In other half-cone there is delocalization forced by the fact that the observables associated with the two half-cones do not commute.

(b) SSFR(s?) occurs for a fixed polynomial P. SSFR involves cognitive measurement cascade decomposing an irreducible representation of Galois group to a tensor product of irreps of relative Galous groups. There are also measurements in quark spin degrees of freedom for representations of relative Galois groups as well as measurements in the degrees of freedom related to the failure of strict classical determinism for the dynamic of the space-time surface.

(c) Hitherto it has been assumed that there is a sequence of SSFRs followed by the counterpart of unitary time evolution. The TGD counterparts for the unitary evolutions would correspond quite generally to scalings and scalings could represent approximately time translations of the second tip of CD.
The situation could be however considerably simpler: there could be only a single SSFR so that the question of when BSFR does occur would become obsolete. The time evolution by the scalings could be assigned to the fermionic degrees of freedom and to the mass shells defined by the roots of P.

One can also consider BSFR from a number theoretic point of view.

(a) Suppose that the state is described by a polynomial P and that the many-quark state corresponding to, say, the lower half-cone of the CD is known. The state in the upper half-cone is not known. The state after BSFR corresponds to the state defined by $Q \circ P$ assignable to the upper half-cone of CD. This state must contain the mass shells assignable to P but with an opposite sign of energy for the Galois singlet states so that a lot of information is preserved. P would represent kinds of Akashic records and each BSFR would add to these records new records and the information content of the Universe would increase.

(b) BSFR must be preceded by the analog of a unitary time evolution in which a superposition of space-time surfaces involving polynomials $Q \circ P$ are present. Note that the information related to P would be conserved. Since Q represents a higher abstraction level in the hierarchy of polynomials the process would mean emergence of larger space-time sheets modelled in terms of magnetic body (MB). Operationally this means that quarks must be transferred to the space-time sheet assignable to the roots of Q. One could also say that the entire state is a superposition of states associated with $Q \cdot P$, for arbitrary choices of Q but that quarks in the lower half-cone are associated with the mass shells of P only.

(c) Here we have considered only the entire state. The intuitive picture has been that BSFRs can occur rather independently: the BSFRs at higher level however induce BSFRs at lower levels: somewhat like the decision of the boss induces decisions at the lower levels of the hierarchy.

When SSFR has taken place and Galois degrees of freedom in the product of relative Galois groups are unentangled, also BSFRs replacing individual polynomials P_i in $P = P_1 ... \circ .. P_n$ with $Q_i \circ P_i$ can occur: without this assumption the highest level would act like a dictator.

(d) When does BSFR occur? If only a single SSFR occurs, there is no problem. If single SSFR involves a sequence of SFRs as measurements for the quark quantum numbers associated with the mass shells characterized by p-adic length scales, one obtains a sequence of scalings giving rise to a subjective time evolution having the increasing CD size as a correlate of geometric time.

If several SSFRs take place, the situation changes. Could NMP force BSFR in the case that there is a sequence of SFRs? Could the CD in the beginning of the SSFR sequence correspond to a sub-CD assignable to P. The spotlight of consciousness would not be large enough. As the size of the CD increases, additional particles become visible and eventually the CD as a perceptive field reaches the size of the entire CD. After this BSFR occurs. As a matter of fact, single SFR in the proposed sense is also consistent with this interpretation.

10.1.3 The notion of time from number theoretic perspective

There are also questions related to the notion of time.

(a) The model for various time related aspects of conscious experience involves ad hoc elements and here an attempt is made to get rid of these elements. How the SSFR involving besides cognitive cascade also other measurements or a sequence of SSFR could correspond to a steady increase of geometric time determined in terms of CD size is the basic question.

(b) Does the position of CD shift to the direction of future in the sequence of BSFRs and if it does so, what could be the natural mechanism causing this? This is one of the key questions.

The existence of stars older than the Universe suggests that the center of mass of CD need not shift to the future. The system would evolve forth and back in time.

On the other hand, the phenomenon of after images and the sleep-awake cycle could be understood also in terms of the shifting of CD to which mental images is assigned. Time crystal like phenomenon at the level of conscious experience implied by the existence of space-time surfaces, which are approximately periodic minimal surfaces, suggests an alternative explanation.

Understanding what happens in memory recall is one of the key challenges and one both classical and quantal aspects of memory recall must be considered. The recent model is considerably simpler than the earlier one and the earlier picture follows without ad hoc assumptions.

10.2 State function reduction from number theoretic point of view

The only way to make progress is to challenge the existing views. The view about how ZEO [L96, L132] [K117] gives rise to a theory of consciousness as a generalization of quantum measurement theory involves several assumptions, which might be challenged as un-necessary and possibly wrong at the level of details. Occam's razor might be needed.

Consider the basic assumptions involved.

(a) The recent picture is based on the general TGD view about physics, which involves the dual views about physics as geometry and physics as generalized number theory. This part of theory seems rather stable.

(b) In the number theoretic vision [L104, L105] functional composition of polynomials plays a key role. A tentative interpretation has been that it corresponds to the formation of many particle states in the case that polynomials appearing as factors of composition are prime polynomials with simple Galois groups. One must challenge this assumption.
Functional composition could also correspond to topological condensation, whose number theoretic interpretation has remained hitherto open. As a matter of fact, free many-particle states could correspond to a products $P = \prod P_i$of irreducible polynomials with simple Galois groups and the functional composition $Q \circ P$ could correspond to a formation of interacting state formed by a topological condensation to a larger space-time sheets. P could also represent the magnetic body of the system as a many-sheeted structure.

ZEO is a crucially important piece of the theory.

(a) The notion of BSFR as a counterpart of ordinary state function reduction (SFR) changing the arrow of time, and SSFR as a counterpart of weak measurement preserving the arrow, are central but there are still considerable uncertainties concerning the details of the picture.

(b) The basic notions such as hierarchy of CDs, zero energy states, and the necessity of both BSFR and SSFR seem to be well-motivated. Also the cascade of cognitive measurements decomposing wave functions for the representations of the Galois group to entangled products of wave functions in relative Galois groups looks convincing. The special feature of Galois entanglement is its directedness which brings in mind attention. The localization of the nondeterminism as failure of strict determinism at space-time level to the frames of space-time surface as analog of soap film (minimal surface) seems also well-motivated. The reconnections indeed involve a failure of determinism naturally as a choice between two options.

10.2.1 What could happen in SSFRs?

Concerning the details of SSFR the situation is less clear.

(a) The assumption has been that each SSFR as a counterpart of weak measurement is preceded and followed by a unitary time evolution increasing the size of the CD in statistical sense. These unitary evolutions could correspond to scalings of CD with the passive boundary fixed. In spin glass systems they would be realized [L133]. The exponential law for the relaxation of magnetization in spin glass would be replaced with a power law so that time would be a logarithm of the linear M^4 time. The scaling operator defining the unitary scaling would be determined by the super-symplectic symmetry in the same way as the conformal scaling operator in string models.

(b) Each SSFR would correspond to an SFR selecting a unique space-time surface among possible holographic alternatives (perhaps selection of braiding distinguished by reconnections) plus a cascade of cognitive SFRs in the Galois group of the space-time surface reducing the wave function to a product of wave functions in its decomposition to relative Galois groups in question. The consciousness theoretic interpretation would be as an analysis. In the opposite time direction it would correspond to a generation of an idea, to a kind of heureka moment as BSFR.
The sequence of SSFRs has been interpreted as a sequence of moments of consciousness defined by the life cycle of self as a conscious entity. BSFR would be a universal counterpart for death followed by a reincarnation with an opposite arrow of time.

(c) Does one really need a sequence of unitary evolutions followed by SSFRs?Could single SSFR as a cascade of cognitive SFRs be enough? This would solve the problem of when BSFR occurs.
For single SSFR, the life cycle of self would be essentially a cascade of cognitive SFRs, a process of cognitive analysis leading to a reduction of quantum coherence. One might argue that this is indeed what aging is at the highest level [L197], and would also conform with the second law of thermodynamics [L130]. The occurrence of SSFRs implies the reduction of the number of choices and this is what seems to take place in aging.
On the other hand, we also have eureka moments and our mental images are born and die, which suggests a hierarchy of subselves realized in terms of function composition for which the cognitive cascades take place. We sleep and this could mean BSFR at some level of our personal self hierarchy. It would seem that the sub-CDs should be able to make several BSFRs during a single SSFR at the higher level. As found, this is possible.

(d) The cognitive measurement cascade as such leads only to an unentangled tensor product of irreducible representations of the relative Galois groups. After this, the observables associated with the Galois representations, with spins of quarks, and non-deterministic classical degrees of freedom must be measured.

Does the sequence of SSFRS correspond to a sequence of scalings of a CD?

The increase of CD in the sequence of SSFRs would give a correlation between the flow of the subjective time as the sequence of SSFRs and geometric time as the size of CD. Is the sequence of SSFRs is really required or whether SSFR naturally decomposes into a sequence of scalings.

The following argument suggests that it is possible to obtain a sequence of scalings of a CD in a natural way in SSFR.

(a) The light-cone proper time a constant hyperboloids correspond to cognitive representations consisting of all algebraic integers in the extension of rationals defined by P. Therefore they correspond to "very special moments in the life of self" as cognitive explosions. The presence of a quark at the point with momentum satisfying this condition is needed to activate it so that cognitive representations are finite. M^8 picture predicts also preferred moments t_n with respect to Minkoski time and also these correspond to the roots of P and define infinite cognitive representations which reduce to finite ones, when quark is required to activate the points of the representation. These preferred moments are naturally associated with massless particles.
As a matter offact, if one requires super-Virasoro symmetry and identifies mass squared with a scaling generator, one can argue that only massless states are possible since the scaling generator must annihilate these states. This leads to a concrete interpretation of the massivation in p-adic thermodynamics. It would be due to an entangling interaction of the massless sub-system with the environment exciting states of sub-system with non-vanishing mass squared: the excited states of the entire system would be massless [L155].

(b) The earlier intuitive picture was that the sequence of SSFRs as a cognitive cascade plus SFRs implied by the failure of the classical determinism increases the size of CD by scalings and makes gradually the roots of the polynomial P visible. This assumption does not look plausible if the size of the CD is determined from the beginning by the largest ramified prime for P.

One can however argue that the perceptive field of the waking up self expands gradually and this correspond to the increase of CD from a size, which is determined by a ramified prime smaller than the maximal, presumably the smallest one so that the increase of the size CD would occur as emergence of increasing p-adic length scales.
Note that the ramified primes appear as divisors for the discriminant which is product for the roots of P. An open question is whether the p-adic primes associated with the masses of Galois singlets can correspond to ramified primes.

(c) Intuitively, the p-adic length scales would naturally correspond to the emergence of mass shells with decreasing mass, and therefore an increasing momentum resolution. Masses are defined by the roots of P or by emergence of Galois confined states at $a = constant$ hyperboloid, which satisfy Galois confinement. Each mass value would correspond to a p-adic mass scale and if the large mass scales emerge first with respect to experienced time, the size of the CD indeed increases.
Note that the cognitive measurement cascade would proceed in the reverse order if the polynomial if Q in $Q \circ P$ corresponds to a larger space-time sheet. Cascades would proceed in opposite orders. This brings in mind the development of sensory perception followed by a motor reaction.

(d) When all mass scales have emerged, the size of the CD is maximal and the BSFR can naturally occur since no information can be gained and NMP [K64] [L130] cannot be satisfied.

(e) In this picture the cognitive state function reduction in the Galois group would occur first. This would give an unentangled tensor product of representations of relative Galois groups. After that measurement of the quantum numbers in the representations of relative Galois groups for the corresponding mass shells would take place in the proposed order.

Could the space-time surface determined by $P_1 \circ ... \circ P_n$ be replaced with that determined by $P_1 \times ... \times P_n$ in the cognitive cascade?

One of the fleeting ideas encountered during the development of the ideas about cognitive measurements was that it could also affect the space-time surface itself rather than only the wave functions in Galois degrees of freedom.

(a) The simplest assumption is that it is just a sequence of SFRs in the group algebra of the Galois group which has decomposition to a a product of relative Galois groups. The wave function in Galois group would be reduced to a product of wave functions in the relative Galois groups. Nothing would happen to the space-time surface itself.

(b) Could the cognitive reduction sequence proceed as $P_1 \circ P_2 \circ ... \circ P_n \to P_1 \times P_2 \circ ... \circ P_n ... \to P_1 \times .... \times P_n$? If so, the space-time surface would be replaced with a union of space-time surfaces associated with P_i. Note that multiple roots can occur reducing the dimension of extension and order of Galois group so that it is a sum of orders rather than product. I have considered this possibility but it seems artificial and ad hoc. I have also considered the possibility that P_i could be replaced with the composite of characteristic polynomial of the density matrix characterizing the entanglement between P_i and $P_{i-1} \circ ... P_n$ so that the measured eigenvalues would be stored in the space-time geometry [L136, L134].
The simplest elegant option is that nothing happens for the space-time surface in the cognitive measurement cascade. Only the Galois entanglement in quark degrees of freedom assignable to quark momenta as points at the mass shells defined by the roots of P and to quark spins would be reduced.

This idea however led to the realization that the surfaces defined by the product polynomials are natural correlates for free many particle states. This will be discussed later.

What kind of polynomials are allowed?

Mathematician's answer to the question of what kind of polynomials should be allowed, could be "irreducible ones". This was also my own first guess.

(a) The original assumption was that only irreducible polynomials are physically acceptable. Irreducible polynomials P with simple Galois groups, and therefore having no product decomposition to polynomials with a lower degree polynomials P_i, are analogous to elementary particles and could define space-time regions assignable to elementary particles. Irreducible polynomials have reducible polynomials as a limiting case. It is difficult to think of throwing them away and one can wonder what physical interpretation they could have.

(b) The product polynomial $P_1 \times ...P_n$ would naturally represent a non-interacting many-particle state consisting of disjoint 4-surfaces. A concrete number theoretic and geometric counterpart for the absence of entanglement could also be in question. A weaker assumption is that this kind of state cannot generate entanglement by interactions.
The surface defined by the product $\prod P_i$ would be singular in the sense that it would not be irreducible polynomial and would be localized at "boundary" of discretized WCW as a union of 3-surfaces in half-cones of CDs associated with P_i defining union of 4-surfaces and correspond to a superposition of space-time surfaces restricting to these 3-D surfaces at lower half-cones.
Therefore the intuition of particle physicists suggests that one should allow product polynomials.

The idea that unentangled free many-particle states have product polynomials as correlates is attractive. One can indeed consider a hierarchy of functional composisites involving also product polynomials.

(a) The lowest level in the functional hierarchy could correspond as a free many-particle state to a product of irreducible polynomials with a simple Galois group as counterparts of elementary particles. For $P(0) = 0$ in $P \circ (\prod P_i)$ the roots of P_i would be roots of P giving rise to the analog of conserved genes. Functional composition with a polynomial would give an interacting many-particle state. P would characterize the interaction with particles and represent a space-time sheet at which the particles represented by P_i have topologically condensed.
It should be noticed that the assumption $h_{eff} = n_0 h_0$, $n_0 = (7!)^2$, is satisfied if there is a ground state polynomial with Galois group corresponding to a product or to functional composite of two polynomials with simple Galois group A_7 and two simple Galois groups Z_2.

(b) Arbitrarily high function composites are possible. The products of polynomials $Q_j \circ (\prod P_i)$ for these interacting states would in turn define higher level many-particle states and one would have a hierarchy analogous to abstraction hierarchy defined by a repeated function composition giving rise to increasingly complex functions. The hierarchy of space-time sheets of many-sheeted space-time would serve as a geometric counterpart. Also more general states can be constructed by allowing products of polynomials belonging to different levels in the hierarchy.

(c) What could be the interpretation of the emerging geometric structures? The roots of Q_j correspond to n mass-shells and their inverse images define $m \times n$ mass shells, where $m = \sum m_i$ holds true. The space-time regions associated with P_i has been replaced with its n-fold covering. The n sheets would define the magnetic body.
If $Q_j(0) = 0$ is true the roots of P_i are roots of the composite: this serves as the analog of conserved genes. If P_i corresponds to an irreducible monic polynomial and has a simple Galois group, one can talk about the analog of an elementary particle. The conservation of genes is approximate if Q_j has a root very small root. If a gene corresponds to a Galois group rather than roots, conservation does not require even this.

(d) An interesting situation is obtained when the ground state consists of a single irreducible polynomial P. For $Q_j(0) = 0$ in the hierarchy, one would obtain MBs associated with P with arbitrary many levels. Could one say that also elementary particles evolve and these MBs correspond to different evolutionary levels of the particle with increasingly complex cognition. Lenin would have been right about elementary particles after all! p-Adic prime characterizing the mass of the particle in p-adic thermodynamics would correspond to the largest ramified prime for the extension considered.

Second interesting situation corresponds to iteration of a single polynomial as $Q \circ P \to Q \circ Q \circ P \to ...$ with $Q(0) = 0$. These roots would correspond to a situation familiar from chaos theory and the inverse roots would approach the boundary of the full Julia set.

(e) The hierarchy of infinite primes [K99] is one of the speculative mathematical ideas inspired by TGD. A geometric interpretation could be in terms of many-sheeted space-time. Number theoretic interpretationin terms of functional composites of polynomials of .... of polynomials suggests that the hierarchy described above gives a connection with the realization as many-sheeted space-time. The primes in the hierarchy of infinite primes could be generalized and correspond to simple Galois groups as analogs of primes.

(f) Whether the phenomenology of the many-sheeted space-time is consistent with this proposal, is an open question. For instance, does the $M^8 - H$ duality predict at the level of H wormhole contacts connecting space-time sheets at different levels of hierarchy. Wormhole contacts have an Euclidean signature of induced metric and could correspond to the roots of P for which the real part is negative and could correspond as Galois confinened states to negative values of mass squared. Also tachyons can appear in the decomposition of Galois singlets to virtual quarks having momenta, which are algebraic integers of the extension of rationals at mass shells determined by the roots of P.

10.2.2 What could happen in BSFRs?

BSFRs correspond to the ordinary SFRs and the new element is that the arrow of time changes. The findings of Minev et al [L83], discussed in [L83], provide empirical support for this. The proposal also solves the question about how the world which can be quantum coherent in arbitrarily long scales can look classical in long scales. The findings of Libet about active aspects of conscious experience [J5] provide an additional support for the notion of BSFR.

Some facts about BSFRs

What do observations say about BSFRs?

(a) The findings of Libet about active aspects of consciousness [J5] find a nice explanation in terms of BSFR as also the findings of Minev et al [L83] in atomic physics scales [L83].

(b) On can argue that if time reversed systems exist they would have been observed a long time ago. This is not the true. According to the standard physics view, time reversed systems send classical signals only to the direction of the geometric past with respect to us. The classical signals from the time reversed systems in the geometric past do not reach us. The time reversed signals from the geometric future do this only if we can detect them and our claimed ability to anticipate future events and precognize suggests that this is possible [L189]. TGD suggests a classical mechanism of memory and anticipations involving time reflection of a signal in BSFR for a subsystem [K87]. Earthquakes are one and candidate for a macroscopic BSFRd discussed in [L86]

(c) There exist stars older than the Universe [E2] discussed from TGD pointmofview in [L84]. This could be understood if the stars evolve by a sequence of BSFRs and the cm time coordinate for the star remains stationary.

The WCW state before BSFR

To understand what could happen in BSFR [L96, L132] [K117] one must first consider the state before the BSFR.

(a) In ZEO the 3-surfaces (mass shells) associated with P_i would define the parts of 4-surfaces in a lower half of the corresponding CD. The proposal has been that they form a Russian doll structure with a common center as origin. Each CD has either of its tips as natural origins but the non-associativity of octonions forced them to select either tip and thus either half-cone of the CD. This means the selection of the arrow of time. The states at the passive tip, the selected one, are passive and correspond to the initial, prepared

state of particle reaction. Galois reduction and selection of branches of minimal surface at frames corresponds to a preparation.

(b) The 4-surfaces associated with P_i in $P = P_1 \circ ... \circ P_i ... \circ P_n$ would be topologically condensed on the portion of the larger space-time surface by wormhole contacts in the lower half of its CD. The wormhole contacts would correspond to tachyon-like mass shells predicted as roots. Galois confinement for physical states would allow only non-negative mass squared. This would give content to the nebulous idea of many-sheeted space-time. In the QFT picture, tachyonic mass squared values would correspond to virtual particle exchanges. One can say that in TGD virtual particle momentum spectrum is discrete and even finite so that one gets rid of divergences.

(c) The state before BSFR would be a state of WCW spinor field localized to, say, the lower half-cone CD_- of CD. All polynomials in the superposition would effectively reduce in CD_- to that associated with P since for $Q \circ P$ there would be no quarks at the mass shells of Q in CD_-. The state in the lower half-cone, determined by P alone, does not provide the information to deduce it. In the operational sense, only a single state determined by P exists.
The proposal is that the analogs of Kac-Moody and Super Virasoro conditions for the super-symplectic algebra [L92] determine the entire superposition over $Q \circ P$:s. The holography at the level of WCW [L104, L105] could fix the state as a WCW spinor field from the holographic data provided by the roots of P. The superposition of ver $Q \circ P$ would correspond to a discretization of a WCW spinor field satisfying the super symplectic gauge conditions [L92].

(d) If the condition $Q(0) = 0$ is satisfied, the roots of $Q \circ P$ consist of the roots of P and the inverse images of the roots of Q by P^{-1}. After BSFR the WCW state is localized to the space-time surface determined holographically by the mass shells for single $Q \circ P$. BSFR can be said to occur in the space of polynomials and conserve the existing roots so that information is not lost.

(e) The space-time surface inside CD_- is fixed by holography determined by mass shells H^3 with positive or negative energy depending on which half-cone is in question. Only one of choice for the sign is possible since otherwise the PE does not exist since the holography is overdetermined.

What could happen in BSFR?

What could happen in BSFR?

(a) In BSFR the state in CD_+ is localized in the same way but becomes physically undetermined in CD_-. The roles of future and past are changed and BSFR would therefore reverse the arrow of time.

(b) BSFR would correspond to a localization to a single polynomial defining proper time $a = constant$ hyperboloids in the positive/negative half cone of the CD, whose size would correspond to the largest ramified prime of the polynomial. The arrow of time changes. The time evolution by BSFRs would be a kind of flip-flop sequence between opposite arrows of time and half-cones of CD.
In TGD inspired theory of consciousness, BSFR would be interpreted as the counterpart of death followed by a reincarnation (these terms are of course understood in a universal sense).

(c) Since the polynomial surface gives rise to a unique discretization defined by the extension of rationals determined by P interpreted as cognitive representation [K18] [L121, L115, L108], one can argue that the localization to a single polynomial in BSFR should be interpreted as a localization only modulo finite measurement resolution. One can ask whether the localization could occur first to a single Galois group and only after that to a single polynomial. The state after the Galois localization would involve a large number of polynomials with the same Galois group and different ramified primes.

(d) Is the opposite process $Q \circ P \to P$ in which some levels disappear and information is lost , possible. Number theoretic evolution inevitably leads to an increasing cognitive

complexity as polynomials with an increasing degree emerge. One cannot however exclude these transitions.

What can one say about the state associated with the polynomial $Q \circ P$ defining the final state. The mass shells of P but with opposite energies can contain quarks besides the mass shells of Q. The Galois confined groups with integer valued momenta are in general different and BSFR could be interpreted as SFR occurring in particle reactions. The conservation of momentum which is true at the limit of infinitely large CD poses constraints on the momenta and masses. Some quarks at lower mass shells must be moved to the mass shells associated with Q. Kind of ionization transferring quarks from the lower levels of the hierarchy to the new level should take place.

Can different levels in polynomial hierarchy make BSFRs independently?

The proposed first guess about BSFRs is not general enough. The point is that the BSFR would occur for all factors P_i defining levels of the hierarchy of MBs simultaneously. The existing picture is that BSFRs are not simultaneous but can occur separately but not completely independently. A BSFR at higher level induces BSFRs at lower levels just like the decision of "boss" at higher level induces decisions at the lower levels. A more general picture would look as follows.

(a) BSFR for $P = P_1 \circ ... \circ P_n$ involves a localization in the space of polynomials which are extensions of type $P \to Q \circ P$. After this a cognitive cascade occurs unentangling relative Galois groups associated with P_i. This process need of course not be complete.
Cognitive cascade is followed by SFRs in quark degrees of freedom and in the degrees of freedom related to classical non-determinism.

(b) After this a particular unentangled P_i could be replaced with $P_i \to Q_i \circ P_i$ in BSFR. This would mean that a CD associated with P_i increases in size. Sub-selves would correspond to P_is and this particular sub-self would thus die and reincarnate. At the level of P this would mean the replacement $P = P_1 ... \circ P_i \circ ....P_n \to P = P_1 ... \circ (Q_i \circ P_i) \circ .... \circ P_n$. In this picture the CD:s associated with P_i could have different arrows of time.
This raises however the question whether Galois groups of P_i:s with different arrows of time entangle in the next BSFR. This could make sense for the same arrow of time only.

10.3 Questions related to the TGD inspired theory of consciousness

TGD inspired theory of consciousness could be seen as an interpretation of the ZEO based quantum measurement theory [L96] [K117]. The physical correlates for the phenomena of consciousness should have a simple description in the proposed framework.

10.3.1 About the notion of time

The basic motivation behind ZEO is that it could provide a solution to the problems related to the difference between experienced time and geometric time, which are usually identified although this is in a striking conflict with basic empirical facts.

(a) One should understand the arrow of time and why the time increases in one direction, at least in a statistical sense. There are two natural geometric times: light-cone proper time a, which is naturally associated with CD and the linear time coordinate t associated with the $M^4 \subset H$.
These two times would correspond to two different views about time evolution already briefly discussed [L155]. Light-cone proper time would be assignable to particles with thermal mass determined by p-adic thermodynamics [K59] and linear Minkowski time to massless particles for which translations must replace scalings. The first one is with respect to scalings and the second one with respect to time translations. Note that scalings and translations do not commute.

Number theoretically both times are very special. For a given extension of rationals all points with algebraic Minkowski coordinates for M^8 can belong to the cognitive representations. A kind of cognitive explosion takes place. Quark momenta are naturally algebraic integers and the actual cognitive representation is determined by the momenta of quarks present in the state and is finite.

(b) The analog of the unitary evolution associated with a should correspond to scaling rather than time translation. If the pairs of unitary processes followed by SSFRs, the unitary process could correspond to the scaling as in super string models.
Super symplectic transformations, acting as symmetries of the "world of classical worlds" (WCW), involve a scaling generator, which would have a representation in terms of super-symplectic algebra and scale the size of the CD. If the p-adic scale corresponds to the largest ramified prime for P, this should mean the increase of the largest ramified prime during time evolution by scalings.

(c) This leads to ask whether the increase of experienced time in SFR, or in the cascade of SFRs associated with it, the polynomial P should be replaced with $Q \circ P$ such that Q has maximal ramified prime larger than that for P. Here one must be however cautious. For a fixed sub-CD, the flow of the experienced time could correspond to the increase of a as a characterizer of the size of the CD
How the possibility of two times might reflect itself as a character of conscious experience? For instance, could everyday experience and some altered states of consciousness such as DMT experiences correspond to different geometric times for the perceptive field. DMT experiences could correspond to experience in which hyperbolic geometry of $a = constant$ surface is projected to $t = constant$ the hyper-plane [L146].
For large values of a, the local curvature of H^3 decreases and at the limit of large values of a H^3 becomes t in a good approximation. The everyday experience could therefore correspond to large a and therefore in a good approximation to $t$whereas the DMT induced states of consciousness would correspond to small a [L146].

Momentum eigenstates and time translations can be considered at 3 levels: corresponding to space-time level, embedding space level and WCW level.

(a) Could ZEO make it possible to talk about wave packets for sub-CDs, or rather, for the state associated with either half-cone of sub-CD. Could one assume that the wave packets of sub-CDs are localized within the largest CD involved? This is the view proposed in [L104, L105].
Sub-CD would correspond to a sector of WCW and define the decomposition of WCW. WCW would also have decompositions according to Galoism group of the polynomial, the degree of the polynomial P, and the number of levels its its functional composition.

(b) Could one define M^4 time evolution at the space-time level as a flow in which the flow lines of time translation as isometry in M^4 are projected to the space-time surface and define a "subjective" space-time view about time translation? H view would be the second view, in which the 3-surface would be a particle-like entity rather than the arena of physics. The notion of the quantum group [A4, A22] could catch this notion. Gravitational and inertial charges could correspond to space-time and embedding space views about conservation laws [K16]. Gravitational time translation could have a representation as a quantum group transformation at the level of X^4.

S-matrix is a fundamental notion in the standard QFT.

(a) The TGD counterpart of S-matrix relating the states assignable to the half-cones of CD identified as Galois singlets made of quarks at fundamental level would correspond to the S-matrix as the particle physicist understands it. This transition would be associated with BSFR. The size of the largest CD would characterize the duration of transition [K16].
TGD suggests that the unitary matrix of QFTs could be replaced with the fermionic counterpart of Kähler metric and therefore as a property fermionic states space [L117] and highly uniquely determined by the infinite-D character of the fermionic state space as also the Kähler metric of WCW [K52, K32, K89].

(b) One has two times, linear time t and light-cone proper time a. For both of them the roots of P correspond to very special moments of time. The time evolutions with respect to t

and a would naturally correspond to translations and scalings respectively. I already proposed that these two times could correspond to perceptive fields defined by $t = constant$ hyperplane appropriate for massless states and $a = constant$ hyperboloid appropriate for massive states.

Should one speak about separate time evolutions for a and t. p-Adic particle massivation suggests that a is the correct time. For large values of a when the curvature of H^3 approaches zero, $a \simeq t$ is a good approximation. Therefore the counterparts of the unitary evolutions could always correspond to scalings.

(c) Typically, the number of unstable particles decreases exponentially on M^4 time t. As already noticed, this kind of time evolution should correspond to a sequence of BSFRs and to perceptive fields which correspond to $t = t_n$ hyperplanes. For the relaxation of magnetization in spin glass the exponential law is replaced with a power law [L133] so that time would be a logarithm of the linear M^4 time. This would naturally correspond to a and scalings. For small values of a, the large curvature of H^3 would imply a strong deviation from the behavior with respect to linear time t. Spin glass systems would therefore correspond to small value of a.

(d) For large values of a the time evolution by scalings associated with BSFRs or SSFRs should have an approximate interpretation as time translations for short enough times Δt. The earlier view has been that the shift of the active boundary of CD takes place in time evolution by SSFRs forcing the scaling of the CD.

Could approximate counterparts of the time translations be induced as scalings of CD leaving the state at the passive boundary invariant and only increasing its size? If so, the time translations by Δt for the other tip of CD would reduce to scalings for which Δt corresponds to the scaling $\Lambda = 1 + \Delta t/T(CD)$ for CD having $T(CD)$ as the temporal distance between its tips? Note that the scalings would be different for the sub-CDs of the hierarchy rather than affecting all sub-CDs in the same way.

For small values of $\Delta t/T(CD)$ this assumption would indeed transform the power law $\Lambda^k = exp(kln(+\Delta T/T(CD)$ with the rate k to and exponential decay $\Lambda^k \simeq exp(-k\Delta T/T_(CD))$ with rate $k/T_C D$.

10.3.2 The notion of memory mental image

The notion of memory mental image [K1, K87, K117] [L96, L101, L124] is one particular test for the ZEO based theory of consciousness. One can criticize the recent ZEO based view for having several ad hoc elements.

(a) Mental images of self correspond to sub-selves of self having sub-CDs as correlates [K61].

(b) Mental image wakes up when SSFR changes its state. The quantal non-determinism, which does not change CD, should correspond to the failure of the classical determinism assignable to the lower-D frames defining the space-time surface as a minimal surface analogous to soap film. At frames the field equations for the full action, which includes besides the volume term also Kähler action, are satisfied so that conservation laws hold true. In other regions the field equations for volume term and Kähler action hold true separately.

Also the reconnections of flux tubes and string world sheets associated with the flux tube involve non-determinism since the strands AC and BD can transform to AC+BD or AD+BC in reconnection.

These transitions could wake up mental images scattered around the space-time surface so that memory mental images would be where the original non-deterministic event occured. The formation of copies of mental images is also expected in the memory recall.

(c) A possible interpretation for the classical non-determinism is in terms of intentional aspects of conscious experience. The superposition of different options could correspond to experience about having not yet chosen from a finite number of options. The non-determinism of SSFRs would in turn correspond to sensory experience.

(d) The spatial braidings of nodes of a network induced by the motion of nodes defining time-like braiding store the information of time like braiding to memory as kinds of Akashic records [L155]. The reconnections, which are possible and unavoidable by the

4-dimensionality of the space-time surface, induce basic braidings even with the motion of the ends of braid strands. This is because the reconnection AC+BC $\rightarrow$ AD+BC generates basic braiding operation as the braided counterpart of a permutation of neighboring braid strands known as SWAP in topological quantum computation.

(e) The earlier view involved some assumptions, which in the recent view look un-necessary. In particular, the former picture led to an un-intuitive idea that the mental images about geometric past are stored in the geometric future. The idea was as follows. As the size of the CD increases, there are moments at which a new $t = t_n$ hyper-plane emerges. The question was whether the emergence of this plane in the sequence of scalings of the CD is accompanied by a generation of mental images in the future half-cone of the CD.
This assumption is unnecessary in the recent picture and also in conflict with it since the upper half of CD remains unconscious to self. If the space-time surface in the interior of the new CD emerging in BSFR contains the same hyperbolic spaces H^3 as $a = a_n$ sections besides the new ones, the new space-time surface contains a lot of information about the previous space-time surface. This could explain why we can remember, perhaps unconsciously, something about the period of sleep if it corresponds to the reversed arrow of time.
The fact that the BSFR conserves information about the earlier polynomial decomposition explains why we can remember something about yesterday even if falling asleep would correspond to BSFR.

(f) After images is one aspect of the memory and since approximately periodic minimal surfaces as analogs of time crystals are possible. The frames and reconnections as singularities and loci of non-determinism and mental can appear in this case repeatedly so that after images could be understood of being due the increase of CD in the sequence of SSFRs.

10.3.3 More questions related to the relationship between subjective and geometric time

The growth of the geometric time should be associated with the sequence of SFRs defining quantum jumps in the sense that some kind of time value assigned to the content of the perceptive field grows in the sequence of SFRs in a statistical sense at least.

What does this statement really mean? Does this statement hold true for the sequences of SSFRs or BSFRs or both? This question was already considered for SSFRs and it was suggests that the sequence of time values defined by light-cone proper time a assignable to the mass hyperboloids associated with Galois confined states could provide this time is the SFRs occur in the order of decreasing mass squared and thus increasing a.

Could the position of CD shift to the direction of future in BSFR?

The flow of time assignable to BSFRS would have a pair of BSFRs establishing the original time direction as a basic step. A physical interpretation could be quantum tunneling. The first guess is that both BSFRs could increase the size of CD by replacing the polynomial P with $Q \circ P$. This is however not true if the largest ramified prime associated with Q is not larger than that associated with P.

One must be careful with the ramified prime conjecture, which is just a guess. Ramified primes are divisors of discriminant of P defined as the product for the squares of root differences. The roots could be larger than the largest ramified prime. Therefore one can challenge the ramified prime hypothesis and consider the possibility that the mass squared values of the physical states satisfying Galois confinement assign to the quantum state a collection of p-adic primes defining p-adic length scales.

The size of the CDs can increase and geometric time defined by the distance from the center of the CD to its tip would increase. Also the size of sub-CDs can increase in BSFRs. Evolution in this manner would mean increase of complexity and emergence of new larger space-time sheets. NMP would force negentropy increase and as a byproduct increase of entropy [L130].

It is however difficult to understand whether and how the center of CD could shift in either time direction unless T violation at the fundamental level induces this. Could the correlation between subjective and geometric be associated only with the SFR sequences assignable to SSFRs?

Periodically appearing mental images and sleep-awake cycle

Consider first periodically appearing mental images and the sleep-awake cycle.

(a) Our mental images typically die and are reborn again. After images represent a basic example of this. Could it be that this process is a sequence of birth and death of a mental image as subself?
We are mental images of a higher level self. Could the wake-up period and sleep period be related by a BSFR and time reversal? Are we after images of this higher level self? Sleep would be a small death. This could explain why we do not remember anything about the period of sleep.

(b) The neuroscience based objection against the necessity of BSFRs is that the disappearance of mental images is caused by the loss of the nerve pulse activity: the neurons in some parts of the brain and CNS become hyperpolarized so that nerve pulse activity relevant to our cognitive consciousness and memory ceases [L150]. I could be conscious but would not remember anything about this period. However, the BSFR for MB associated with the part of CNS in question could induce the loss of the nerve pulse activity.
During the wake-up period the metabolic energy feed effectively increases the values of h_{eff} particles and activates higher levels to self-hierarchy. Perhaps this activates BSFRs inducing additional polynomial factors for polynomials $\circ P_i \circ ...$ corresponding to subselves. The size of the CD increases if BSFR occurs and the tip of the CD is in the future of the self that died. Could the tip correspond to the geometric time for the moment of wake-up of time reversed self?

(c) After the second BSFR the geometric time for the self in the original time direction is determined most naturally by the center of the CD. It would not be shifted unless there is some mechanism causing a shift. If the shift occurs its direction could be fixed by the arrow of time for higher level self in the hierarchy.
Why would the center of the CD to which the geometric time is naturally assigned shift towards a preferred time direction in H? If the scaling is the basic transformation associated with BSFR, the scalings would define time evolutions as approximate translations for linear time if the hyperboloid in question has small enough curvature. There would be no reason for the shift of the cm of CD. The idea about time evolution as shift of the cm of the CD would not make sense.

(d) One can indeed image another explanation for after images and sleep-awake cycle would involve a time crystal like system. In TGD this kind of system would correspond to MB as a minimal surface with an approximately periodic structure. After images and our sleep-awake cycle would reflect this kind of periodicity for subselves.
One can imagine that there is a time-like lattice of sub-CDs assignable to the periodic structure of classical nondeterminism (say reconnections appearing periodically). The sub-CDs do not shift but there would be a kind of wave which wakes up the sub-CDs, and is shifted in a preferred time direction. The time direction assignable to a larger CD representing the environment could define the preferred time direction. Time-like braids could provide a realization for these waves. Their reconnections involve classical and quantum non-determinism and if the reconnections appear periodically, their wake-up could induce a sequence of mental images of self. Note that this explanation can confirm with the explanation in terms of BSFR for the sub-CDs.

(e) Directed attention is one basic aspect of consciousness. The structure of Galois entanglement is hierarchical directed downwards in the tower of relative Galois groups. This direction would be from larger to smaller p-adic length scales. Also SFRS at quark level related to the non-determinism at the frames of space-time surface as a minimal surface and at braids is involved. Could the attention shift from sub-CD to sub-CD in the preferred time direction and in this way give rise to a temporal sequence of wake-ups of

sub-CDs?

How to understand memory recall?

There is also the problem of memory recall as active process rather than a spontaneous emergence of memory. Both classical and quantum description for memory recall is suggested by quantum-classical correspondence.

(a) In the classical picture, memory recall/anticipation would involve communication with the geometric past/future. Time reflection involving BSFR for the signal as a sub-self would take place.

(b) A lot of information is preserved almost as such in BSFR $P \to Q \circ P$ since for $Q(0) = 0$ mass spectrum is preserved. Note that the mass shells as roots of P in the half-cones of CD have only a different sign of energy. Therefore a lot of information about previous time reversed incarnations preserved and therefore also about previous lives in the same time direction. One could speak of Akashic records. Akashic records would be also realized in the dynamical braiding with nodes connected by flux tubes.

(c) One could also understand memory recall as a wake-up of memory mental images during the period associated with a single SFR. If this is due to the finite classical non-determinism at frames and reconnection points, this would change the entire space-time surface but possibly only after the singular point. This change would have interpretation as classical communication and time reflection if BSFR occurs at the singular region.

Chapter 11

New results about causal diamonds from the TGD point of view

11.1 Introduction

This work is a response to two very interesting articles related to the notion of causal diamond (CD).

11.1.1 The metric for the space of causal diamonds

Dainis Zeps sent article [B4] (`https://rb.gy/gcfvus`) related to the space of causal diamonds (cd) of M^4 (CD is the Cartesian product $cd \times CP_2$ of cd, defined as intersection of future and past directed light-cones, and of CP_2).

Although it remains unclear whether the proposal for the identification of the moduli space is realistic in the TGD framework, where also a simpler realization of the moduli space can be considered, the article led to a clarification of many aspects related to ZEO and the space of CDs as the backbone of the "world of classical worlds" (WCW).

11.1.2 The existence of a hyperbolic generator of conformal group defining a flow, which maps causal diamond to itself

Gary Ehlenberger sent a link to a very interesting article [B16] (`https://rb.gy/z7o7wj`) related to causal diamonds (cd) of 4-D Minkowski space.

The article is very interesting from the TGD point view since causal diamond (CD) of $H = M^4 \times CP_2$ is the key object in zero energy ontology defining the ontology of TGD. CD is defined as the Cartesian product $CD = cd \times CP_2$ of the causal diamond $cd \subset M^4$, identified as an intersection of future and past directed light cones, and of CP_2.

The basic findings of [B16] are as follows.

(a) The generator of K of special conformal transformation in time direction, scaling generator D and generator P_0 of time translation generate an $SL(2, R)$ algebra. A suitable combination of these 3 generators defines a generator of what generates hyperbolic time translations, call it S. Its exponentiation generates an analog of time evolution in conformal quantum mechanics. What is remarkable is that this flow takes the CD to itself so that the time range of time evolution can be said to correspond to the distance between the tips of the CD.

The flow lines of the exponentiated Killing vector would have an interpretation as the world lines of accelerated observables with constant acceleration determined by the initial value of the radial M^4 coordinate.

The hyperbolic time evolution is time-like only in the interior of the second light-cone associated with CD. Only a single arrow of time is allowed by time-likeness. It is time-like also outside the light-cones.

(b) The time evolution of a static CD observer is equivalent to a time evolution of conformal QM defined by a hyperbolic Hamiltonian. The flow states for a fixed value of radial coordinate r correspond to a time evolution from the value of hyperbolic time $\tau = -\infty$ to $\tau = \infty$. This evolution corresponds to a finite time interval with respect to the ordinary Minkowski time t.

One obtains a family of states corresponding to time evolutions for various values of t. These states are so-called coherent states, which are not orthogonal and their inner product for values $t = t_1$ and $t = t_2$ defines a correlation function of conformal QM.

The behaviour of 2-points functions of conformal QM in CD is equivalent to that for thermal QFT in M^4. One can say that static CD observers falling freely along the flow lines of the Killing vector observe the vacuum state of the inertial M^4 system as a thermal state characterized by Unruh temperature $T = \hbar/2\pi L$ (`https://rb.gy/qxyp8q`), where L is the size of CD .

11.1.3 Could these findings have significance for TGD

An obvious question is whether these findings could have significance for TGD, in particular for the zero energy ontology (ZEO) [L96, L144, L136] [K117], which replaces the standard ontology as a foundation of quantum theory and in this way solves the basic paradox of quantum measurement theory.

Zero energy ontology (ZEO) and CDs

Causal diamond (CD) defines the analog of quantization volume in the embedding space $H = M^4xCP_2$ inside which the zero energy states are superpositions of space-time surfaces, which connect the light-like boundaries of CD. In the TGD inspired theory of consciousness, CD corresponds to a 4-D perceptive field of self.

The allowed space-time surfaces are preferred extremals (PEs) analogous to Bohr orbits and satisfy almost completely deterministic holography forced by the general coordinate invariance. Quantum states can be also regarded as superpositions of pairs of 3-D states assignable the opposite boundaries of CD and constructed using second quantized fermions of H satisfying free Dirac equation or its modification in the case that also M^4 allows the analog of Kähler structure suggested by the twistor lift of TGD. At the limit of large CDs also the Poincare quantum numbers are opposite at the opposite boundaries of CD.

The TGD based proposal is that the time evolution at the level of "world of classical worlds" (WCW), which consists of these preferred extremals for given CD, is defined by a conformal scaling leaving the passive boundary of causal diamond and states at it invariant but affect the active boundary and 3-D states at it. The gradual increase of CD would correspond to the growth of geometric time correlating with the flow of subjective time defined by "small" state function reductions (SSFRs) as analogs of weak measurements and this time evolution replaces the trivial time evolution of Zeno effect in TGD and gives rise to self as a conscious entity. In "big" SFRs (BSFRs) the roles of the active and passive boundaries change and the arrow of time changes.

Under certain conditions the evolution by scaling can be approximated by a time translation. The scalings commute with the Lorentz transformations mapping the passive boundary of CD to itself. This time evolution allows us to understand spin-glass type systems [L133]).

From the point of view of ordinary time evolution defined by energy, the difference is that the relaxation processes obey fractal power law rather than exponential decay. This is a characteristic feature of the N-point functions of conformal field theories (CFTs) as opposed to those of massive quantum field theories (QFTs). The conformal invariance of 2-D conformal theories generalizes since the light-cone boundary $\delta M^4_{\pm} \times CP_2$ and light-like 3-surfaces in general allow extended conformal invariance. $\delta M^4_{+} \times CP_2$ allows also supersymplectic invariance for light-like radial coordinate, which takes the role of complex coordinate.

One can say that in the TGD framework the 2-D conformal field theories generalize to dimension $D = 4$. In particular, the boundaries of space-time surfaces and the 3-D surfaces at the boundaries of CDs define 3-D holographic data for the generalized conformal field theory.

Poincare group acts in WCW rather than at the level of space-time and M^4

In the TGD framework, the great conceptual leap is made possible by the moduli space of CDs is that 4-D Poincare and conformal groups would not act at the level of space-time or of CD but at the level moduli space of CDs forming the backbone of WCW.

In TGD, Poincare invariance need not be a symmetry of the action at the space-time level as has become clear already earlier. Indeed, the twistor lift of TGD suggests that M^4 has a Kähler form contributing to Kähler action of H so that Poincare and Lorentz symmetries would be broken at the level of M^4.

This picture would fit nicely with the breaking of Lorentz invariance implied by the momentum and polarization vectors assignable to massless particles and also with the view of hadrons based on quarks characterized by a place carrying 2-D longitudinal momenta. This kind of flexibility gives a strong support for the WCW approach.

The quantum numbers of the zero energy states assignable to a given CD must correlate or be equal with the quantum numbers, such as four-momentum and angular momentum assignable to the wave function in the moduli space of CD.

(a) The value of mass squared for CD should correspond to that for the generator of conformal scalings realized in super symplectic and super-Kac-Moody type degrees of freedom in the interior of CD.

(b) One can assign to the modes of the second quantized spinor field of H 4-momenta and the total momentum associated with these at either half-cone of CD would naturally correspond to the momentum assignable to CD.

(c) Classical charges are conserved for action and also these should be identical with those assignable to CD and with the wave function in the moduli space of CDs. Here interesting questions relate to the violation of translational invariance and Lorentz invariance induced by the M^4 Kähler form.

(d) In case of TGD, CD means actually $cd \times CP_2$: also the total quantum numbers assignable to CP_2 should be the same for CD and the wave function in the space of CDs.

Problem and questions

In the TGD framework, the existence of a hyperbolic generator S mapping cd to itself and the properties of the corresponding flow raise some questions.

(a) The exponentiation of a hyperbolic generator defines a diffeormorphism of CD, which would deform the space-time surface in the interior of the CD. One would have a problem since this deformation is not expected respect the preferred extremal property.
In TGD, hyperbolic generator S, just like supersymplectic generators, can act only at the boundaries of CD and affect the data at them. These data define boundary conditions for holography, which extends this action to an action on the space-time surface inside the CD. If the hyperbolic flow is modified at all at the boundaries of CD, this induces a modification of the preferred extremal at the level of the space-time surface.

(b) The flow induced by S corresponds to a flow that maps the states for a fixed value of radial coordinate r ($r = constant$ means that system is "at rest") from time $\tau = -\infty$ to $\tau = \infty$ and this corresponds to relativistic at the level of CD accelerate motion with acceleration $a = 1/L$, L the size of CD. The initial and final points of motion correspond to point $(t_{\pm}(r), r)$ at the boundaries of CD. Somewhat disappointgly, the flow does not affect the points at the boundaries at all.

(c) What is however possible is that the time evolution as an exponentiation of the hyperbolic generator labelled by t affects the quantum states at the boundaries of CD for each value value of t. One can say that time evolution is represented as unitary time evolution at the boundary of CD.

This would relate the states at the points of boundary with different values of light-like radial coordinate. This correlation could be interpreted in terms of radial conformal invariance and could be manifested in terms of conformal correlation functions. This is just what one expects since the light-like radial coordinate for the light-cone boundary is analogous to the complex coordinate for ordinary conformal invariance.
Hyperbolic time evolution would define unitary action on zero energy states and could define "small" SFRs (SSFRs), which does not scale CD so that the geometric time defined by the distance between the tips of CD is not changed. In TGD inspired theory of consciousness this kind of SSFRs would correspond to "timeless" conscious experience. Could the sequences of these time evolutions followed by SSFRs correspond to meditative states, which are reported to be timeless? SSFRs involving scalings of CD would in turn correspond to ordinary ordinary conscious experience involving the sensation of time flow.

These findings force to reconsider the basic assumptions of ZEO.

(a) The assumption has been that only SSFRs scaling the size of CD possible? Could one think that only the SSFRs corresponding to the hyperbolic time evolution are possible. The size of CD remains unaffected in the sequence of SSFRs.
Could the scalings of CD correspond to SSFRs or could they precede BSFRs in which the arrow of time changes? Note that the scalings would affect the WCW spinor fields representing zero energy states at the level of moduli space of CDs whereas hyperbolic time evolutions would affect only the WCW spinor field in "internal" CD degrees of freedom.

(b) One can assign to the 2-point functions at the boundary of the CD a temperature given by $T = \hbar/L$, where L is the size of the CD. Could this temperature and thus the size of CD correlate with the physical temperature of the environment? In fact, I have already ended up with the view that L codes for the analog of cosmic temperature gradually reduces during the sequence of SFRs.

11.2 Two possible identifications for the space of CDs and its metric

The space of causal diamonds (CDs) forms the backbone of the "world of classical worlds" (WCW). Each CD interpreted as a geometric correlate for the perceptive field corresponds to a sub-WCW. Zero energy states are realized as superpositions of space-time surfaces inside CD and pairs of fermionic Fock states at boundaries of CD. The space of CDs would define cm degrees of freedom in WCW.

A possible interpretation [B13] (`https://rb.gy/m1dvwq`) of CDs assigned with, say geodesic lines, is that the size of the CD (temporal distance between its tips) defines the duration for a "moment of consciousness". This interpretation makes no distinction between subjective and geometric time. This distinction is however very real as many examples from everyday life demonstrate.

The increase of the size of CD in "small" state function reduction (SSFR) inducing a small scaling of CD would correspond to the increment of geometric time identified as the distance between the tips of CD. The basic TGD based proposal is that this corresponds to the duration of experienced moment of subjective time in SSFR. The duration of the moment of consciousness between two SSFRs would thus correspond to an increase of the size of the CD rather than to its size.

One can consider two very different identifications of the moduli space of CDS.

11.2.1 TGD in inspired option for the moduli space of CDs

Consider first the TGD inspired identification for the moduli space of CDs.

(a) It is easy to see that the space of CDs is 8-D. The position of either tip or of center of the CD gives M^4. The Lorentz transformations $SO(3,1)$ leaving either tip of CD invariant

and the group D of scalings leaving the cm of CD invariant give new CDs. The isotropy group of the CD is $SO(3)$. This gives 8-D space.

(b) The first guess is that the space of CDs is the coset space $D \rtimes P/SO(3)$. The division by $SO(3)$ is due to the fact that a given CD corresponds to a unique rest system and is invariant under rotations. Translations of M^4, that is M^4, code for the position of the cm or tip of CD, and D corresponds to the size of CD. Locally one would have an 8-D product $D \rtimes M^4 \times H^3$, H^3 is 3-D hyperbolic space analogous to mass shell. There might be some delicate effects changing the topology.
The naive guess that the signature of the metric is (1,7), is wrong. For the Lorentz group $SO(1,3)$ the signature is $(3,3)$ and for H^3 as coset space $H^3 = SO(1,3)/SO(3)$ the signature is $(3,0)$ rather than $(0,3)$ as one might expect. This has no physical implications. If D has space-like signature, $D \rtimes M^4 \times H^3$ has signature $(0,1) + (1,3) + (3,0) = (4,4)$. This is what one obtains also for the $SO(2,4)/SO(1,3) \times SO(1,1)$ option so that options could be equivalent.

11.2.2 The identification of the moduli space of CDs inspired by conformal invariance

An identification of the moduli space of CDs inspired by conformal invariance is considered in [B4] (`https://rb.gy/gcfvus`). The 5-D $AdS_5 = SO(2,4)/SO(1,3)$ appears in AdS/CFT correspondence and is associated with $4 \to 5$ holography whereas the space-time surfaces inside CD realize $3 \to 4$ holography. This might have served as a motivation for the proposal: maybe the idea has been that one cold generalize holography by introducing 8-D space $SO(2,4)/SO(1,3) \times SO(1,1)$ as analog of AdS and its "boundary" as a 7-D space.

The proposal for the space of CDs

The proposal of the article is that the space of CDs is given by $SO(2,4)/SO(1,3) \times SO(1,1)$ 8-D space.

(a) $SO(2,4)$ is the 15-D conformal group of M^4 including Poincare transformations, scalings and also the 4-D group of special conformal transformations. $SO(2,4)$ acts linearly in 2+4-D Minkowski space $M(2,4)$. The action of special conformal transformation is however singular and this might mean difficulties. CD is defined by a 2-D sphere of M^4 defining the maximal ball of CD and thus CD.
The space of CDs would be 8-D have signature (4,4) also now. This can be seen by noticing that boosts correspond to time-like directions and rotations to space-like directions so that the signature of $SO(2,4)$ is $(8,7)$. $SO(1,3)$ has signature $(3,3)$ and $SO(1,1)$ has signature $(1,0)$. Signature $(4,4)$ is indeed the outcome. Maybe the two candidates for the space of CDs are identical.

(b) Why $SO(2,4)$ would be a correct choice for the group considered. The hyperbolic time evolution as an exponential of special conformal transformation in the time direction defined by CD maps the lower boundary of CD to the upper boundary. Special conformal transformation can be composed from an inversion with respect to the middle point of the CD followed by an ordinary translation followed by inversion. Inversion $x^\mu \to x^\mu/x^2$ performs a local scaling of the point of the point $(\pm t, r = T \mp t)$ of the CD boundary to $(\pm t, r = T \mp t)/(-T^2 \pm 2Tt)$ and scales the CD boundary. This scaled boundary is translated and preserves its shape. The inversion scales this CD down. Therefore special conformal transformations can leave the shape of CD invariant but induce Lorentz transformation, scaling, and translation.

(c) The intuitive expectation is that the subgroup dividing $SO(2,4)$ should leave CD invariant. If so, $SO(1,1)$ should map the CD to itself. A possible identification is as the group of special conformal transformations in the time direction defined by CD. If $SO(1,3)$ corresponds to the usual Lorentz group, it does not leave the CD invariant unlike $SO(3)$. This suggests a different interpretation. Perhaps the division means that $SO(1,3) \times SO(1,1)$ consists of Lorentz boosts and hyperbolic special conformal transformations

leaving the center point of CD invariant. Only $SO(3) \times SO(1,1)$ would leave the CD unaffected.

(d) The basic distinction from the TGD inspired proposal is that there is no holography involved with CD. Rather, it seems that one starts from the idea that one has $7 \to 8$ holography is associated with the 8-D $SO(2,4)/SO(1,3) \times SO(1,1)$. 7-D subset of CDs would provide the holographic data. One can, of course, consider this kind of holography in WCW cm degrees of freedom.
For this option, the identification $SO(3,1) \times SO(1,1)$ could have the same role as $SO(3)$ in the case of the Poincare group or Lorentz group. This would give for CD Lorentz degrees of freedom and assignable with the $SO(1,1)$ mapping CD to itself.

How representations of the Poincare group could be realized in $SO(2,4)/O(1,3) \times SO(1,1)$?

The representations of the Poincare group should be realized in the moduli space of CDs. How this is achieved is not obvious for the conformal group option.

(a) It would seem that instead of finite-D possibly non-unitary representations of the rotation group $SO(3)$ as in the case of P, non-unitary finite-D representations of $SO(1,3) \times SO(1,1)$ characterize what might be called generalized spin degrees of freedom? The situation would resemble that in Poincare invariant QFTs for which one has non-unitary finite-D representations of $SO(3,1)$ given by say spinors. It is not clear whether the induction gives rise to a direct sum of state spaces associated with mass shells H^3 as the physical intuition would suggest.

(b) What seems like a paradox is that the Poincare group allows 4-D translations as Cartan algebra whereas $SO(2,4)$ has 3-D Cartan algebra. Constant mass squared for Poincare irreps however means that only 3 momentum generators are dynamical. $SO(2,4)$ Lie algebra contains 3-D Cartan algebra, which consists of commuting rotation generators of $SO(4)$ and $SO(2)$ having a discrete spectrum. Momenta are not expected to have a similar discrete spectrum without special assumptions. Intriguingly, the number theoretical vision of TGD, involving the notion of Galois confinement TGD, predicts that the spectrum of physical stats is integer valued in suitable units.

(c) For the TGD inspired option the moduli space is identified as $D \rtimes P/SO(3)$ and the situation is much simpler and differs from the construction of the representations of the Poincare group only by the presence of the scaling group with defines the analogs of unitary time evolutions preceding SSFRs. The scaling group would reduce by a symmetry breaking forced by the number theoretical picture to a discrete subgroup of scalings giving a discrete mass squared spectrum.

(d) $SO(2,4)$ acts as symmetries of massless theories to which ordinary twistor approach applies so that the proposed picture is attractive in the framework of massless QFTs in M^4. Masslessness in M^4 sense conforms with the invariance of the state space of massless particles under scalings.
In the TGD framework, the masslessness holds true in the 8-D sense and also the twistor space of CP_2 enters the game so that masslessness in the M^4 sense is not absolutely necessary and the physical expectation is that the mass square spectrum is integer valued using as the momentum unit defined by CD size scale. Note however that the ground states of super symplectic representations are massless in this sense.

(e) The space of CDs would be non-compact and would have 4 time-like directions. Holography analogous to AdS/CFT correspondence, with AdS interpreted as space-time, does not look plausible.

11.2.3 Questions about the dynamics in the space of CDs

CDs define a decomposition of WCW to sub-WCWs. The intuitive picture is that one has a network of CDs acting as analogs of interaction volumes and that "particle lines" connect the CDs to each other. One would approach standard ontology as these networks analogous to

Feynman diagrams increase. In standard ontology one can speak not only about events, but something that exists. This would be like a transition from Eastern to Western world view.

Should one try to describe these particle lines by modifying the space of CDs and by introducing interactions between CDs? Does it make sense to assume that overlapping CDs interact in the sense that the space-time surfaces belonging to two different CDs touch? If CDs are interpreted as perceptive fields, this does not look like an attractive idea. The emergence of larger Feynman diagram-like structures would only mean emergence of larger CDs containing sub-CDs. Of course, understanding the interaction between CD and sub-CDs remains a challenge.

For the simplest option based one has the space of CDs, in which CDs are like particles with internal degrees of freedom. How can one construct transition amplitudes in the space of CDs?

(a) If one can assign representations of the Poincare group to CDs, they would be analogous to particles characterized by momenta and angular momenta having also conformal weight as a quantum number associated with scalings. They would also have internal dynamics, which have been the main target of attention hitherto.

(b) Transitions are expected to occur between CDs with different positions, sizes and different rest systems (direction of time line defined by the tips). In the recent picture, state function reductions are assumed to correspond to scalings only.
One would expect that the transition amplitude between quantum states for the moduli space propagation between two different CDs has a kinematic part, which one might hope to reduce to symmetry considerations just as for the propagation of particles in Minkowski space.

(c) There is also an inner product of zero energy states related to CDs. The basis of the zero energy states characterized by holography are expected to differ by the action of an element $g(CD_1, CD_2)$ of the group $SO(4,2)$ or of $D \times P$ transforming the CDs to each other.
The transition amplitude should be proportional to the overlap of these states and therefore to the matrix element of $g(CD_1, CD_2)$ between the zero energy states associated with CD_1 and CD_2.

(d) Physical intuition suggests that the transition amplitudes are small for "large" transformations $g(CD_1, CD_2)$ and that in good approximation small translations, Lorentz boosts, and scalings are preferred. In the approximation that translations and Lorentz boosts affecting the center point of CD are trivial, only scalings and hyperbolic evolutions remain under consideration.

11.3 TGD inspired questions and ideas related to the interpretation of the hyperbolic flow

The interpretation of the findings related to hyperbolic time evolution in the TGD framework inspire several questions and ideas.

11.3.1 The flow lines of time-like special conformal transformation as a motion with a constant acceleration

The exponentiated hyperbolic generator S corresponds to a relativistic motion in M^4 with a constant acceleration a, which is essentially the inverse of the size L of CD: $a = hbar/L$ for $c = 1$, where L is the size of CD identified as distance between its tips. Could this constant acceleration correspond to a representation for an acceleration of the system defined by CD in an external gravitational field, which is constant in the first approximation?

Note that this acceleration is huge when compared with that assignable to macroscopic systems. Gravitational acceleration g at the surface of Earth corresponds to a thermal energy of order 10^{-21} eV. The size of the CD would be in this case of order 10^{15} m.

It has been already noticed that in the TGD framework S can affect only the holographic data at the boundaries of CD. The action of S exponentiates to a unitary hyperbolic time evolution on quantum states at the boundaries of CD. The two-point functions of the conformal QM are thermal with temperature determined by the scale L of CD so that the acceleration $a = 1/L$ can be said to make itself visible via Unruh effect (`https://rb.gy/qxyp8q`).

11.3.2 Can one assign thermodynamics to CD?

One can assign to the CD a temperature. I have earlier proposed that the expansion of CD by sequences of SSFRs could be interpreted as a stepwise cosmic expansion with temperature decreasing like $\hbar/L$. This would conform with the finding that the astrophysical objects themselves do not seem to participate in the expansion.

(a) In QFT in M^4, constant acceleration corresponds to the so-called Unruh temperature proportional to $\hbar \times a$. For the ordinary value of $\hbar$, this temperature is extremely small for the accelerations encountered in macroscopic quantum systems. An accelerated system sees the vacuum of an inertial system as a black body at Unruh temperature.
Note that the blackhole temperature is analogous to Unruh temperature and proportional to $\hbar GM/R^2 \propto \hbar/GM$ (this temperature is extremely small for astrophysical blackhole-like entities).

(b) The conformal 2-point functions of a CFT inside a CD with "energy"/Hamiltonian associated with infinitesimal special conformal transition, behave like those for ordinary CFT at finite temperature $T_{CD} = hbar/L$, L the size of CD. T_{CD} is analogous to Unruh temperature but much larger.
For a massive particle with Compton length L , the CD temperature would be of order $T_{CD} = m = hbar/L$. This would be more like ordinary temperature for a system of mass m moving in a volume defined by Compton length. I have proposed that CDs are characterized by this temperature and the expansion of CD in the sequence of SSFRs leads to the reduction of this temperature analogous to that taking place in cosmology.

What could be the interpretation of T_{CD}?

(a) For the cell scale the CD temperature T_{CD} would be of order of the energy of visible light. Could T_{CD} relate to bio-photons? Could CD temperatures correspond to those in ordinary thermodynamics and could they be interpreted as a kind of sensory/cognitive representations for the real temperatures in terms of the internal physics of CD?

(b) In p-Adic thermodynamics [K59] [L164], energy is replaced with mass squared interpreted as proportional to conformal weight as in string models. The p-adic analog of the temperature is inverse of an integer and corresponds to a dimensional p-adic temperature $T_p = \hbar log(p)/L_p$, where L_p is the p-adic length scale proportional to $\sqrt{p}$. p-Adic length scale corresponds to the length scale defined by the Compton length of the particle. p-Adic length scale hypothesis states that preferred p-adic primes are near to powers of 2, or possibly also other small primes and that these primes correspond to fixed points of discrete p-adic coupling constant evolution. Number theoretic vision of TGD suggests a concrete mechanism implying this [L180].
A possible interpretation is that p-adic massivation and p-adic temperature characterizes the density matrix for the particle entanglement with the environment [L164]. p-Adic temperature is assigned with a scaling which changes the size of the CD and could be perhaps associated with "big" CDs.
T_{CD} would naturally correspond to the p-adic temperature $T_p = \hbar log(p)/L_p$.

(c) $T_{CD} = \hbar/L$ generalizes to $T_{CD} = \hbar_{eff}/L$. For gravitational Planck constant $\hbar_g r/\hbar = GMm/beta_0$, $\beta_0 < 1$, where M is some large mass, say Earth mass, one has $T \propto (GMm/beta_0)m$.
If the size scale of CD is expected to scale lik h_{eff}, one obtains a zoomed version of the system and temperature is not changed. This applies also to the temperature $T_{CD,gr} = \hbar_g r/L$ if L scales like $hbar_{gr}$. Note that for $\hbar_{gr}(Earth)$ assignal to dark particles at gravitational flux tubes, gravitational Compton L is about .45 cm and does not depend on mass m (Equivalence Principle). For electrons and protons $T_{CD,gr}$ would be unrealistically high.

11.3.3 Could the dynamics of CD define a sensory map of the exterior of CD?

The time evolution by a special conformation maps the CD into itself. This is a surprising result. The infinitesimal generator vanishes at the light-like boundaries and the generator is time-like for either half-cone of the cd.

In TGD, CD is identified both as the analog of quantization volume and the perceptive field of self. This raises some questions.

(a) The special conformal transformation in time direction consists of an inversion I with respect to the center point of the CD followed by an ordinary time translation followed by the same inversion I.
Ordinary time translation in the exterior is mapped to the special conformal transformation inside the cd. Does this imply some kind of cognitive or sensory map of the exterior world to the interior world? Note that the same can be done also for the other special conformal transformations. Is this something that the monads of Leibniz might be doing?

(b) Inversion is also involved with the $M^8 - H$ duality and gives a semiclassical realization of Uncertainty Principle [L104, L105]. The mass shells $H^3 \subset M^4 \subset M^8$ with mass m are mapped by inversion $m \to a = \hbar_{eff}/m$ to cosmic time $a = constant$ hyperboloids of $M^4 \subset H$.
$M^8 - H$ duality, has an interpretation as a generalization of momentum-position duality. This duality is natural since quantum TGD is essentially the generalization of wave mechanics obtained by replacing point-like particles with 4-D surfaces obeying holography. Could one interpret the special conformal transformations in terms of $M^8 - H$ duality. If so, special conformal transformations could be seen as mirror images of translations of in momentum space.
Twistor approach [B7] to scattering amplitudes involves a duality between two Minkowski spaces in which dual conformal groups act. $M^8 - H$ duality suggests a natural identification of these two Minkowski spaces as space-time and momentum space and could correspond to this duality.

(c) In zero energy ontology (ZEO) [L96, L144, L136] [K117], the time flow corresponds to the increase of CD (at least in statistical sense) taking place in scalings of CD? For a sequence of time-like special conformal transformations realized as unitary hyperbolic time evolutions the experienced flow of time should therefore cease. Could these sequences serve as correlates for "timeless" meditative states of consciousness?

11.3.4 Could astrophysical SSFRs correspond to special conformal transformations leaving CD size unaffected?

There are also questions related to the TGD inspired cosmology, which can be quantum coherent in arbitrarily long length scales. This would explain the constancy of the temperature of CMB.

In the TGD inspired cosmology [K95, K62], the cosmic expansion does not take place for astrophysical objects (stars and planets at least) as a smooth process but as rapid "jerks" in which flux tubes as thickened cosmic strings suffer phase transitions increasing their thickness and reducing their string tension [K2, L84, L137]. This is also an empirical fact and not understood in general relativity.

On the other hand, the emergence of complex life forms in the Cambrian Explosion is a biological mystery. TGD explains it in terms of this kind of rapid expansion of the radius of Earth by factor 2 bursting highly developed life forms from underground oceans to the surface of Earth [L71, L140, L126, L172].

Should one modify the views of ZEO [L96, L144, L136] [K117]? Could one think that at quantum level the TGD analog of unitary time evolution could correspond to a sequence of "small" state function reductions (SSFRs) followed by hyperbolic time evolutions, which do not scale up the CD? This even in astrophysical scales. In this view, only "big" SFRs (BSFRs) changing the arrow of time and occurring at the level of magnetic body (MB) would

correspond to the scalings of CD and a pair of BSFR would bring back the original arrow of time. This would be the case if CD size corresponds to that for a *real* physical system rather than for the perceptive field of a conscious entity as assumed hitherto.

11.3.5 About the quantum realization of hyperbolic time evolution in TGD framework

What one can say in the TGD framework about the quantum realization of the exponentiated S using holography?

(a) The situation can be understood by noticing that in the lowest approximation the motion is given by $r = r_0 + gt^2/2$ so that a parabola intersecting the light-cone boundary is obtained in a finite time. S is well-defined at the light-like boundaries of CD.

(b) Holography inside CD does not allow assignment of a flow inside CD to the representation of the exponentiation of S represented as an operator. S is not parallel to the light-like boundaries, in which case the action of the superposition of 3-surfaces would be non-trivial. Therefore only the action in fermionic degrees of freedom can be non-trivial.

(c) The action of S on the quantum state at the boundary makes sense and is analogous to that of a Hamiltonian in Hilbert space at time= constant hyper-surface. Zero energy state is the sum of over pairs of 3-D states located at passive and active boundaries of CD and by holography the action of exponentiation of S at the passive boundary and determines the action of S at the active boundary. There is no flow inside the CD. Holography defines the state at the opposite boundary.
One obtains a one parameter family of exponentiations of S analogous as unitary time evolution operators $U(\tau)$. The value of the parameter τ in the exponential runs from $-\infty$ to $+\infty$ and corresponds to a finite range for the ordinary time coordinate t. This is indeed analogous to 1-D conformal QM since the angular and radial degrees of freedom are effectively absent. The light-like radial coordinates take the role of complex variable z in conformal field theories.

11.4 Motion of CDs in the moduli space and kinematic qualia

The proposal that CD serves as a correlate for the perceptive field of self implies that the motions of CDs in the moduli space of CDs gives rise to the kinematic qualia assignable to various kinds of motions.

The first thing to notice is that the transformations, which leave the position of CD that is the center point of CD invariant, are in a special role.

(a) These transformations consist of Lorentz group $SO(3,1)$, scalings, plus possibly also the subgroup $SL(2,R)$ of special conformal transformations leaving the center point of CD invariant. This group would characterize the internal degrees of freedom analogous to the orientations of a rigid body.

(b) Besides this there are transformations of $SO(2,4)$ affecting the center point of the CD. The moduli space $SO(4,2)/SO(1,3)\times SO(1,1)$ could correspond to these transformations in the space of generalized positions of CD.

(c) $SO(1,3)\times SO(1,1)$ would leave the center point of the CD invariant and code for various shapes of the CD with one point fixed. This space would consist of various shapes of CD representing the states of motion of the CD. For instance, if a CD moves in a particular direction with some velocity. The CD would have a shape characterized by a corresponding Lorentz transformation. This group includes also scalings leaving center point invariant.

11.4.1 The motion at quantum level

One can consider the situation both at quantum and classical level.

(a) At the quantum level the system would be characterized by a wave function in moduli space and small state function reduction (SSFRs) would correspond to steps in the motion. The analogues of both position and momentum measurements are possible and these could by $M^8 - H$ duality correspond to position measurements in the space of CDs assignable to M^8 and H. This duality could correspond to the duality of twistor Grasmannian amplitude realized in terms of ordinary and momentum twistors [L61].
If a localization takes place in the degrees of freedom considered as commuting degrees of freedom at each step, one obtains a discrete motion in these degrees of freedom.

(b) The M^4 position of CD would define naturally Cartan algebra and SSFRs involving a position measurement in E^3 would define the discrete motion in M^4.

(c) This discrete motion in H would give rise to kinematic qualia such as experience of motion with constant velocity and acceleration. The localization in the space of CDs with respect to scaling would fix the size of CD and therefore geometric time as a correlate of subjective time identified as a distance between the tips of CD. The localization with respect to the time coordinate of CD is impossible and does not allow to identify Minkowski time as an observable.
Scalings increasing the size of CD in a statistical sense would correspond to the growth of geometric time as distance between the tips of CD correlating with the subjective time identifiable as a sequence of SSFRs.

(d) D and boost and rotation generators (call them K_z and J_z) of the Lorentz group leaving the center point of the CD invariant can serve as observables for states localized in the moduli space.
What about momentum eigenstates in the moduli space? D does not commute with momentum so that for momentum eigenstates D is not well-defined. K_z and J_z would be analogous to helicity since their identification depends on the position of CD or momentum of momentum eigenstate. The measurement of D implies delocalization with respect to the size of CD. The dual measurement of the size of CD, call it L, means a measurement of geometric time.
For a given size L of CD one can construct momentum eigenstates as analogues of plane waves so that the measurement of L seems to commute with the measurement of momentum. Geometric time as a gradual increase of the size of CD would flow only during the measurements involving measurement of L.

Can the scaling operator D correspond to the "stringy" scaling operator L_0?

There is a problem related to the identification of conformal weights as eigenvalues of the scaling operator L_0 as mass squared eigenvalues. In string models, the scaling operator L_0 acting in complex coordinate z of the string world sheet is proportional to the mass squared operator and commutes with it. L_0 commutes with the mass square operator but the scaling operator D does not. What could be the counterpart of L_0 in TGD?

One can consider several candidates for L_0 in TGD. Light-like 3-surfaces appear at the level of both embedding space and space-time surface so that there are two basic types of candidates. These two kinds of scaling generators could relate to the notions of inertial and gravitational masses and therefore to the Equivalence Principle.

Consider first the embedding space level.

(a) The light-like radial coordinate r for the light-cone boundary would provide the first guess for L_0 as scaling $L_0 = r\partial_r$. L_0 however scales the size of the light-like boundary and therefore CD so that this interpretation can be challenged.
On the other hand, the basic assumption is that the states at the passive boundary of CD are unaffected under SSFRs so that scaling should not affect the momenta. Note that the center point of CD must be shifted in time direction under the action of CD so that one has a combination of D and P_0.

(b) The most stringy candidate for L_0 would be as the scaling generator $L_0 = zd/dz$ for the conformal transformations of S^2 of light-cone boundary representable as $S^2 \times R_+$. Remarkably, L_0 does not affect the size of the CD.

The generators of globally defined conformal transformations of S^2 are representable as Möbius transformations representing $SL(2,C)$. One can even compensate for the conformal scaling factor associated with these transformations by a suitable radial scaling of r depending on z so that they act as isometries.

Light-like 3-surfaces appear also at the level of space-time surfaces. Both the light-like 3-surfaces defining boundaries of space-time surfaces [L159], and the boundaries between Euclidean wormhole contacts and Minkowskian space-time regions, identified as deformed CP_2 type extremals, allow by their metric 3-dimensionality extended conformal invariance.

(a) One assign light-like coordinate r with the light-like 3-surface and the scaling generator $L_0 = r\partial_r$ is highly analogous to L_0.

(b) Also now one has the representations $X^2 \times R_+$ and complex coordinate for X^2 defines counterpart of L_0.

(c) Could L_0 assignable to X^2, represent gravitational mass squared? Could holography assign momenta to the light-like 3-surfaces identifiable as gravitational momenta and by Equivalence Principle be identical with inertial momenta assignable to the boundaries of CDs. Gravitational-inertial dictotomy would reflect the space-time embedding space dichotomy.

(d) Classical TGD is an exact part of quantum TGD and the conserved classical momenta assignable to the space-time surfaces are also natural candidates for gravitational momenta. The inertial momenta would be assignable to the CDs.

11.4.2 The motion at the classical level

At the classical level would have motions in moduli space consisting of small pieces, which are geodesic lines in $D \rtimes P$ or $SO(4,2)$.

(a) Causality would mean that only discretized world lines consisting of pieces which are time-like or light-like geodesic lines are considered (recall that the signature of the moduli space is $(4,4)$.

(b) A small transformation of the group $D \rtimes P$ or of $SO(2,4)$, which is representable as an action of a Lie algebra generator, would describe a basic step in the motion. In the quantum case, one must have Cartan algebra and one can argue that all classical motions consist of small translations or scaling rotation, and boost commuting with it.
The measurements of the size and position of CD are dual measurements and the measurement of the size of CD would give rise to the experience flow of time correlating with the flow of the geometric time.

(c) For $D \rtimes P$ small translations along geodesics of M^4 would be basic building bricks of translational motion and the direction of small translation would change step by step in curvilinear motion.
For $SO(2,4)$ also special conformal transformations affecting the center point of the CD could be considered classically. They do not however commute with translations so that at least quantum mechanically they would be excluded. The 4 special conformal transformations could however serve as a dual set of observables instead of translations.

(d) A Lorentz boost of CD would code for the velocity associated with a given step of translational motion and would be determined by the direction and size of the step. It would be coded by the shape of the CD characterized by the direction of the time-like axis connecting its tips. The shape of the CD would change during the motion.

(e) Rotational motion around the center point would leave center point and CD itself invariant but affect the zero energy state of CD. More general rotational motion would correspond to steps consisting of translations.

11.5 Questions related to ZEO

ZEO involves several questions which are not completely understood. Do SSFRs correspond to repeated measurements for a set O of commuting observables? Does BSFR occur when a

new set of observables not commuting with the set O are measured? What exactly happens in SSFR?

11.5.1 Questions related to SSFRS

SSFRs as a generalization of Zeno effect and weak measurements

Consider once again the question related to the identification of SSFRs. SSFRs are identified as the TGD counterpart for weak measurements, generalizing the notion of repeated measurements giving rise to the Zeno effect.

(a) The most straightforward generalization of the Zeno effect is that in the kinematic degrees of freedom for CDs the sequence of SSFRs corresponds to a sequence of measurements of commuting observables. BSFR would take place always when the set of measured observables changes to a new one, not commuting with the original set.

(b) D, K_z and J_z leave the center point of CD, identified as position of CD, invariant. D does not commute with momenta. Should one just accept that momenta and $\{D, K_z, J_z\}$ are two sets of mutually commuting observables and that the change of this set induces BSFR.
The size of CD and therefore the value of the geometric time would change in the sequence of measurements of D, K_z and J_z but not in the sequence of momentum measurements one would have superposition over different sizes of CD and time would be ill-defined as also Uncertainty Principle requires. This would conform with the original view.

What really happens in SSFRs?

I have written a lot of what might happen in SSFRs and BSFRs but I must admit that the situation is still unclear and the proposals depend on what one takes as starting point assumptions, which can be overidealizations.

On the more general level, the sequence of SSFRs would correspond to dispersion in the moduli space of CDs and if SSFRs correspond to the measurement of same commuting observables identified as generators of $SO(2,4)$ or $D \rtimes P$ or their duals as generalized position in the moduli space, rather simple picture emerges of what can happen.

BSFR would take place when the new set of observables not commuting with the original set emerges. What are the conditions forcing this? If one assumes that sleep is induced by BSFR, it becomes clear that this does not happen at will but when metabolic energy resources are depleted and the system must rest. The dissipation of the time reversed system looks like self-organization and the system heals during sleep. Also homeostasis would rely on BSFRs in various scales making it possible to stay near quantum criticality.

But what exactly happens in SSFR? It seems clear that the states at the passive boundary are not changed. But what happens to the passive boundary?

(a) Do the contents of sensory experience assigned with the sequence of SSFRs localize
Option a: to the active boundary of the CD or
Option b: to the 3-ball at which the half-cones of the CD meet.

(b) What happens to the passive boundary itself in SSFR? The scaling occurs for the entire CD but there are two basic options.
Option 1: The scaling leaves the *center point* of the CD invariant. Passive boundary is shifted towards past just like active boundary towards future.
If the sensory experience is assigned to the active boundary (Option a)), option 1) is consistent with what happens when we wake up. The time has been flowing during sleep but we have not been aware of this. The arrow time would be determined solely by the change of the state at the active boundary.
If the sensory experience is assigned with the 3-ball (option b)) at the center of CD (Option b)), time does not flow in the sequences of SSFRs.
Option 2: The scaling leaves invariant the tip of CD associated with the passive boundary so that it is not shifted at all but is scaled. This option is consistent with both option

a) and b) for the localization of the experience of time flow. However, waking-up from sleep would take at the time when we fell asleep: this does not make sense.
The model for sleep favours option a)+1) for which CDs would define ever expanding sub-cosmologies changing the arrow of time repeatedly. Any conscious entity would eventually evolve to a cosmology, a kind of God-like conscious entity.

(c) One can also consider other empirical inputs. There are stars and even galaxies older than the Universe. Their existence is consistent with option a)+1).
CDs form a scaling hierarchy. CDs in the distant geometric past assignable to stars and galaxies are much smaller than the cosmological CD. The scaling cosmological CD inducing the time flow takes place much faster than the scaling of the much smaller astrophysical CDs. Cosmological time runs much faster and astrophysical CDs remain in the distant geometric past.

(d) A third test is based on after images, which appear repeatedly. They correspond to sub-CDs of a CD. Could the after images correspond to life cycles of the *same* sub-CD as I have proposed? This is the case if the sub-CDs are comoving in the scalings of the CD shift. This looks rather natural.

11.5.2 More questions and objections related to ZEO and consciousness

The best way to make progress is to make questions and objections against the existing view, which is often far from clear. In the following I raise some questions of this kind.

What could BSFR mean biologically?

(a) In have considered the possibility that BSFR could mean as biologically birth in opposite time direction. This however leads to rather complex speculations.
The most natural assumption is that it means what it says, the emergence of a new CD [L184] as a perceptive field of a conscious entity. This does not require that biological death would be a birth in the opposite time direction although this cannot be excluded. This means one counter argument less.

(b) I have considered the idea that in BSFR the size of a CD could decrease dramatically so that the reincarnated CD would be much smaller than before BSFR. This would make possible what one might call childhood. The idea is that the painful memories from the end of the lifecycle could be deleted. This model however requires rather detailed assumptions about how the memories of life cycle are stored at the active boundary of CD. The oldest memories would reside near the tip of CD and newest nearest to the intersection of the half-cones of the CD.
Is this picture consistent with the view about SFR as a localization in the space of CDs? Since the number of CDs larger than given CD is much larger than those with size smaller than it, one can argue that the size of CD increases in statistical sense without limit in SFRs. If one can assume that death involves localization in the space-like degrees in the space of CDs (E^3 position and size of CD), the reduction of CD size looks rather implausible. If the preceding SSFR involved also this kind of localization then the CD after BSFR would in statistical sense be larger than it was before BSFR.

(c) Can CDs interact? For instance, can a CD catch the sub-CD defining a mental image of the CD with which it overlaps? This is not the case: it is not possible to catch the spotlight of consciousness.

CD serves as a correlate for the perceptive field of self. Self is also an active causal agent. This aspect must relate to the zero energy states defined as superpositions of space-time surfaces inside a CD.

(a) CD defines a perceptive field, a kind of spotlight of consciousness, which makes it possible to sensorily perceive the space-time surface, which continues outside CD although one can also imagine a situation in which this is not the case. Saying that mental image co-moves means that the spotlight moves.

(b) Self has also causal powers. SSFRs change the state at the active boundary of CD. This induces changes inside the future light-cone in turn define perturbations of CDs of the geometric future possibly inducing BSFRs.
Since the superposition of 3-surfaces at the active boundary of CD changes in SSFR, SSFRs have an effect on the geometric future. This is of course the case: our acts of free will affect the world around us but conform with causality.
Almost deterministic holography for space-time surfaces and zero energy states dramatically reduces the freedom of free will due to state function reductions . The delocalization in WCW taking place in the space of CDS during the analogues of unitary time evolutions preceding SSFR improves the situation.
One can also imagine a situation in which nothing changes at the boundaries of CD: self is completely passive: this is of course true at the passive boundary and can be true also at the active boundary in special situations. The classical time evolution for preferred extremals is not fully deterministic. Space-time surface is analogous to a 4-D soap film with frames and the case of 2-D soap films suggests that a finite non-determinism is assignable to the frames. This kind of SSFRs would not affect the space-time surface around CD at all. Pure cognition or meditative states might correspond to this kind of SSFRs.

The notion of ego is central in Eastern philosophies. How could one understand this notion in the ZEO based theory of consciousness?

(a) Ego means that mental images want to survive. Self survival instinct is an analogous notion although it refers to the biological body. The quantum state at the passive boundary of the CD defines a good candidate for ego since it is indeed preserved during the sequence of SSFRs during which the set of measured observables is preserved.

(b) BSFRs means death of self or subself as a sub-CD. Also the external physical perturbations arriving at the passive or active boundary can affect the quantum state at it and can induce BSFR. The self assignable to CD is exposed to perturbations, which might induce BSFR. A simple example of this kind of perturbation would be a blow in the head inducing a loss of consciousness.
Ego preservation could mean that self does its best to make the periods of time with an opposite arrow of time as short as possible. This is not in conflict with the fact that the durations of sleep and awake states are roughly the same if a given arrow of time means that the time fraction spent in a state with this arrow of time dominates over that in a state with an opposite arrow of time.
At the magnetic bodies carrying dark matter as phases with large h_{eff}, the interactions perturbing the boundaries of CD are expected to be rather weak. One has something analogous to a quantum computer isolated from the external world.

(c) This suggests a more quantitative definition of the period with a fixed arrow of time. One expects that consciousness with a given arrow of time can have gaps. There is indeed empirical evidence suggesting that our flow of consciousness has gaps. Perhaps the wake-up-sleep ratio of the periods with different arrows of time is what matters. For a given arrow of time, the system would be dominantly in wake-up state or in sleep state.
At a given level of self-hierarchy there is some average time for a given arrow of time and it is expected to increase at the higher levels. Magnetic bodies carrying dark matter interact only weakly with lower levels of the hierarchy, in particular ordinary matter, would make possible long periods with a given arrow of time, in the first guess proportional to say h_{eff}.

(d) What could biological death as a process at the level of ordinary biomatter mean? Is biological death determined by the situation at the lower hierarchy levels? On the other hand, dark matter at MBs defines a control hierarchy and is gradually thermalized as suggested in [L193] so that the ability to perform biocontrol is reduced. Also the ability to gain metabolic energy is reduced and makes it difficult to preserve the arrow of time. Since the average value of h_{eff} is reduced, the system becomes more vulnerable to perturbations inducing a BSFR changing the arrow of time.

There are also questions related to metabolism.

(a) A metabolic energy feed is needed to preserve the distribution for the values of h_{eff}. The energies of quantum states increase with h_{eff} and in the absence of a metabolic energy feed, the values of h_{eff} at MBs tend to decrease. The system becomes more vulnerable to perturbations and the BSFRs changing the arrow of time occur more often. The system becomes drowsy.

(b) Sun serves as a fundamental source of metabolic energy but TGD leads to a proposal that also radiation from the core of Earth, which happens to be at the same wavelength range as solar radiation could have served and maybe still serve as a source of metabolic energy.

(c) I have proposed remote metabolism as a mechanism in which the system contains a subsystem with an opposite arrow which emits energy, say dissipates, in opposite time direction and thus seems to gain metabolic energy if seen from the standard arrow of time.
This is possible if there is a system able to receive the *effective* negative energy signals. For instance, a population reversed laser could serve as such a system. The second option is that the environment loses thermal energy so that the second law in its standard form would be violated. For instance, heat could be transferred from a system with a given temperature to a system with higher temperature. The dissipation for the time reversed system looks like self-organization. Sleep periods would in this picture mean gain of metabolic resources and healing.

(d) Also life with the opposite arrow of time needs metabolic energy. We receive metabolic energy basically from the Sun. Could the Sun serve as a source of metabolic energy also for the time reversed systems? The answer is positive.
To understand why, one must clarify what the change of the arrow of time means. Time reversed signals have positive energy and only the reversed time direction makes them look like negative energy signals. The sum of energies for the sub systems with opposite arrows of time is conserved apart from effects due to finite sizes of CDs (Uncertainty Principle). Also life with an opposite arrow of time can use solar energy as a metabolic energy source.

(e) The biological death is assumed to be due to the loss of quantum coherence at the level of MBs inducing a loss of ordinary coherence in short scales implying bodily decay. What could the situation be in the next reincarnation with the same arrow of time? Does the next life with the same arrow of time end at roughly the same time so that the size of the CD would become rather stationary. There would not be much progress.
Or could the MB be able to preserve the quantum coherence for a longer time in the next reincarnation? Since the quantum coherence of MB naturally explains the coherence of the ordinary biomatter, impossible to understand in the standard physics framework, there is no reason why MB could not achieve this feat in the next incarnation.

11.5.3 Is Negentropy Maximization Principle needed as an independent principle?

The proposal has been that Negentropy Maximization Principle (NMP) [K64] [L130, L50] serves as the basic variation principle of the dynamics of conscious experience. NMP says that the information related to the contents of consciousness increases for the whole system even though it can decrease for the subsystem. Mathematically, NMP is very similar to the second law although it states something completely opposite. Second law follows from statistical physics and is not an independent physical law. Is the situation the same with the NMP? Is NMP needed at all as a fundamental principle or does it follow from number theoretic physics?

The number theoretic evolution is such a powerful principle that one must ask whether NMP is needed as a separate principle or whether it is a consequence of number theoretical quantum physics, just like the second law follows from ordinary quantum theory.

Two additional aspects are involved. Evolution can in adelic physics [L60] be seen as an unavoidable increase in the algebraic complexity characterized by the dimension $n = h_{eff}/h_0$ of extension of rationals associated with the polynomial define space-time surface at the

fundamental level by socalled $M^8 - H$ duality [L104, L105]. There is also the possibility to identify a quantum correlate for ethics in terms of quantum coherence: a good deed corresponds to a creation of quantum coherence and the evil deed to its destruction.

How do these two aspects relate to the NMP? Is NMP an independent dynamical principle or a consequence of number theoretic (adelic) quantum physics?

Consider in the sequel "big" state function reduction (BSFR) as the counterpart of the ordinary state function reduction. I'm not completely sure whether the following arguments can be also applied to SSFRs for which the arrow of time does not change.

One can consider two alternative formulations for NMP.

Option I

Option I is the simpler and physically more plausible option.

(a) BSFR divides the quantum entangled system at the active boundary of CD into two parts, which are analogous to the measurement apparatus and the measured system. The selection of this partition is completely free and decided by the system. This choice corresponds to an act of free will. Depending on conditions to be discussed, the action of the measurement to this pair can be trivial in which case the entanglement is not reduced. The measurement can also reduce the entanglement partially or completely and the p-adic entanglement negentropy and entropy decreases or becomes zero.

(b) If the partition into two parts is completely free and if the choice is such that NMP, or whatever the principle in question is, allows BSFR, the quantum coherence decreases. Number theoretic evolution suggests that the principle telling when BSFR can occur is number theoretic.

There is a cascade of BSFRs since BSFRs are also possible for the emerging untangled subsystem and its complement. The cascade stops when the entanglement becomes stable.

(c) What condition could determine whether the reduction of the entanglement takes place? What could make the entanglement stable against BSFR?

Number theoretical vision suggests an answer. Physical intuition suggests that bound states represent a typical example of stable quantum entanglement. Bound states correspond to Galois confined states [L162, L127, L142, L143] for which the momenta of fermions are algebraic integers in an extension of rationals but total momentum has integer valued components. This mechanism for the formation of the bound states would be universal.

A natural number theoretical proposal is that the entanglement is stable if the entanglement probabilities obtained by diagonalizing the density matrix characterizing the entanglement belong to an extension of rationala, which is larger than the extension, call it E, defined by the polynomial P defining the space-time surface. An even stronger condition, inspired by the fact that cognition is based on rational numbers, is that BSFR can take place only if they are rational.

This kind of entanglement would be outside the number system used and one can argue that this forces the stability of the entanglement. A weaker statement is that the reduction is possible to a subspace of the state space for which the entanglement probabilities belong to E (or are rational).

(d) This option could replace NMP as a criterion with a purely number theoretical principle. This does not however mean that NMP would not be preserved as a principle analogous to the second law and implied by the number theoretic evolution implied by the hierarchy of extensions of rationals.

Could free will as the ability to do evil or good deeds reduce to number theory that is to the choice of a partition, which leads to either increase or decrease of entanglement negentropy and therefore of quantum coherence?

The basic objection can be formulated as a question. How can the conscious entity know whether a given choice of partition leads to BSFR or not? Memory must be involved. Only by making this kind of choices, a system with a memory can learn the outcome of a given choice. How could the self learn, which deeds are good and which are evil? The answer is

suggested by the biologically motivated view of survival instinct and origin of ego [L184] based on SSFRs as a generalization of Zeno effect.

(a) Conscious entity has a self characterized by the set of observables measured in the sequence of SSFRs. BSFR as a reduction of entanglement occurs when a new set of observables not commuting with the original set are measured. In BSFR self "dies" (loses consciousness). Second BSFR means reincarnation with the original arrow of time.

(b) The perturbations of the system at both boundaries of CD are expected to induce BSFRs and to occur continually. Therefore the arrow of time is fixed only in the sense that it dominates over the opposite arrow.

(c) Self preserves its identity (in particular memories defining it) if the second BSFR leads to a set of observables, which does not differ too much from the original one. The notions of survival instinct and ego would reduce to an approximate Zeno effect.

(d) This mechanism would allow the self to learn the distinction between good and evil and also what is dangerous and what is not. A BSFR inducing only a brief period of life with a reversed arrow of time could teach the system when the BSFR leads to a reduction of entanglement and loss of coherence.
The harmless BSFRs could provide a mechanism of imagination making survival possible. Intelligent systems could do this experimentation at the level of a self representation of a system rather than in real life and the development of complex self representations would distinguish higher life forms from those at a lower evolutionary level.

Option II

Option II is stronger than Option I but looks rather complex. I have considered it already before. NMP would select a partition for which the negentropy gain is maximal in BSFR or at least, the decrease of the negentropy is minimal. One must however define what one means with negentropy gain.

Before considering whether this condition can be precise, it is good to list some objections.

(a) Is the selection of this kind of optimal partition possible? How can the system know which partition is optimal without trying all alternatives? Doing this would reduce the situation to the first option.

(b) Free will as ability do also evil deeds seems to be eliminated as a possibility to either increase or decrease entanglement negentropy and therefore quantum coherence by choosing the partition of the system so that it reduces negentropy.

(c) If the BSFR cascade would lead to a total loss of quantum entanglement, the entanglement negentropy would always be zero and NMP would not say anything interesting. On the other hand, if the selection of the partition is optimal and the number theoretic criterion for the occurrence of the reduction holds true, it could imply that nothing happens for the entanglement. Again the NMP would be trivial.

(d) What does one mean with the maximal negentropy gain?

What does one mean with a maximal negentropy gain?

Option II for NMP says that for a given partition BSFR occurs if the entanglement negentropy increases maximally. What does one mean with entanglement negentropy gain? This notion is also useful for Option I although it is not involved with the criterion.

(a) Entanglement negentropy refers to the negentropy related to the *passive* edge of the CD (Zeno effect). Passive boundary involves negentropic entanglement because NMP does not allow a complete elimination of quantum entanglement (bound state entanglement is stable). The new passive boundary of CD emerging in the BSFR corresponds to the previously active boundary of CD.

(b) For option I for which the concept of good/bad is meaningful, the number theoretical criterion could prevent BSFR and stop the BSFR cascade. There is however no guarantee that the total entanglement negentropy would increase in the entire BSFR cascade. This

would make the term "NMP" obsolete unless NMP follows in a statistical sense from number theoretic evolution: this looks however plausible.
The unavoidable increase of the number theoretical complexity would force the increase of p-adic entanglement negentropy and NMP as an analog of the second law would follow from the hierarchy of extensions of rationals.

11.6 Appendix: About the action of $SL(2,R)$ inside causal diamond

$SL(2,R)$ appearing as conformal symmetries of conformal field theories and mapping the upper half plane of the complex plane to itself by Möbius transformations. I have collected the basic facts about how SL(2,R) is realized for causal diamonds. These facts can be found also from [B16].
The Lie algebra of $SL(2,R)$ is spanned by the generator $D_0 r\partial_r + t\partial_t$ of scaling with respect to the center point of CD, by the generator $P_0 = \partial_t$ of time translation in the direction defined by the line connecting the tips of CD, and by the generator $K_0 = 2tr\partial_r + (t^2 + r^2)\partial_t = 2tD_0 + (r^2 - t^2)P_0$ of a special conformal transformation in time direction obtained as IP_0I, where I is the inversion with respect to the center point of CD. Conformal Killing vector is linear combination of form

$$\xi = aK_0 + bD_0 + cT_0 \ . \tag{11.6.1}$$

For $b = 0$ the center of point of the CD is at origin $(t = 0, r = 0)$. The generators obey the Lie-algebra

$$[P_0, D_0] = P_0 \ , \quad [K_0, D_0] = -K_0 \ , \quad [P_0, K_0] = m2D_0 \ . \tag{11.6.2}$$

The time evolution of conformal QM is defined by a Hamiltonian which in its most general form is given as $G = i(uP_0 + vD_0 + wK_0)$. The conformal Hamiltonians G can be classified by the Casimir invariant

$$C = D_0^2 - \tfrac{1}{2}(K_0P_0 + P_0K_0) \ . \tag{11.6.3}$$

This corresponds to the invariance of the determinant of the matrix $(b, 2c; 2a, b$ given by $\Delta = b^2 - 4ac$.

(a) For $\Delta < 0$ one has generators of elliptic transformations analogous to rotations in the Lorentz group.

$$R = \tfrac{1}{2}(\alpha P_0 + \tfrac{K_0}{\alpha}) \ . \tag{11.6.4}$$

is a representative of this class. One has $\alpha = L$, where L is the radius of CD defined by the maximal radial distance from the time axis of CD. In the sequel will use the notation α used also in [B16] The distance between the tips of the CD is $2L$. The radial conformal Killing vector is everywhere time-like.

(b) Generators with $\Delta = 0$ generate parabolic transformations, null rotations. Also now the radial conformal Killing vector is time-like everywhere except for the light-cone emanating from $t = -b/2a$, $r = 0$

(c) Generators with $\Delta > 0$ generate hyperbolic transformations analogous to Lorentz group perspective. Dilation D and the generator

$$S_0 = \tfrac{1}{2}(\alpha P_0 - \tfrac{K_0}{\alpha}) \ . \tag{11.6.5}$$

serves as a representative for this class. In this case the conformal Killing vector is null at the tips of the light-cone $(t = t_\pm, r = 0)$, $t_\pm 0 - b + \sqrt{\Delta}/2a$, time-like inside either light-cone or outside both light-cones, and space-like everywhere else.

One can assign to S_0 *resp.* R_0 time coordinates T *resp.* τ in such a way that one has

$$R_0 = \partial_T \quad , \quad S_0 = \partial_\tau \quad . \tag{11.6.6}$$

These time coordinates are related to Minkowski time t by

$$t = \alpha tan(T/2) = \alpha tanh(\tau/2) \quad . \tag{11.6.7}$$

One finds that the range $(-\alpha, \alpha)$ for t corresponds to the range $(-\infty, \infty)$ for τ and to the range $(-\pi, \pi)$ for T.
S_0 has a representation as a differential operator

$$S_0 = \frac{1}{2\alpha}[(\alpha^2 - t^2 - r^2)\partial_t - 2tr\partial_r] \quad . \tag{11.6.8}$$

S_0 maps CD identifiable as the region $|t| + vertr| < \alpha$ to itself.
One can identify so-called diamond coordinates via the formulas

$$t = \alpha \frac{sinh(\tau)}{cosh(x)+cosh(\tau)} \quad , \quad r = \frac{sinh(x)}{cosh(x)+cosh(\tau)} \quad . \tag{11.6.9}$$

The ratio of the equations gives $t/r = sinh(\tau)/sinh(x)$. For small values of τ and x this gives $(t \simeq \alpha\tau, r \simeq \alpha x$. From $t = \alpha tanh(\tau/2)$ one can solve $sinh(\tau)$ and use it to the expression of t/r to get

$$sinh(x) = 2\frac{t}{\alpha}/(1 - (\frac{t}{\alpha})^2) \quad . \tag{11.6.10}$$

$sinh(x)$ is constant for the flow lines.
In diamond coordinates, the line element of Minkowski metric reads as

$$ds^2 = \frac{\alpha^2}{(cosh(x)+cosh(\tau))^2}(-d\tau^2 + dx^2 + sinh(x)^2\Omega^2) \quad . \tag{11.6.11}$$

and the flow lines correspond to a particle at rest. Diamond coordinates are analogous to the natural coordinates of a freely falling system.
The integral curves of the Killing flows defined by S_0 are obtained as

$$t^2 - (r - \alpha\omega)^2 = \alpha^2(1 - \omega^2) \quad , \quad \omega = \frac{1}{tanh(x)} \quad . \tag{11.6.12}$$

ω is constant along these curves and varies in the range $[1, \infty)$. This equation should be equivalent with the equation already obtained. The integral curves correspond to a relativistic motion with constant acceleration given by $a(x) = sinh(x)/\alpha$ which is constant along each integral curve for which x indeed remains constant. For the line passing through origin one has $a = 0$.

Chapter 12

About concrete realization of remote metabolism

12.1 Introduction

The idea of "remote metabolism" (or quantum credit card, as I have also called it) emerged more than a decade ago - and zero energy ontology (ZEO) provides the justification for it. The idea is that the system needing energy sends negative energy to a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

12.1.1 Short Glossary About The Basic Concepts Of TGD

The model involves several new physics elements. It is good to begin with a little glossary to get a rough view about basic ideas of TGD and TGD inspired biology. The following list explains briefly the notions relevant to the ontology of TGD Universe.

- The notion of ***many-sheeted space-time*** (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) distinguishes between TGD and special and general relativities. In TGD framework space-times are regarded as a 4-D surfaces in certain 8-D space $M^4 \times CP_2$ obtained from empty Minkowski space M^4 by adding four small dimensions. The study of field equations characterizing space-time surfaces as "orbits" of 3-surfaces (3-D generalization of strings) forces the conclusion that the topology of space-time is non-trivial in all length scales. Many-sheeted space-time consists of space-time sheets in various length scales with smaller sheet being glued to the larger ones by wormhole contacts (see **Fig.** `http://tgdtheory.fi/appfigures/wormholecontact.jpg` or **Fig. ??** in the appendix of this book) identified as building bricks of elementary particles. The sizes of wormhole contacts vary but are at least about CP_2 size (about 10^4 Planck lengths) and thus extremely small for ordinary elementary particles.
- The notion of many-sheeted space-time forces the replacement of reductionism with ***fractality*** . This is the basic motivation for applying TGD in, say, biology. The most radical prediction is the existence of scaled variants of physics of strong and weak interactions in various length scales, and biology is especially interesting in this respect. Fractality reflects itself as various length scale hierarchies.
  (a) ***p-Adic physics*** as a physics of cognition and intention and the fusion of p-adic physics with real number based physics are new elements. p-Adic mass calculations lead to the ***p-adic length scale hypothesis*** stating that preferred p-adic length scales correspond to primes p near powers of two: $p \simeq 2^k$, k positive integer. Mersenne

primes M_k of form 2^k-1, and Gaussian Mersennes $M_{k,G}$ of form $(1+i)^k-1$ (k some prime in both cases) are especially favored with biologically interesting length scale range [10 nm, 2.5 μm] containing as many as four electron Compton scales assignable to Gaussian Mersennes, which could be seen as a number theoretic miracle.

(b) ***Dark matter hierarchy*** realized in terms of a hierarchy of values of effective Planck constant as integers using $\hbar$ as a unit. Large value of h_{eff} makes possible macroscopic quantum coherence crucial in living matter. For instance, it allows dark ELF photons with energies above thermal energy ($E = h_{eff}f$).

- ***Topological field quantization*** . This distinguishes between TGD and Maxwell's electrodynamics. TGD leads to a geometrization of the notion of classical field. Both weak, electromagnetic, and gluon fields are known once the space-time surface as a solution of field equations is known. This implies an enormous reduction in the number of degrees of freedom but the many-sheeted space-time brings in additional degrees of freedom allowing to avoid conflicts with known experimental facts about fields.
  Topological field quantization means that fields are replaced by quanta of space-time. For instance, constant magnetic field decomposes into space-time surfaces of finite size representing flux tubes or sheets. Field configurations are like Bohr orbits carrying very specific "archetypal" field patterns. Radiation fields corresponds to so called topological light rays or massless extremals (MEs), magnetic fields correspond to magnetic flux quanta (flux tubes and sheets) having as primordial representatives "cosmic strings", electric fields correspond to electric flux quanta (say cell membrane), and elementary particles have so called CP_2 type vacuum extremals as basic building bricks.
- ***Field body*** and ***magnetic body*** . These notions follow from topological field quantization. In TGD Universe a physical system has a corresponding field identity - field body or magnetic body - in the sense that a given topological field quantum corresponds to a particular source (or several of them - say in the case of flux tube connecting two systems). In Maxwell's electrodynamics one cannot achieve this kind of identification since the fields created by different sources superpose. Superposition is replaced with a set theoretic union implying that only the *effects* of the fields assignable to different sources on test particle superpose.
  Field body and magnetic body bring in new degrees of freedom highly relevant in TGD inspired quantum biology. Magnetic body has hierarchical onion-like structure reflecting corresponding structure for the system with which it is associated. One can also speak of ***dark magnetic body*** corresponding to the value of effective Planck constant $h_{eff}/h = n$. Dark space-time surface can be regarded as an analog of n-sheeted Riemann surface - an n-furcation of space-time surface occurring because of the extremely non-linear dynamics of Kähler action.
- ***Magnetic body as an intentional agent using biological body as a sensory receptor and motor instrument*** is an attractive identification but one should be cautious. One could argue that magnetic body and biological body together form the natural intentional unit - kind of "super-body" - and that in remote metabolism energy is transferred between biological and magnetic body parts. Note however that personal magnetic body has a hierarchical onion-like layered structure and that several magnetic bodies can use the same biological body making possible remote mental interactions such as hypnosis [L21].
- ***Magnetic flux tubes and sheets*** serve as "body parts" of the magnetic body, and one can speak about magnetic motor actions. Besides concrete motion of flux quanta analogous to ordinary motor activity, basic motor motor actions include the contraction of magnetic flux tubes by a phase transition reducing Planck constant, and the change in thickness of the magnetic flux tube changing the value of magnetic field and thus the cyclotron frequency. Reconnections of the flux tubes allow to magnetic bodies to get in contact and temporal variations of magnetic fields inducing motor actions of magnetic bodies favor the formation of reconnections. Flux tube connections at molecular level bring a completely new element to biochemistry. Flux tube connection serves as a space-time correlate for attention in TGD inspire theory of consciousness. ATP-ADP process could have interpretation in terms of reconnection.

- ***Cyclotron Bose-Einstein condensates*** of various charged particles can accompany magnetic bodies. Cyclotron energy $E_c = hZeB/m$ is much below thermal energy at physiological temperatures and magnetic fields possible in living matter. In the transition $h \to h_{eff}$ E_c is scaled up by a fractor $h_{eff}/h = n$ and for sufficiently high value of h_{eff} cyclotron energy can be above thermal energy $E = h_{eff}ZeB/m$. The observations of Blackman about quantum like effects of radiation at harmonic of Ca^{++} cyclotron frequency could be used as motivation for introducing the hierarchy of Planck constants. The proposal is that cyclotron Bose-Einstein condensates associated with DNA and cell membrane - perhaps cell membrane proteins - play a key role in biology.
- *Massless extremals (MEs)/topological light rays* are extremals of the Kähler action replacing radiation fields in Maxwell's theory. Laser beam serves as a good analogy for ME. MEs are tubular space-time surfaces carrying classical fields propagating with light velocity. Since the waves propagate in single direction only there is no dispersion and MEs make possible precisely targeted communications without loss of information. Linear superposition is possible in the direction of ME. Both electromagnetic, weak, color and gravitational fields are present as induced fields. MEs can carry light-like currents and can be charged: in Maxwell's theory this is not possible. For charged MEs polarization has a longitudinal component. Tesla's scalar waves are obvious analogs for charged MEs. Charged MEs can however serve as correlates also for charged particles like electron.
- ***Josephson junctions*** are junctions between two super-conductors, say, parallel wires or analogs of capacitor plates carrying supra currents. ***Josephson current*** is generated when there is a phase difference $\Delta\Phi(t) = \int ZeVdt/h$ between the two super-conductors involved. Josephson current is of the form $J = J_0 sin(\Delta\Phi(t))$. For constant voltage V the current is oscillating with ***Josephson frequency*** $f_J = ZeV/h$. The frequency for cell membrane is rather high for the ordinary value of Planck constant but $h \to h_{eff}$ scales it down so that even ELF frequencies are possible. The charge carriers of Josephson current are in accelerated motion and expected to radiate. The radiation is quantum process analogous to emission of photon by an atom and occurs with quantized energies coming as harmonics of Josephson energy ZeV having interpretation as electrostatic energy gained by the charge carrier "freely falling" through the junction. Charged particle can jump to the other side of cell membrane by absorbing positive energy Josephson photon or sending negative energy Josephson photon. This would define the basic mechanism of charge transfer for ionic pumps.
  In TGD inspired biology Josephson junctions are associated with electric flux quanta of which cell membrane carrying extremely strong electric field represents the basic example. In low length scale resolution one can regard the entire cell membrane as a Josephson junction. In improved length scale resolution cell membrane proteins are natural candidates for Josephson junctions and might define quantum counterparts for channels and pumps. The conjecture is that superconductors and Josephson junctions form a length scale hierarchy. The levels of this hierarchy can communicate by exchange of Josephson photons if the values of h_{eff} and Josephson energies were the same for them.
- The recent view about ***negentropic entanglement*** forced by Negentropy Maximization Principle (NMP) [K64] is very simple and leads to a connection between negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book), dark matter hierarchy, p-adic physics, and quantum criticality. NMP holds true only in the intersection of realities and p-adicities - that is, applies in the situations in which density matrix for a system and its complement is multiple of identity matrix resulting in general quantum measurement identified as a measurement of the density matrix. Negentropic entanglement is always maximal entanglement so that the density matrix is proportional to unit matrix and corresponds to a value of effective Planck constant equal to the integer $\hbar_{eff} = n\hbar$ telling the number of the entangled states. The p-adic prime assignable to the system corresponds to the largest prime power factor of n. n has interpretation as the number of sheets of multi-sheeted covering defining n-furcation of space-time sheet and the n-furcation is manifestation of quantum criticality implying n-sheeted covering property. Negentropic entanglement is a prerequisite for an experience defining abstraction as a rule having as instances the state pairs appearing in the entangled

state. Note that the state pairs are not unique since any unitary transformation acting in the same manner to the two entangled state basis is allowed.

- In ***zero energy ontology*** (ZEO) physical states are pairs of positive and negative energy parts having opposite net quantum numbers and identifiable as counterparts of initial and final states of physical event in ordinary positive energy ontology. Positive and negative energy parts of the zero energy state are at the opposite boundaries of ***causal diamond*** (CD) defined as a double-pyramid-like intersection of future and past directed light-cones of Minkowski space.
  There is a fractal hierarchy of CDs within CDs (and perhaps also overlapping with each other). The sizes of CDs (definable by the temporal distance between its tips) come as integer multiples of CP_2 time T_{CP_2} and the fundamental time scale $T = .1$ s of biology corresponds to $T = nT_{CP_2}$, $n = M_{127} = 2^{127} - 1$. This time scale corresponds to the secondary p-adic time scale assignable to electron and is macroscopic. As a matter of fact, all elementary particles correspond to macroscopic time scales: this predicts a direct connection between elementary particle physics and macroscopic physics.
  In TGD inspired theory of consciousness CD defines what might be called a spot-light of consciousness in the sense that the contents of conscious experiences associated with given CD are about the space-time sheets in the embedding space region spanned by CD. Physical states are superpositions of pairs of positive and negative energy parts at opposite boundaries of causal diamond (CD) defined as double-pyramid-like intersection of future and past directed light-cones of Minkowski space. The conserved quantum numbers of positive and negative energy parts are opposite. Zero energy state is actually a superposition of zero energy states associated with CDs of different size scale characterized by integer. Time evolution with respect to subjective time is a sequence of state function reductions at opposite boundaries of CDs involving localization of that boundary and state fiunction reduction at it but necessarily forcing the de-localization of the opposite boundary. During this process CDs in the superposition tend to increase in size, and this gives rise to the experienced flow and arrow of time. The pairs of state reductions at opposite boundaries correspond to sensory percept followed by motor action as reaction at the level of the brain. Phase conjugate laser beam would represent a standard example of negative energy photons.
  Negative energy signals would have several functions: realization of intentional action initiating neural activity in geometric past would explain Libet's well-known findings, memory as communication with geometric past with time reflection in time direction defining "seeing" in time direction, and remote metabolism.

12.1.2 Plan of the chapter

The model of remote metabolism and the vision behind it is applied to biology. It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal mechanism of metabolism with magnetic body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling's theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from "large" magnetic bodies.

The model identifies Josephson frequency with the subharmonic of the frequency characterizing the periodicity of a periodic voltage perturbation assumed to correspond to cyclotron frequency in biological applications. Together with quantization conditions for charge and effective Planck constant it leads to precise quantitative predictions for capacitor-like systems

acting as dark capacitors. Also a relationship between the magnetic field at magnetic body of the system and the voltage of the capacitor-like Josephson junction emerges.

The predictions allow new quantitative insights about biological evolution as emergence of Josephson junctions realized as capacitor-like systems both at the level of cell, DNA and proteins, and brain. h_{eff} can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters. h_{eff} serves as a kind of intelligence quotient and its maximization requires the maximization of both the voltage and area of the membrane-like capacitor system involved. This is what has happened during evolution. Indeed, the internal cell membranes, cortical layers and DNA double strand in chromosomes are strongly folded, and the value of membrane electric field is roughly twice the value of the electric field for which di-electric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

The claimed properties of Tesla's "cold electricity" suggest interpretation in terms of dark matter in TGD sense. This leads to a proposal that a transition to dark phase occurs when the value of voltage equals the rest mass of charged particle involved. This criterion is generalizes to the case of cell membrane and relates the values of h_{eff}, p-adic prime p, and threshold potential for various charged particles to each other. The idea that nerve pulse corresponds to the breakdown of super-conductivity as a transition from dark to ordinary phase receives additional support. The resulting picture conforms surprisingly well with the earlier speculations involving dark matter and p-adically scaled variants of weak and color interactions in biologically relevant length scales. An extremely simple mechanism producing ATP involving only the kicking of two protonic Cooper pairs through the cell membrane by Josephson photon as a basic step is proposed is proposed. Also the proposal that neutrino Cooper pairs making sense in TGD framework but not not in standard model could be highly relevant not only for cognition but also metabolism finds support.

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` [L23].

12.2 Quantum credit card

The receiving system serving as energy storage would be analogous to a population reversed laser and one can imagine at least two new physics options for the laser like system.

12.2.1 Two realizations for the "population inverted laser"

The two options could be realized for ordinary matter at biological body and for dark matter at the magnetic body respectively.

(a) One possibility is provided by zero point kinetic energy depending on the size scale of the space-time sheets $E \sim \hbar^2\pi^2/2mL^2(k)$, where $L(k)$ is the p-adic length scale given by p-adic length scale hypothesis stating that p-adic primes $p \simeq 2^k$, k integer are favored. m refers to the mass of the particle transferred between space-time sheets as the laser like system is excited or de-excited. I have considered the identification for a hierarchy of metabolic energy quanta in terms of p-adic length scales comings as square roots of powers of two and defining a hierarchy transition energies which are not identifiable as ordinary molecular transition energies [K17]. The ordinary metabolic energy quantum whose nominal value can be taken as .5 eV belongs to this hierarchy and corresponds to proton for atomic p-adic length scale $L(139)$ or to electron Cooper pair with p-adic length scale $L(149)$. From $m_p/2m_e \simeq 2^{10}$ and from the ratio of p-adic mass scales $2^{(149-139)/2} = 2^5$ it follows that zero point kinetic energies are approximately the same. This option makes sense for visible matter and also for dark matter: the zero point kinetic energies are same since $L(k, \hbar_{eff}) = (\hbar_{eff}/\hbar)L(k, \hbar)$ is very natural assumption. $\hbar_{eff} = n\hbar$ is the effective value of Planck constant. This hierarchy most naturally holds true for ordinary matter and I have discussed unidentified spectral lines from outer space as a possible evidence for the existence of this hierarchy.

(b) Second option would be natural in dark matter sector for dark matter residing at the magnetic body of a given system serving as the energy storage of the system. The cyclotron Bose-Einstein condensates of bosonic ions or Cooper pairs of fermionic ions would define the analog of population reversed laser. TGD inspired nuclear physics allows also to have bosonic counterparts of fermionic ions behaving chemically in the same manner as their fermionic counterparts [K67]. The excitation energy would be defined by cyclotron energy $E_=h_{eff}f_c$, $f_c = qB/4\pi m$: here q and m are the charge and mass of the charged particle in question. If the value of $\hbar_{eff}$ is large enough, cyclotron energies are above thermal energy. For ordinary value of Planck constant they are typically very small.

The realization of quantum credit card for the latter option relies on reconnection of the magnetic flux tubes of the system extracting the energy and those associated with the energy storage. The energy storage could be higher onion-like layer of the personal magnetic body of the system or even some other magnetic body. The reconnection is possible only if the magnetic field strengths of reconnecting flux tubes are identical. Therefore the system needing energy should be able to tune the field strength on the receiving flux tubes by varying their thickness (conservation of magnetic flux guarantees that field strength behaves as inverse of the cross-sectional area of the flux tube). The reconnection gives rise to a formation of a flux tube between two systems and the system needing energy can send negative energy received by the excited cyclotron BE condensate.

This mechanism can also be behind the binding of molecules to corresponding receptors allowing the molecule to recognize the presence of the receptor after which the contraction of the flux tube by a phase transition reducing $\hbar_{eff}$ would bring the molecule to the receptor. Also water memory and homeopathic healing - and also immune system - would rely on the same mechanism. This mechanism appears also in the model of hypnosis as a kind of hijacking of parts of brain of the subject by hypnotist and in the general model of remote mental interactions.

12.2.2 Support for quantum credit card mechanism

There is some empirical support for the credit card mechanism.

(a) Photons of phase conjugate laser light behaves like negative energy photons in the sense that second law holds true in the reversed direction of geometric time which must be distinguished from experienced time.

(b) Popp has identified a process equivalent to "sucking of energy" in living matter, interpreting it as an extraction of energy in the form of bio-photons [I100]. Extraction mechanism allows interpretation in terms of sending of negative energy photons, which can also be dark. In TGD Universe bio-photons would result as dark photons decay in energy conserving manner to ordinary photons [K19]. The decay rate could be very small so that the intensity of dark photons could be quite high.

(c) Sleighdogs (see `http://tinyurl.com/zg9j3p9`) [I30] can run for several days without eating and no signatures of ordinary metabolism have been found. This phenomenon cannot of course be specific to sleigh dogs. Remote metabolism could explain the phenomenon as an extraction of metabolic energy from non-standard sources in absence of standard sources - say from the magnetic body associated with the collective formed by the dogs.

(d) Yan Xin Qigong practitioners report that in so called Bigu state there is no need to eat solid food at all for days, weeks, months or even years. Western science is beginning to take Bigu state (`http://tinyurl.com/y7unnww4`) seriously [I19] and the first national conference on Bigu state was held at the Pennsylvania State University in 2000, with presenters such as as Rustum Roy, founding director of Penn State's Materials Research Laboratory and Hans Peter Duerr, former director of the Max Planck Institute.

One could argue that these individuals live by utilizing dark light as metabolic energy. Does living matter use quantum credit routinely or only in special situations when ATP-ADP mechanism is not available or the neural processing of incoming information leading to the decision

about motor action is too slow? Quantum credit card mechanism allows also to initiate the neural activities preceding motor action in the geometric past and Libet's experiments indeed give support for this. Intentional action could be also seen as a top-down process in reverse time direction in which neural activity would be the last step.

One could also raise a more heretical question: could metabolic energy be always received by quantum credit card mechanism? Could the mysterious "high energy phosphate bond" actually reflect the fact that the metabolic energy is extracted from the magnetic body of ATP or some system containing it? Could energy reservoirs be filled by sending dark photon radiation exciting cyclotron states (EEG would be only one example of dark photons)? Or could ATP→ ADP fill energy reservoirs at magnetic body?

The best manner to test this is by studying cells under metabolic deprivation. Ling [I66] has argued that ionic pumps and channels do not actually exist and the experimental support for this was his experimental finding that cells continue to function under metabolic deprivation. This could be also interpreted as support for the hypothesis that the ionic currents flowing through cell membrane are supra currents so that dissipation is very low and pumping is un-necessary. My own argument [K24] runs as follows:

> "One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [I66] by exposing cell to a cocktail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and also stop the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is also the case for the membrane potential, so that the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy."

My proposal has been that pumps and channels can be there, but are needed basically for the purpose of taking samples about the state of the cellular environment. This view was inspired by the vision that cell membranes serve as sensors communicating information about the cellular environment to the magnetic body. Metabolic energy is however needed for other purposes and one might argue that the finding of Ling supports the view that a cell in this kind of situation uses quantum credit card to extract energy from some magnetic body.

12.2.3 Gut cells without mitochondria can survive: proof for the notion of remote metabolism?

Gut cells can survive without mitochondria (see `http://tinyurl.com/hqq79th`)! There are many other strange findings. Visible and IR light energize human skin cells transferring energy for the cells- the analog of photosynthesis. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy. NASA has studied sleigh dogs able to run for days without eating and showing no signs of getting tired.

Could photosynthesis work also in animal mitochondrial cells? The basic mechanism could be essentially the same: electron transfer chain providing energy to pump protons through cell membrane against potential gradient. This is the key step of both photosynthesis and cellular respiration. After that protons flow spontaneously back through ATP synthase and liberate energy to build ATP from ADP. This is like power plant. In plants solar photons provide the energy for electrons. In the animal cells dark photons with large $h_{eff} = n \times h$ (transforming now and then to biophotons) could do it. In the case of IR lmetabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism: I have called it quantum credit card mechanism or remote metabolism [L46].

Now even mitochondria are missing! Could remote metabolism work also without mitochondria? ADP→ATP transformation should occur since ATP is the universal energy currency.

Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle extracting the energy from nutriens: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. Again one quantum objection against vulgar darwinism. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation.

12.3 Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses:really?

I encountered in Facebook a really bizarre sounding title reading *The incredible pictures scientists say prove invisible alien entities ARE here on Earth* (see `http://tinyurl.com/hvsqbhj`) and just for curiosity decided to add one click to the web page in question (means higher income from ads) knowing that this is just what they want me to do! The story involves aliens spying us so that the street credibility index of the story reduced zero. The tool to detect the spies would be Santilli's telescope using concave lenses. Santilli, who is familiar to me, also talks about two types of invisible terrestrials detected by his telescope. It would be easy to ridicule but let us be patient.

An earlier article with title *Apparent detection of antimatter galaxies via a telescope with convex lenses* [H14] (see `http://tinyurl.com/hmkhml6`) reports a detection of antimatter galaxies. There is also an article with title "Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses" published in American Journal of Modern Physics [H3] claiming an independent observation of antimatter galaxies, antimater asteroids, and antimatter cosmic rays by Santilli's telescope (see `http://tinyurl.com/hezdys2`). These articles say nothing about aliens spying us.

Since I suffer from a pathological trait of taking half-seriously even the weirdest stories, I decided to learn what Santilli's telescope using concave lenses might mean. Ordinary telescope uses convex lenses (see `http://tinyurl.com/oqfjsly`). The light rays coming from the other side converge to form a picture of the source. For concave lense the light rays coming from the other side diverge so that concave lense does not sound like a good idea for detecting light coming from distant objects.

It is however claimed that Santilli's telescope detects light sources in darkness. This is only possible if the index of refraction $n = c/v$ characterizing the medium via the ratio of light velocity in vacuum to the velocity of light in medium changes sign. From Snell's law $n_1 sin(\theta_1) = n_2 sin(\theta_2)$ follow the basic facts about lenses (see `http://tinyurl.com/ybpdwweo`). It is possible to construct lenses which have negative index of refraction so that concave lense behaves like convex one. Presumably this is not be the case now since according to the existing theory, ordinary light would have the negative index of reflection (unless it is somehow transformed when arriving to the lense).

Concerning the theoretical arguments Santilli makes several claims, which do not make sense to me.

(a) The photons are identified as antimatter photons assumed to have negative energies. These antimatter photons are assumed to have repulsive gravitational interaction with ordinary matter. The claim is that this implies negative index of refraction. This does not make sense since gravitational interaction is quite too weak to cause refraction. Electromagnetic interaction must be in question. Antimatter photons are claimed to propagate with superluminal speeds and arrive instantaneously from remote galaxies. The assumption is in dramatic conflict with what we know about antimatter.

(b) Refractive index is claimed to be a property of light. This does not make sense: refractive index characterizes medium. Its sign however changes when the energy of photon changes sign. From Snell's law the sign of refractive index must change sign as the light enters to the concave lense. This would require that Santilli's antimatter photons transform to ordinary photons.

These arguments are more than enough for dooming the claims of Santilli as pseudoscience but what if there is something in it? The experimental finding is so simple that if it is not an artefact of poor experimentation, some interesting - possibly new - physics could be involved. So let us looks the situation from different point of view forgetting the theory behind it and taking seriously the claimed observations. Could one explain the findings in TGD framework?

Zero energy ontology (ZEO) is one of the cornerstones of TGD and could indeed explain the claims of Santilli and colleagues. In ZEO zero energy states are pairs of positive and negative energy states at opposite light-like boundaries of causal diamonds (CD) forming a scale hierarchy. Zero energy states are counterparts of physical events in standard ontology.

(a) ZEO predicts that the arrow of time can have both directions. In ZEO based quantum measurement theory state function reductions occur at either boundary of CD. Conscious entities correspond to sequences of reductions leaving everything unaffected at the boundary (Zeno effect) but changing the situation at the opposite boundary, in particular increasing its distance from the fixed boundary, which gives rise to the experienced flow of time. The first reduction to opposite boundary replaces the zero energy state with time reversed one. This can happen also for photons.

(b) The particles with non-standard arrow of time are not antimatter (I have considered also this possibility since it might explain the experimental absence of antimatter) but propagate in reverse time direction and have negative energies. There is a considerable evidence for this notion. Phase conjugate laser beams known to obey second law in reverse time direction would be one example. There are also old observations of Akimov and Kozyrev [H8, H5] claiming that the instrument of Akimov gives three images of distant astrophysical objects: one would be from past, one from recent, and one from future. I do not know about the construction of Kozyrev's instrument but one can ask whether it involved concave lenses. Also the notion of syntropy introduced by the Italian physicists Fantappie [J30] conforms with this picture. In biology syntropy is in central role since in biology time reversed radiation would play a key role.

(c) Since the sign of the energy is negative for phase conjugate photons, their refractive index is negative. n_2 for concave lense and n_1 for the medium behind lense must have opposite signs to explain the claims of Santilli and colleagues. This happens if the incoming negative energy photons from the geometric future are transformed to positive energy photons photons at the surface of the lense. This process would represent time reflection of the incoming negative energy photons to ordinary positive energy photons propagating inside lense.

The claimed results could be an outcome of a bad experimentation. What however remains is a test of ZEO - or more precisely, the notion of time reversed photons - using telescopes with convex lenses. The implication would be possibility to see to the geometric future using telescopes with concave lenses! An entire geometric future of the Universe would be open to us! This possibility is a good enough reason for seeing the trouble of proving experimentally that Santilli is (and I am) wrong! Negative index of refraction as a function of frequency is a real phenomenon in condensed matter physics (see `http://tinyurl.com/ybpdwweo`), and one can of course ask whether also it involves the transformation of positive energy photons to negative energy photons.

12.4 Comparison Of Ling's Vision Of The Cell To TGD View

Gilbert Ling (`http://tinyurl.com/ycsbhejz`) has proposed a theory of cell and living systems which challenges some basic assumptions of standard cell biology [I119, I66, I67, I68, I49, I61, I62]. This theory has several points of contact with the TGD view about living matter and it is interesting to compare the two approaches.

12.4.1 Ling's Basic Ideas And Concepts

Ling challenges the notions of ionic pumps and channels, the notion of high energy phosphate bond, and the prevailing view about the role of ATP as energy currency. Ling also questions the views about the role of water and lipid layers of cell membrane in biology. Reading Ling's article about mitochondria [I62] revealed to me how little is known about living matter and how primitive the theories really are. It is difficult to avoid the feeling that the biochemical approach is a heroic attempt to understand living matter without appropriate concepts and ideas and therefore doomed to lead to a vicious cycle of ad hoc hypotheses.

Ling's finding [I67] that a cell can survive for days under conditions of metabolic starvation is his basic argument in favor of the proposal that ionic pumps do not actually exist and that the transfer of various ions and molecules through cell membrane relies on different mechanisms.

Ling's theory [I66] is summarized in the article "Main principles of Ling's physical theory of the living cell" (`http://tinyurl.com/y7rz5twy`) by Vladimir Matveev [I119]. Ling introduces several new notions.

(a) ***The notions of resting state and activated state*** .
Biological basic structures in various scales appear in two states: resting state and activated state. These states are characterized by the associations between molecular pairs (to be described below). In the resting state most proteins are folded being covered with ordered water giving rise to several layers at the surface of the folded protein. Some protein however remain unfolded. In active state this layer melts and the protein's charged active sites become active and associations form between them and various ions or other active sites. Some proteins are unfolded also in the resting state. According to Ling ATP, water, and potassium ions (K^+) are adsorbed on the active sites of the unfolded proteins in resting state. In the activation ATP molecules are split and they give up phosphate ions to other molecules.

(b) ***Association between two molecules - call them*** A ***and*** B ***for definiteness*** .
Association of B with A means that B tends to be adsorbed by A. Ling's argument [I66] goes as follows. Consider molecules A and B with opposite charges and assume that A is fixed in space (A could be protein and B ion). The fixing of the position reduces the kinetic energy and therefore reduces the total energy of the pair since Coulomb interaction energy is negative. Therefore the association of the molecules is energetically favored. An example of an associated pair would be protein and ion attaching to a charged active site of the protein, which is either anionic or cationic (negatively or positively charged). In this case one can indeed assume that the position of the protein is fixed.

(c) ***Selective adsorption of*** B ***by*** A .
Adsorption probability described quantitatively in terms of affinity of A with respect to B - is enhanced by the presence of association so that one can speak of selective adsorption. Affinity of A with respect to B is defined as the energy liberated as B is attached to A. Electron affinity (`http://tinyurl.com/ycok9n4`) of atom is an especially important affinity. In Ling's theory affinities of various biomolecules or their functional groups with respect to water molecules, Na^+ and K^+ ions, and other functional groups appear as parameters. In particular, the affinities of C=O and N-H groups of the peptide bonds of proteins with respect to water molecules and other such groups are important. Also the affinities of COOH groups of the amino-acid residues containing two COOH groups with respect to Na^+ and K^+ ions are important.
Affinities characterize the state of the molecule: in particular, they are different for the resting state and activated state. For instance, unfolded proteins are highly affine with respect to K^+ in the resting state and with respect to Na^+ in the activated state. The phase transition changing the affinities accompanies the generation of action potential. The challenge is to understand why the affinities with respect to two ions with same charge and naïvely with same chemical properties are not essentially same. In principle, the definition of affinity as energy liberated in adsorption can explain this in terms of details of molecular chemistry since the geometry of the molecules matters besides charge distribution. The exponential dependence of Boltzmann factors appearing in equilibrium distributions could explain strong dependence of affinity on molecule.

The physical nature of selective adsorption - that is affinity - is assumed to depend on electron density in the functional group considered. Low electron density characterizes the resting state and high electron density the activated state. The main regulator of the electron density is ATP, which has electron acceptor properties (Ca^{++}, signal factors, hormones, and chemical modifications of proteins serve as regulators) In the resting state ATP adsorbed to the protein site displaces electron density to the adsorption site and when ATP is split, the electron density is transferred to the activated state. This displaced electron density is analogous to "high energy phosphate bond".

(d) ***Adsorption of water*** .
In Ling's theory the role of water [I49] differs from than in standard theory. The polypeptide backbone of any completely unfolded protein has a geometrically regular order of positive (N-H) and negative (C=O) charges of the dipoles. This geometry is complementary to the space between water molecules surrounding the protein. This complementary makes possible multilayer adsorption of water on the protein surface. Large fraction of the cellular water is transformed to an ordered water. The outcome are stronger dipole-dipole interactions (hydrogen bonds are the major contributors). As a consequence, the water layers become a poor solvent as compared to bulk water and solutes are displaced from the volume of the adsorbed water. Ordered water acts like an ice layer serving as a barrier against diffusion of large solute molecules. The ordered water at cell surface is assumed to explain cell's selective permeability.
As the cell is activated, the "ice layer" melts and diffusion into cell becomes possible and is not prevented by lipid layers. Also the selectivity of each functional group of polypeptide changes: instead of a high affinity with respect to water molecules one has a high affinity with respect to the functional groups of the back-bone. This gives rise to secondary structures of protein (such as alpha-helix).

(e) ***Induction process changing in a phase transition-like manner the associations between molecule pairs*** .
Activation process is a thermodynamical phase transition. Ling uses as an analog system magnet, a roughly linearly ordered sequence of magnetizable nails, and iron powder. When the magnet is brought to the system, the first nail is magnetized and magnetizes the second nail, which in turn magnetized the third, ... The nails also attract that iron powder. The outcome is the organization of the system to a linear structure minimizing free energy. Skeptics can of course argue that this is just a metaphor involving in essential manner non-locality brought in by the presence of the long range magnetic field. Chemistry is however local and it is difficult to see how the non-locality could creep in without introducing some explicit realization for it. The problem is actually much more general: how it is possible that biomolecules manage to find their associates in the dense molecular crowd: how molecule A recognizes the presence of molecule B and how A and B then go to find each other to react chemically.

12.4.2 The Fundamentals Of Ling's Vision From TGD View Point

It came as a surprise that Ling's basic notions have rather direct TGD counterparts in terms of magnetic flux tubes and their dynamics based on reconnection and phase transitions changing the value of $\hbar_{eff}$ inducing the change of flux tube length.

The new view about metabolism

More than 15 years ago I used [K17] Ling's finding [I67] related to the ability of the cell to survive under metabolic deprivation as an argument to support the hypothesis that ionic currents are supra currents running with low dissipation; in addition direct measurements support the quantal character of these currents identified as Josephson currents - in particular the fact that they do not depend on the properties of the membrane in question. Ling does not assume channels and pumps [I61], although in TGD framework they could be present. My cautious proposal has been that they exist for the purpose of taking samples about the molecular environment generating chemical sensory data communicated to the appropriate

appropriate part of the magnetic body. In any case, metabolic energy is needed for may other purposes - in particular, in the transition to activated state, and one could argue that Ling's experiments indicate the existence of an un-identified energy source used when ordinary metabolic energy is not available.

The recent view about TGD suggests that magnetic bodies serve as metabolic energy reservoirs analogous to population inverted lasers defined by excited cyclotron BE condensates of electron and proton Cooper pairs and of various ions. Electronic Cooper pairs are preferred because of their small mass. Quantum credit card mechanism would allow the extraction of energy from the BE condensates by sending negative energy dark photon signals leading to de-excitation of the BE condensates. In this framework the questionable notion of high energy phosphate bond could be replaced with the storage of energy of this kind associated with ATP or with a system containing ATP. The loading of metabolic batteries could take place by sending positive energy dark photons to excite the BE condensates in question and solar radiation could do this as it generates ATP from ADP by adding single phosphate ion. In cell respiration dark photons at the magnetic body of molecules providing the energy would do the same thing using essentially the same mechanism involving electrons and transfer of three protons per ATP through mitochondrial cell membrane.

TGD counterparts for the basic notions of Ling

Ling's vision is very attractive - at least from a TGD point view. One can however wonder whether it can be realized in the framework of standard chemistry. Can the proposed mechanism of association really lead to the selective adsorption? In particular, it is not clear how a given active site of protein can select between ions of same charge? The basic concepts of Ling find natural TGD counterparts and TGD allows one to overcome the restrictions posed by sticking to the framework of standard chemistry.

(a) In TGD framework the notion of association would reduce to that of flux tube or a flux tube pair connecting a pair of molecules or molecule (say active site of protein) and ion. Flux tube pair is favored since it allows to interpret reconnection process as touching of closed flux loops associated with A and B so that flux tube pair connecting A and B is generated.

This view fits also nicely with one of the variants of the model of DNA as topological quantum computer [K5]. For the variant in question the two flux tubes would carry electrons at their ends and the spin states of the two electrons would give rise to 4 states in 1-1 correspondence with DNA nucleotides so that one would obtain a realization of DNA code in terms of flux tube pairs.

Flux tube connections allow without further assumptions an additional selectivity in the sense that they can can exist between protein active site and on a particular ion only. As such Ling's proposal cannot distinguish between ions of same charge. TGD allows flux tube connections also between various biomolecules and even between larger structures so that the notion of association is not restricted to protein-ion pairs or pairs of active sites. These connections are absolutely essential for the understanding of DNA transcription, translation and various bio-catalytic processes.

(b) Adsorption process would mean a reduction of the length of the flux tube by a phase transition induced by the reduction of the value of $\hbar_{eff}$ so that molecules would get near to each other and chemical reaction would become possible.

It is intuitively clear that the length of the magnetic flux tube increases by $\hbar_{eff}/\hbar = n$ in the phase transition $\hbar \to \hbar_{eff}$, or more generally by $\hbar_{eff,2}/\hbar_{eff,1}$ in the phase transition $\hbar_{eff,1} \to \hbar_{eff,2}$. Consider a momentum eigenstate $exp(ipz/\hbar_{eff,1})$ with wave vector $k_1 = p/\hbar_{eff,1}$ defined at a straight flux tube satisfying periodic boundary conditions and therefore satisfying $k = m2\pi/L$, L the length of the flux tube. Suppose that momentum p is conserved in the phase transition. This means that wave vector k is transformed from $k_1 = p/\hbar_{eff,1}$ to $k_2 = p/\hbar_{eff,2}$. To preserve the periodic boundary conditions the length of the flux tube must be scaled by $\hbar_{eff,2}/\hbar_{eff,1}$.

(c) Induction process would mean a phase transition inducing reconnection process changing the flux tube connections between molecule pairs. This process would be a quantum

phase transition. Whether two molecule can associate depends on the values of the local magnetic fields associated with the reconnecting flux tubes. If the values of both the magnetic field and flux tube thickness are same for the two tubes, association is possible. The value of the flux tube thickness allows to discriminate between different ions of same charge. Flux tube thicknesses characterize also the state of the system (resting state and various activated states). It is also possible that the protein can vary the thickness of the flux tube and therefore reconnect with different molecules. The change of flux tube thickness would take place in the quantum phase transition changing the connectedness structure of the net formed by molecules. The phase transition can be seen as a motor action of the magnetic body. Magnetic body "wakes up" in the activation process.

Concrete examples about a process in which flux tube connectivities change in a phase transition-like manner would be melting of the "ice layer" around a folded protein bringing the proteins into "open air". The shortened flux tubes connecting the active sites of the peptide backbone and di-carboxylic amino-acid residues to water molecules would expand in $\hbar_{eff}$-increasing phase transition and de-reconnect. Water would transform to ordinary water. The resulting closed flux tubes accompanying amino-acids can reconnect with similar loops associated with other active sites of peptide and various secondary structures (such as α-helix) of the protein can form. I have discussed TGD inspired models of protein folding in [K11] in a rather light-hearted manner - mainly as an exercise in order to get familiarity with the notion of magnetic flux tube - and it would be interesting to reconsider the situation by characterizing the active sites by values of magnetic field/cyclotron frequency.

(d) Why should the $\hbar_{eff}$ increasing phase transition accompanying the activation process require energy? The following argument suggests an explanation.

i. As explained, the length of the flux tube is proportional to $\hbar_{eff}$ and therefore changes. What happens to the thickness of the flux tube? The simplest assumption is that magnetic field strength is preserved so that cyclotron energy scales like $\hbar_{eff}$ if the sheet containing single high frequency boson is transformed to an n-sheeted state with one low frequency boson at each sheet. This brings to mind Bose-Einstein condensate and one can ask whether the formation of BE condensates of genuine bosons could have a microscopic space-time description as n-furcations.

If bosons are Cooper pairs of fermions one encounters a problem with fermion number conservation in positive energy ontology. In ZEO one can in principle avoid this problem but one can argue that the change of fermion number in quantum jump for the positive energy part of the state is too radical an option. One possibility is allowance of fractional fermion number for a given sheet so that one can say that Cooper pair is de-localized between the sheets. One could also start from many-fermion state so that in the final state one would have one Cooper pair per sheet of the n-sheeted covering. For very large values of n this option is highly questionable.

ii. The conservation of magnetic flux poses an additional constraint. If the number of sheets becomes n-fold and the total flux is conserved, the flux of single sheet must be a fraction $1/n$ the original total flux. Therefore the transition producing n-sheeted covering of flux tube scales down its cross sectional area roughly by a factor $1/n$.

iii. A further condition comes from the quantization of magnetic flux telling that the net flux is integer multiple of $m_i\hbar_{eff i,i}$ in the initial state ($i = 1$) and final state ($i = 2$). Conservation of the magnetic flux gives $m_1 n_1 = m_2 n_2 = m$ so that integer m giving the flux in units of $\hbar$ must be divisible both by n_1 and n_2. Therefore the phase transition can occur only when the magnetic flux using $\hbar$ as unit is larger than 1 and the allowed values of n_i are factors of m. For large values of integer n_2 this means that the thickness of the magnetic flux in the initial state must be macroscopic.

iv. What happens to the magnetic energy of the flux tube? By considering a constant magnetic field one easily finds that flux conservation and invariance of B together with longitudinal scaling imply that the energy is scaled by integer $n = \hbar_{eff,2}/\hbar_{eff,1}$. Therefore part of the metabolic energy would be needed to make the flux tubes longer and thus to gain quantum coherence in a longer scale.

One could say that the pumping of the metabolic energy is needed to preserve macro-

scopic quantum coherence. An attractive idea is that the energy is extracted from some magnetic body by sending negative energy dark photons. The contraction of flux tubes would occur spontaneously and liberate magnetic energy and reduce the value of $\hbar_{eff}$. It is natural to interpret this process as dissipation and loss of potentially conscious information.

(e) Also the notions of resting state and activated state of biological structure (cell, protein, etc) have natural counterparts in TGD framework, together with the vision about the role of ordered water in biology. I have used the metaphor "cellular winter" for the resting state and "cellular summer" for the activated state induced by the feed of energy to the system so that it begins to self-organize. The TGD inspired model for ordered water (see `http://tinyurl.com/y7z69e8p`) [L18] [K50] relies on topological quantization of the magnetic field giving rise to flux sheets giving rise to layered structure and there is also a connection with the notion of pairs of dark DNA identified as sequences of dark protons at opposite sides of the layer realizing genetic code [K67, K50].

It seems that the basic notions of Ling's theory - in particular the notion of association, which in my view remains questionable in the framework of standard chemistry - find natural counterparts in TGD framework. The view about cell membrane as Josephson junction leads to a new view about nerve pulse with Josephson currents of Cooper pairs of electrons and fermionic ions and of bosonic ions serving in the key role.

The ground state of the axon would correspond to a propagating soliton sequence mathematically analogous to that appearing in the sequence of mathematical penduli. Nerve pulse would correspond to a propagating perturbation analogous to that obtained by kicking one pendulum to rotate in opposite direction. The detailed modelling of ionic currents is a fascinating challenge, and the view about the pairing of molecules and ions by flux tubes could provide a much more detailed and maybe realistic view about what really happens at cell membrane. It would also allow us to answer the question of whether pumps and channels are needed or whether they could be replaced with the TGD variants of the notions introduced by Ling.

Clearly, the basic question is whether standard biochemistry based on locality assumption is enough to describe living matter or whether the non-local quantum physics involving dark matter at magnetic flux tubes and transforming living matter from a soup of free ions and molecules to a dynamical Indra's net formed by biomolecules and flux tubes connecting them is needed .

Ling's view about ionic pumps and channels as compared to TGD views

Ling has empirical evidence that the prevailing ionic pump paradigm is wrong. The basic assumption of the prevailing theory is that both water molecules and various ions inside cell are free. This determines the kinetic equations used in the modelling of ion concentrations in chemi-osmotic theory [I62]. Ling assumes that in the resting state the important ions are adsorbed to proteins and that the activation of the cell changes the situation.

Besides adsorption also the notions of association and induction are needed in the formulation. Ling also emphasizes the role of the cellular water [I49]. Cellular water is not ordinary water but ordered water forming multilayered coverings of biomolecules in the resting state of the cell. This covering prevents various chemical activities of the molecules below the "ice layer". Only when the ordered water around proteins and other molecules melts, they become active and can participate biochemical reactions via their active anionic or cationic sites to which ions or other biomolecules attach. In this framework the notions of ionic pump and channel must be given up or reformulated.

This picture is consistent with that provided by TGD. Instead of treating cell interior as a soup of free molecules one must treat the system as a kind of dynamical Indra's web in which flux tube connections are changing all the time. If ions are part of this web, one cannot apply ionic pump theory unless one can neglect the constraints caused by the presence of flux tubes.

The most important implication is that the web dictates to a high degree what biochemical reactions can occur and also takes care that the reactants are brought

together when needed by reducing the value of Planck constant for appropriate flux tubes of the web. This transition also induces phase transitions changing the volume of a given region of cell. Sol-gel phase transition is basic example in this respect. It would seem that the best manner to describe the transfer of various molecules and ions through the cell membrane in TGD framework is as motor activities of the magnetic body of the cell quantum mechanically rather than biochemistry trying to reduce everything to single particle level and to thermodynamics.

The fact is however that channel and pump proteins exist and must have some function. The minimal function would be taking of samples from the chemical environment. Also in the generation of nerve pulses various voltage-gated ion channels play a key role. As will be found, the construction of a simple model for these channels demonstrates that quantal versions of channels and pumps emerge rather naturally in TGD framework: as a matter of fact, channel and pump proteins realize dark Josephson junctions! In particular, dissipation for ionic pumps is minimized since the transfer of ion through the cell membrane is a purely quantal process involving absorption/emission of Josephson photon with large value of h_{eff}. The unexpectedly low dissipation indeed served as a partial motivation of Ling in his approach.

12.4.3 The Role Of ATP According To Ling And In TGD Framework

The notion of high energy phosphate bond and the real role of ATP in biology has been one of the long standing problems of TGD inspired biology. What is certainly clear is that ATP/ADP in which phosphate ion is transferred to the acceptor molecule is a fundamental process. Often this process is interpreted in terms of the transfer of metabolic energy and the view is that "high energy phosphate bond" carries the energy.

TGD inspired theory of consciousness however suggests a deeper meaning for ATP/ADP process.

(a) Negentropic entanglement serves in TGD Universe as a correlate for a conscious experience of understanding: negentropic entanglement (NE) (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) would be transferred in the process. The NE need not as such correspond to conscious experience but its presence makes possible conscious experience. Negentropically entangled systems would define what I have called "Akashic records", whose reading by interaction free quantum measurement (and idealized notion) would give rise to conscious experiences. "Akashic records" would be representations defining the reflective level of consciousness giving rise to memories, predictions, sensory and cognitive representations, etc [K29].

(b) My own view have been that ATP either carries and provides, generates, or induces a transfer of NE . I have considered all these options. The key observation is that negentropic entanglement is not a single particle property but characterizes the relationship between two particles. If ATP gives P to a particle B one would expect that B is one of the negentropically entangled particles in the final state. The other particle - call it A - must be negentropically entangled with P.

(c) The recent view about NE forced by Negentropy Maximization Principle [K64] is very simple and leads to a connection with dark matter hierarchy, p-adic physics, and quantum criticality [K64] [L20]. The NE which can result in quantum measurement is always maximal entanglement so that density matrix is proportional to unit matrix and correspond to a value of effective Planck constant equal to the integer $\hbar_{eff} = n\hbar$ telling the number of the entangled states. NE is a prerequisite for an experience defining abstraction about the rule having as instances the state pairs appearing in the entangled state. Note that the state pairs are not unique since any unitary transformation acting in the same manner to the two entangled state basis is allowed.

(d) In the recent case this would mean that P and A at the ends of the exchanged flux tube $A---P$ must have NE characterized by integer n and that the flux tube $A---P$ associated with ADP in the initial state is associated with molecule B in the final state. The transfer of NE is indeed in question. The exchange of the flux tube $A---P$ can take place using reconnection process as the basic process.

(e) NE is conjectured to have as a correlate the braiding of the flux tubes connecting the entangled systems. Does this conjecture survive in the recent case? The flux tubes connect two partonic 2-surfaces at the boundary of causal diamond (CD). The space-time correlate for $\hbar_{eff} = n\hbar$ is the analog of n-sheeted Riemann surface. At the partonic 2-surfaces the sheets co-incide. Is it possible for the 3-D projections of the n sheets of single flux tube to become braided (linked and knotted)?
If closed flux loops associated with A and B reconnect to form a *pair of* flux tubes connecting them (as suggested above) one has two alternative reconnections and one of them is uniquely selected by the conservation of flux. The first has minimal braiding and second one does not. Therefore two-tube connections do not guarantee that NE always corresponds to non-trivial braiding.
The following argument assigns the braiding to *single* flux tube.
   i. TGD also predicts another kind of braiding assignable to the ends of string world sheets at which the solutions of the Kähler-Dirac equation are localized by the conditions that electric charge as spin-like quantum number is well defined for them (eigenstate property). The string ends at the 3-D light-like orbit of the partonic 2-surface define a braid and the other ends of strings at other partonic 2-surfaces get braided during time evolution so that space-like braidings are generated.
   ii. The strings seems to be in a natural 1-1 correspondence with magnetic flux tubes defining their cores. If this is the case the braiding for strings corresponds to the braiding for flux tubes idealized with infinitely thing strings. For $\hbar_{eff} = n\hbar$ one should have a light-like braiding of the ends of strings assignable to different sheets of the n-fold covering at the orbit of partonic 2-surface and this braiding would induce the space-like braiding.

It must be admitted that the connection between braiding and negentropic entanglement remains an attractive conjecture at this moment.

What does the transfer of NE mean metabolically?

(a) As already noticed, Ling does not believe that energy is transferred in this process and "high energy phosphate bond" is certainly a questionable notion. I tend to believe that also energy is transferred as well but the open question is where it comes from. One can argue that the energy is needed to overcome the potential wall separating the states distinguished by different braidings.
Remarks:
   i. Four-dimensional spin glass property of TGD Universe gives rise to a fractal energy landscape and different valleys could be characterized by different braiding structures and phase transitions changing these structures would lead from a valley to another one.
   ii. Spin glass property means breaking of ergodicity. In a phase transition from resting state to activated state a large number of these transitions would occur and ATP $\rightarrow$ ADP transferring the entanglement would also involve the extracting of energy from some magnetic body to overcome the potential wall.

(b) There is a large number of candidates for the carrier of the energy and Ling's findings about metabolic deprivation suggest that several magnetic bodies can in principle provide the metabolic energy. The energy could be assigned to a population inverted cyclotron BE condensate at the magnetic body of P, ATP, the flux tube AP, or a larger system containing ATP.
Ling introduces permanently unfolded proteins as a special system and the magnetic body of single unfolded protein or even the system defined by them could be the carrier of the cyclotron BE condensate. One could imagine that under normal circumstances the magnetic body assignable to ATP or a system containing it provides the metabolic energy but under metabolic deprivation (as cells in Ling's experiment [I67]) the metabolic energy could be extracted from some other magnetic body. One can compare ATPs with jam jars in the refrigerator: when the jam jar becomes empty, the jam jars in the cellar can come to the rescue. This would require the generation of magnetic flux tube contact to the bigger energy storage using reconnection mechanism and tuning of flux tube strength and would require some time.

(c) I have proposed that in photosynthesis solar photons excite the cyclotron BE condensate of electron Cooper pairs at the magnetic flux tubes of some system. This conforms with the idea that magnetic bodies serve as energy supplies and that the motion of the system defined by magnetic body and biological body is basically transformation of cyclotron energy to kinetic energy, chemical energy, heat and other forms of energy needed by the visible part of the organism. TGD assigns to electron with standard value of Planck constant a causal diamond (CD) with a size, which corresponds to 10 Hz frequency defining a fundamental biorhythm. This would conform with the fundamental role of electrons in metabolic energy storage. There are of course many details to be filled in but this picture looks to me very attractive.

12.4.4 Ling's Theory From The Perspective Of TGD Inspired Theory Of Consciousness

Ling formulates his theory using ***only the notions of biochemistry and thermodynamics*** . This means taking a risk since it is not at all obvious that these notions are enough for understanding life. My personal conviction is that one cannot really understand life without a theory of consciousness. Ling ends up with the notions natural in TGD inspired theory of consciousness but a proper justification of these notions remains lacking because it is simply impossible in the conceptual framework used. Basic problem is of course the non-locality of association process having no description in standard biochemistry.

One can indeed interpret the ATP/ADP process also from the point of view of TGD inspired theory of consciousness from ***purely quantal perspective*** , and I have already discussed the interpretation of the process as a ***transfer of negentropic entanglement.***

(a) Flux tubes serve as correlates for attention and ATP serves as re-orientation of the attention by inducing reconnection process. In the transition $A - -C\&B - - - D \rightarrow A - - - D\&B - - - C$ by reconnections the attention of A is directed from B to C and attention of B from D to A.
Note: Is direct attention really asymmetric with respect to A and B? Could attention be symmetric at the fundamental level? Is the "directed" only due to the fact that A is responsible for the variation of flux tube thickness in order to get in tune. The belief that I am aware of the presence of some system but not vice versa might indeed be an illusion: the other system could also be aware about my presence, even in the case that I regard it as "inanimate". It might be however possible to tell which of the two systems performs magnetic motor action generating flux tube connection (by tuning the field value so that reconnection takes place). This argument applies even to the ordinary sensory perception. The conservation of the signed magnetic flux assigns an arrow to the flux tube and gives precise selection rules: the magnitudes of the fluxes are same for reconnected flux tubes of and also signs so that only one reconnection instead of two is possible.

(b) Ling's model assigning different roles to permanently unfolded proteins and folded proteins in resting state has a nice interpretation in TGD context. ATPs are attached to the permanently folded proteins in the resting state. The unfolded protein A would be connected to the phosphate P of ATP by flux tube, and one could say that protein A directs its attention to ATP. The permanently folded proteins would be like guards of a bastion in a permanent wake-up state. In resting state the folded proteins would "sleep".

(c) As the system is activated, the flux tube connection A—PB is generated and one can say that A directs its attention to B, which could be ion, other protein, or some invader molecule. If A has the role of guard, one can expect that A can control the thickness of the flux tubes of its magnetic body and in this manner tune to detect the presence of other molecules. Therefore the system of unfolded proteins could define the part of cell which is in permanent wake-up state and monitors the state of the cell. Activation would wake up and unfold the folded proteins and the cell would be in a kind of alarm state as long as external perturbation lasts.

12.5 Capacitor-Like Josephson Junctions As Systems With Large h_{eff}/h?

Both Tesla coil and magnifying transmitter can be regarded as a pair of systems in which primary drives secondary system with resonant frequency so that energy is transferred to the secondary. Primary has air gap which acts as a switch. Above a critical voltage about 10 V in the air gap a di-electric breakdown occurs and current runs through the gap. What is remarkable is that the duration of the breakdown period is few milliseconds: this is the time scale for the nerve pulse and suggests an analogy with cell membrane which is also a system with ultrahigh voltage between the plates of a capacitor-like system defined by the two lipid layers of the cell membrane. Also the secondary coil, which can be regarded as a plate of capacitor with Earth defining the second plate, develops local di-electric breakdowns seen as "mini lightnings". The analogy with cell membrane suggests that also these breakdowns are mathematically analogous to the generation of nerve pulse. The glossary of the introduction explains the basic notions related to Josephson junctions.

12.5.1 Cell Membrane As Josephson Junction

I have developed a model for cell membrane as Josephson junction leading also to a model of nerve pulse, and there is interesting to see whether the findings of Tesla could be understood in terms of this model.

(a) Cell membrane is assumed to be a Josephson junction in which a Josephson current

$$J = J_0 sin(\frac{Ze\int V(t)dt}{h_{eff}}) \tag{12.5.1}$$

is running. For a constant resting potential $V(t) = V_{rest}$ one obtains

$$J = J_0 sin(\omega t) \ , \ \omega = 2\pi f_J \ . \tag{12.5.2}$$

a current oscillating with the Josephson frequency

$$f_J = \frac{ZeV_{rest}}{h_{eff}} \ . \tag{12.5.3}$$

Z is the charge of the super-conducting charge carriers. Electronic Cooper pairs with $Z = 2$ are certainly involved and very probably also bosonic ions and Cooper pairs of fermionic ions. The Josephson currents run along super-conducting space-time sheets. $V(t)$ varies rather slowly. Josephson current generates dark Josephson photons with frequencies coming as multiples of f_J having interpretation in terms of EEG and its generalizations [K40].

The dominating contribution to the membrane voltage is constant resting potential. Besides this there is varying part reflecting various activities near cell membrane and the idea is that dark Josephson photons emitted by Josephson current communicate sensory information about these activities to the magnetic body.

(b) Without further assumptions one cannot predict the value of $h_{eff} = nh$. One can however end up with a prediction for h_{eff} by considering a more general situation in which the voltage containing time dependent part - briefly "AC part".

i. Suppose that this contribution is periodic with a period characterized by AC frequency f_{AC}. This does not mean that the AC part is of simple sinusoidal form but only that $V(t)$ is a superposition of harmonics of some fundamental frequency f_{AC} containing also a constant part defining the resting potential. The alternating part of voltage is expected to relate closely to cyclotron contribution to the membrane voltage so that cyclotron frequency f_c of electron, proton or some ion defines a good candidate for f_{AC} which would depend on cell. Neglecting nuclear binding energies the cyclotron frequencies of ions in given magnetic field are subharmonics of proton's cyclotron frequency.

ii. The natural assumption is that in dynamical equilibrium the periodicity of Josephson current is that of the alternating current. This gives as the first guess the condition

$$f_J = f_{AC} \tag{12.5.4}$$

One can also consider also sub-harmonics:

$$f_J = \frac{f_{AC}}{l} \quad , \quad l = 1, 2... \tag{12.5.5}$$

so that Josephson radiation would be seen as master and cyclotron radiation as slave. This condition fixes the value of h_{eff}:

$$\frac{h_{eff}}{h} = l \times \frac{ZeV_{rest}}{hf_{AC}} = n = 1, 2, ... \quad , \quad l = 1, 2, .. \ . \tag{12.5.6}$$

From this formula one can readily calculate the value of h_{eff} assignable to say EEG frequencies and integer valuedness of h_{eff}/h fixes the spectrum of EEG frequencies and implies that this spectrum can be regarded as union of sub-harmonics of maximum frequencies f_{max} such that each sub-harmonic corresponds to its own value of h_{eff}. The cyclotron frequencies of various ions in given magnetic field correspond in first approximation to various values of n in above equation and by small tuning of the magnetic field strength associated with flux tubes carrying particular kind of ions the same formula applies to all ions.

iii. For $f_{AC} = f_J$ option the value of h_{eff} would be completely fixed by the periodic perturbation and the system produces dark photons with harmonics of Josephson frequency. For more general option $\hbar_{eff}$ is divisible by integer l which would naturally relate to p-adicity with p-adic prime appearing as a factor of l. The results is rather powerful and gives the long sought for quantitative grasp about the hierarchy of effective Planck constants.

(c) The integer quantization of h_{eff}/h implies that the resting potential of the cell membrane obeys integer quantization for given value of l and that the changes of the membrane potential correspond to quantized change of the charge of the effective capacitor from $Q = CV$. The resting potential of the cell membrane is indeed known to be quantized. The unit for the resting potential is known as miniature end plate potential (`http://tinyurl.com/y8czhhpm`) of order $\Delta V = .5$ mV to be compared with the resting potential of order 60 mV. This would give $\Delta h_{eff}/h_{eff} \sim 1/100 = \Delta n/n$ if neither l nor f_{AC} changes. The changes of h_{eff} would be of order one per cent.

I have made a conjecture that the phase transitions changing h_{eff} are such that $h_{eff}/h = n$ is replaced with its factor. In this case the change of h_{eff} is large and cannot apply in the case considered. h_{eff}/h can be kept however constant if the change $l_i \to l_f$ compensates the change of V_{rest} so that one would have

$$\Delta \frac{V_{rest}}{V_{rest}} = \frac{l_i}{l_f} - 1 \simeq -\frac{\Delta l}{l} \quad .$$

l is however expected to be rather small integer on basis of the model of EEG so that Δl need not compensate small changes of V_{rest}. h_{eff}/h remains also invariant if V_{rest} and magnetic field defining cyclotron frequency can scale in the same manner. This follows from the basic conditions automatically. If neither l or B is changed then a phase transition satisfying $\Delta n/n < 1$ must occur and proceed via a transition to an intermediate state with $h_{eff} = h$ - that is ordinary matter.

12.5.2 Quantization Of The DC Voltage Of Capacitor From The Quantization Of Charge

For a given value of $f_{AC} = lf_J$ the formula for h_{eff}/h implies quantization of the capacitor voltage. The quantization of the voltage of a capacitor follows also from the quantization of charge implying $\Delta Q_{min} = e$ as the minimal change of charge. This gives a condition on the AC frequency f_{AC}:

$$\Delta(\frac{h_{eff}}{h}) = l\frac{Ze\Delta V_{min}}{hf_{AC}} = lr\frac{Ze^2}{Chf_{AC}} = k \ . \tag{12.5.7}$$

Here r is the number of elementary charges in the pulse changing the voltage. If this condition is assumed to hold true for all values of l and r, one can conclude that

$$\frac{Ze^2}{Chf_{AC}} = s = 1, 2, ... \ . \tag{12.5.8}$$

and that s divides k. This is true for any k for $s = 1$. This would give a quantization condition for $\lambda_{AC} = c/f_{AC}$:

$$\begin{aligned} \lambda_{AC} = \lambda_{min} = \frac{\hat{C}}{2Z\alpha} \ , \quad \alpha = \frac{e^2}{4\pi\hbar\epsilon_0 c} \simeq 1/137 \ . \\ \hat{C} = \frac{C}{\epsilon_0} \ , \qquad \epsilon_0 = 8.854 \times 10^{-12} F/m \end{aligned} \tag{12.5.9}$$

Equivalently, one would have

$$f_{AC} = f_{max} = \frac{c}{\lambda_{min}} = \frac{2Z\alpha c}{\hat{C}} \ . \tag{12.5.10}$$

λ_{AC} as the minimum wave-length is therefore dictated by capacitance. In biological applications $f_c = f_{max}$ follows.

Before discussing concrete examples note that C is expressed using Farad as unit: micro-, nano-, and picofarad are more natural units. $\hat{C}$ having dimension of length makes manifest the geometric meaning of C. The allowed values of f_{AC} must come as sub-harmonics of the maximum frequency determined completely by the capacitance.

(a) For a plane capacitor one has

$$\hat{C} = \frac{\epsilon_r A}{d} \ . \tag{12.5.11}$$

Here $\epsilon_r = \epsilon/\epsilon_0$ is the relative permeability, and A and d are the area of the plate and d the distance between them. For $\hat{C} = 1$ m one has

$$\lambda_{min} \simeq \frac{\hat{C}}{m} \times 67.5 \ , \quad f_{max} \simeq \frac{1}{\hat{C}/m} \times 4.4 \times 10^6 Hz \ . \tag{12.5.12}$$

(b) This gives strong bound on the capacitance. For instance, in the experiments of Tesla f_{AC} is in the range $20 - 100$ kHz. For $f_{AC} = f_{max}$ the corresponding range for $\hat{C}$ is 1.15 mm-0.23 mm. For $f_{AC} = f_{max} = 10$ kHz one would have $\hat{C/m} \simeq 2.30$ mm.

(c) Kennelly-Heaviside layer has thickness $d = 90 - -150$ km and be approximated as a spherical capacitor with

$$\hat{C} = \epsilon_r \times \frac{4\pi R^2}{R - \frac{R^2}{R+d}} \simeq \frac{4\pi R^2}{d} = \frac{A}{d} \ . \tag{12.5.13}$$

In this case one has $f_{max} \simeq 19$ minutes.

12.5.3 Constraint On Cyclotron Frequency

The TGD inspired model of EEG [K40] suggests that f_J assignable to the neuronal membrane is around 5 Hz. This would suggest that it is second sub-harmonic of an ionic cyclotron frequency around 10 Hz (say that of Mg^{++}) or the third sub-harmonic of cyclotron frequency of Ca^{++} equal to 15 Hz. This would support the formulas

$$f_J = \frac{f_c}{l} \quad , \quad f_c = f_{max} = \frac{2Z\alpha c}{\hat{C}} \quad . \tag{12.5.14}$$

Through these equations the field values at magnetic flux tubes, cell membrane potential, and the shape and size of cell membrane would be in tune. This constraint relates cyclotron frequency and therefore the value of the magnetic field at given flux tube to the capacitance. In terms of the magnetic length $L_B = \sqrt{h/eB}$ this gives rise to the following equivalent correspondences

$$\begin{aligned} L_B &= \sqrt{\frac{r_C \hat{C}}{\alpha} l} \ , \\ \hat{C} &= \frac{\alpha}{l} \frac{L_B^2}{r_C} \ . \end{aligned} \tag{12.5.15}$$

Some numerical correspondences are helpful in quantitative estimates. $B = 1$ Tesla corresponds to magnetic length $L_B \simeq 64.3$ nm, and capacitance of 1 Farad to the "capacitance length" $\hat{C} = 1.1 \times 10^{11}$ m. Compton length for electron is $r_C \simeq 2.43 \times 10^{-12}$ m.

Some comments from the point of view of the model of cell membrane as super conductor are in order.

(a) The effects of ELF radiation on vertebrate brain suggest the presence of endogenous magnetic field with field strength $B \simeq 2B_E/5$, where $B_E = .5 \times 10^{-4}$ T is the nominal value of the Earth's magnetic field with magnetic length $L_B = 14.4$ μm. For electron the corresponding value of $\hat{C}$ would be $\hat{C} = .62$ m for $l = 1$. For large neurons with radius of order 10^{-4} m one has $\hat{C} \simeq 12.6$ m^2 for $l = 1$. For $l > 1$ the proportionality $\hat{C} \propto 1/l$ however allows smaller cell sizes.

(b) For proton and ions $\hat{C}$ would be obtained by scaling down the electronic $\hat{C}$ by the mass ratio $m_E/Am_p \sim 2^{-11}/A$, A the mass number of nucleus. For proton one would have $\hat{C} = 3.3 \times 10^{-4}$ m and for Ca^{++} ion with mass number $A = 40$ one would have $\hat{C} \simeq 1.3$ μm, which corresponds to the length scale of cell nucleus and could characterize nuclear membrane as capacitor.

(c) Somewhat unexpectedly, ions would correspond to a capacitor assignable to nuclear membrane whereas electron would correspond to size scale of large neuron. Alternatively large value of l could allow smaller cell sizes. Electron could also correspond to a multicellular system behaving effectively as a single capacitor by quantum coherence. DNA double strand and its subsystems might also correspond to the capacitor-like systems involved with both electrons, protons, and ions.

12.5.4 What About More General Capacitor-Like Systems?

There is a temptation to assume that the situation for the air gap of Tesla coil and for the capacitor formed by the secondary and Earth is same as for the cell membrane except that the DC voltage is replaced with AC voltage. The generalization might apply quite generally to any capacitor-like system.

(a) Now electronic and possibly also protonic Cooper pairs with large $\hbar_{eff}$ would be the current carriers. Josephson currents would be present all the time. Dielectric breakdown would be analogous to nerve pulse. The analog of the membrane potential would be defined by the voltage associated the Earth's electric field $E_E \simeq 100$ V/m unless DC voltage is present. Note that the orientation of the capacitor with respect to the Earth's electric field matters. This would define Josephson frequency in absence of other currents and one would have Josephson current even for an ordinary capacitor with frequency $f_J = ZeV/h_{eff}$. Same conditions would apply to f_J and f_{AC} as for cell membrane system. Only V_{rest} would be replaced with V_E so that one would have

$$\frac{h_{eff}}{h} = \frac{ZeV_E}{hf_{AC}l} = n \quad , \quad l = 1, 2.2, ... \quad , \quad n = 1, 2, ... \quad . \tag{12.5.16}$$

for the space-time sheet along which the Josephson current runs. The value of effective Planck constant is therefore completely fixed! Rather remarkably, the proposed amplitude modulation mechanism predicts exactly the same value $\frac{h_{eff}}{h}$ as ratio of Josephson frequency for ordinary Planck constant and of AC frequency and it might be possible to regard the two mechanisms as equivalent.

(b) If *all* capacitor-like systems carry a small oscillatory Josephson current satisfying $f_J = f_{AC}$ ($l = 1$ in more general formula) in presence of AC current, one could assign to a capacitor a unique value of h_{eff} depending on it orientation with respect to Earth's electric field. This would predict production of dark photons with the AC frequency and its harmonics. Also a capacitor added to DC circuit would carry a small dark Josephson current but now one cannot predict the value of h_{eff} as found in the beginning. This indeterminacy would conform nicely with the quantum criticality of TGD Universe: a small periodic perturbation would fix the value of h_{eff}. The new physics might be present in ordinary AC circuits and might relate to the poorly understood $1/f$ noise in electric circuits. Dark Josephson currents and probably also supra currents would be present in ordinary circuits and one might imagine building a technology based on this new form of high T_c superconductivity.

(c) By introducing to the Josephson potential constant part artificially, one can increase the value of h_{eff}/h and cell membranes have indeed done just so.

12.5.5 What $F_J = F_{Ac}/L$ Condition Implies For Earth's Electric Field?

As argued, if the situation is analogous to asymptotic self-organization pattern, the Josephson current must be periodic having the same periodicity as the external AC voltage. This is guaranteed if $V_J(t)$ is a superposition of Fourier components coming in multiples of f_{max}.

(a) If this condition is satisfied and if the voltage $V(t$ contains a DC part - containing at least the contribution V_E associated with the Earth's electric field - to the Josephson voltage, then the condition $f_J = f_{AC}$ reads as

$$f_J = \frac{ZeV_E}{h_{eff}} = \frac{f_{AC}}{l} = \frac{f_{max}}{l} \quad , \quad f_{max} = \frac{2Z\alpha}{\hat{C}} \quad . \tag{12.5.17}$$

The value of h_{eff}/h for $f_{AC} = f_{max}$ would be given by

$$\frac{h_{eff}}{h} = \times \frac{eV_E}{hc}\frac{\hat{C}}{2\alpha l} = n \quad . \tag{12.5.18}$$

(b) This in turn poses a condition to $\hat{C}$. For a plane capacitor one has $\hat{C} = \epsilon_r A/d$. This formula applies in good approximation also to spherical capacitor. For a more general capacitor-like system - defined by say folded cell membrane or the neuronal membrane containing also axon and dendites - the capacitance can be parametrized as $\hat{C} = yA/d$. For $E_E = x \times 100V/m$ one $eV_E/hc = d \times x \times 10^2 eV/hc \times m^{-1} = d \times 1.24 \times 10^8 x \times m^{-2}$ and one obtains

$$\frac{h_{eff}}{h} = 1.24 \times 10^8 \epsilon_r xy \times \frac{A}{m^2}\frac{1}{2\alpha l} = n \quad . \tag{12.5.19}$$

This translates to a quantization condition for the area of the plane capacitor:

$$A = nl \times A_{min} \quad , \quad A_{min} \simeq \frac{118}{\epsilon_r xy}\ (\mu m)^2 \quad . \tag{12.5.20}$$

The size scale of the minimal capacitor is that of cell: in cell scale nk is small integer and therefore also n is near unity. That condition correctly relates the size scale of the cell to the magnitude of the electric field of Earth strongly suggests that both E_E and B_E have been key players in the evolution of life and also supports the vision about Kennelly-Heaviside layer as the analog of cell membrane.

(c) As discussed, also Kennelly-Heaviside layer with thickness $d \sim 100$ km can can be approximated as a spherical capacitor with $\hat{C} \simeq xA/d$. One obtains expression for nl from the expression of A as a multiple of A_{min} as

$$nl = \epsilon_r xy \times 4.56 \times 10^{24} \ . \quad (12.5.21)$$

The allowed values of n and l are huge. In the case of cell membrane the values of l would be however rather small. For the value of n corresponding ot $n \sim l$ one has $n \leq 2 \times 10^{12}$. The frequency of dark variants of visible photons with energy 2 eV would correspond to dark photon with frequency around 150 Hz, which is somewhat above EEG range.

12.5.6 Cell Membrane, DNA Double Strand, And Cortical Layers As Capacitor-Like Josephson Junctions

Earth's electric field E_E would not allow large h_{eff} Josephson photons generated by capacitor-like Josephson junctions with much larger size than that of cell. By previous arguments neurons can emit large $\hbar$ Josephson photons and the high value of the resting potential saves the situation: large h_{eff}/h as a prerequisite of intelligent life provides the answer to the question why strong voltages are needed in biology. The resting potential $V_{rest} = .06$ V is by a factor $x = V_{rest}/E_E d \simeq 6 \times 10^4$, $d = 10^{-8}$, stronger than that corresponding to E_E.

Cell membrane as capacitor

Using spherical capacitor as a model for the cell membrane as starting point in the parameterization of capacitances as $\hat{C} = yA/d$, the quantization condition deriving from quantization of elementary charges reads as

$$\begin{aligned} \frac{h_{eff}}{h} &= 7.44 \times 10^{14} \epsilon_r y \times \frac{A}{m^2} \times \frac{1}{2\alpha l} = n \ , \\ A &= nl \times A_{min} \ , \ A_{min} \simeq \frac{20}{\epsilon_r y} \times (nm)^2 \ . \end{aligned} \quad (12.5.22)$$

A scale of about 5 nm defines the size scale of the minimal capacitor. $n \sim 2^{16}$ is possible even for the size scale of cell nucleus.

For a large neuron with size scale of 10^{-4}m one obtains $h_{eff}/h \sim 10^{10}$. The area of cell membrane can be increased by folding and cell interior is indeed filled with a folded membrane. This allows even larger value of h_{eff}/h at neuronal level. Therefore one can understand the required large values of h_{eff}/h and a direct correlation between the evolutionary level measured by h_{eff}/h and cell size scale and total membrane area is predicted.

DNA double strand as capacitor?

Each DNA nucleotide carries two units of negative charge. Could one somehow assign a pair of cylindrical surfaces with the highly coiled DNA double strand and describe it as a cylindrical capacitor? Where are the positive charges? Are positive charges associated with Earth identified as a cylindrical surface around DNA with radius of order $L(151) = 10$ nm defining the radius of the chromosome? And is the idealization as a perfect conductor meaning constant charge distribution at the coiled inner cylindrical surface and outer chromosome surface really justified?

In any case, the capacitance of co-axial cable is given by

$$\hat{C} = \frac{2\pi\epsilon_r \times L}{log(R_2/R_1)} \quad (12.5.23)$$

is good approximation for the capacitance of the system if it behaves as a conductor. $\hat{C}$depends linearly on length L. Similar formula is expected to apply in the first approximation also to the coiled DNA strand defining chromosome. The value of h_{eff}/h would increase as the total length of DNA strand increases during evolution: for human DNA the length is about $L \sim 1$ m. The linear charge density per unit length is for double strand $4e$ per nucleotide pair

and makes $6e/nm$ so that the total charge is $6eL/nm$ and about 6×10^9 for human DNA. $R_1 = 1$nm and $R_2 = 10$ nm are reasonable first estimates.

The expressions for various parameters are

$$\begin{aligned} \hat{C} &= \frac{2\pi\epsilon_r \times L}{log(R_2/R_1)} \simeq 14.5\epsilon_r L \ , \\ f_{max} &= 2Z\alpha \times log(\frac{R_2}{R_1}) \times \frac{c}{2\pi\epsilon_r \times L} \simeq 3.2\ MHz \ , \\ \frac{h_{eff}}{h} &= n = \frac{24\pi}{l} \times (L/nm) \simeq \frac{1}{l} \times 75.4 \times (L/nm) \ , \\ L &= nlL_{min} \ , \ L_{min} = \frac{1}{24\pi}\ nm \simeq .13\ Angstrom \ . \end{aligned} \tag{12.5.24}$$

For $L = 1$ m (of the order of the total length of human DNA) one obtains $h_{eff}/h \simeq .75 \times 10^{11}/l$. Cyril Smith [J7] claims that for water memory frequency ratio $f_h/f_l = 2 \times 10^{11}$ is special: this ratio corresponds in TGD framework to h_{eff}/h [K50]. $L_{min} \simeq .1$ Angstrom means that non-standard values of Planck constant can be important already for the shortest possible DNA strands. f_{max} is of order MHz and for largest possible values of l ($n = 1$) $f_J = f_{max}/l$ is or order 10^{-5} Hz: $n = l$ gives $f_{max} \simeq 10$ Hz which is perhaps not an accident.

Also proteins are charged (the sign and magnitude of the charge depends on pH of the environment) and this suggests that also they define capacitor type Josephson junctions.

Cortical layers as Josephson capacitors

TGD Universe is fractal and therefore a highly attractive idea is that also the highly folded layers of various brain areas correspond to capacitor-like systems acting as Josephson junctions. Also the six cortical layers- decomposing to cortical columns of radial size scale of order mm would correspond to Josephson junctions but in smaller length scale. The hierarchy of Planck constants would thus make itself directly visible in the structure of brain.

The total area of cerebral cortex (`http://tinyurl.com/yabvl2gs`) is about.25 m^2. For $A = .25$ m^2 - possibly making sense for the highly neural circuits associated with the highly folded membrane-like structure defined by cortical layers - one would have $nl = 1.25 \times 10^{14} \times (\epsilon_r/1.18)$ so that $h_{eff}/h = n \leq 1.5 \times 10^{14}\epsilon_r$ holds true. The frequency of a dark variant of 2 eV visible photon would be about 40 Hz for $\epsilon_r = 1$. This happens to be the celebrated thalamo-cortical resonance frequency (`http://tinyurl.com/8vt8pzu` suggested to be an important correlate for consciousness.

This estimate can be criticized since the value of the voltage is taken to be the resting potential. 10-20 mV is the typical value of the oscillating EEG potential (`http://tinyurl.com/2mapqg`) when measured from subdural electrodes and one expects that the constant part has magnitude which is larger: in the case of cell membrane by a factor of order 100. If the ratio is same in the scale of cortex, one would have "resting potential" of order 1.2-2-4 V which is by a factor 50-100 higher than resting potential. The average thickness of human cortex is 2.8 mm - largest for mammals but for mouse (2.2 mm) larger than for macaque (1.7). In the Earth's electric field $E = 100$ V/m the maximum voltage difference over is 0.28 V of this distance which would be roughly twice the nominal value.06 V of the resting potential. Interestingly, the thickness of cortex is known to be thicker for meditators (`http://tinyurl.com/25rncxg`) [J15]: in principle this means larger value of h_{eff}. One can wonder what happens when the local section of (folded) cortical layer is not orthogonal to the Earth's electric field. If cortical layer behaves as an ideal conductor, the surface charges should arrange the situation in such a way that the voltage is same along cortical layers and that the orientation of head does not matter.

The quantization of capacitance basically due the quantization of elementary charges and $f_J = f_{AC}/l$ condition is rather strong. Cell membrane is however able to change its shape and could find a shape in which the condition is satisfied.

Artificial life?

The above considerations inspire the question about a recipe for building primitive life forms. Both magnetic and electric fields are needed. Concerning the electric part of the system the following recipe comes in mind.

(a) Take a capacitor-like system with as large area as possible and feed in electric field as sum of as strong as possible DC part and AC part. From charge quantization the frequency characterizing the periodicity of AC part must be subharmonic of a fundamental frequency expressible in terms of the capacitance. Capacitance itself and thus the area of capacitor is quantized too. In living matter the quantization rules require a flexible geometry. This might explain why living matter is "soft". Cell membranes can indeed vary their capacitance by deforming their shape. The frequency f_{max} identified as cyclotron frequency f_c in turn can be varied by varying the flux tube thickness. Maybe this kind of softness is required for artificial cells too. The resulting system is critical in the sense that it satisfies very strong quantisation conditions but state function for density matrix makes the system critical and thus gives excellent hopes for "self-organized quantum criticality".

(b) The inclusion of magnetic fields is certainly an essential element. In the case of cell membrane and DNA one assumes that flux sheets traverse through DNA double strand and cell membrane and also flux tubes connecting DNA and lipids are assumed. How couls the magnetic body be realized artificially? In Tesla coil secondary serves both as inductance and capacitor so that also magnetic body is present and is able to perform "motor actions" essential for generating reconnections. Here the identification $f_J = f_{AC}/l = f_{max}/l = f_c/l$ would give an additional constraint: $f_c = f_{max}$.

Remote metabolism and the question about simplest possible metabolic pathway

Remote metabolism suggests an extremely simple manner to produce ATP without the need for metabolic machinery and allowing to avoid production of free radicals causing molecular damage. This mechanism could explain the reported ability to survive without nutrition described in the introduction [I30, I19].

(a) Drop out all initial steps of the oxidative phosphorylation appearing in both photosynthesis and cell respiration (`http://tinyurl.com/2cfx4x`), and replace the last step involving formation of ATP using ATP synthase (pumping protons against membrane resting potential) with much simpler process.

(b) The final step in oxidative phosphorylation involves dropping of 4 protons through the cell membrane. The liberated electrostatic energy goes to ATP as it is formed. The electrostatic energy ZeV_{rest}, $E = eV_{rest} \simeq .06$ eV depends on the charge Z of the charged particle only. One can therefore imagine several basic units: two Cooper pairs of protons, two Cooper pairs of fermionic ions or two doubly charged ions such as Ca^{++}, and electron Cooper pairs moving in opposite direction through the membrane could liberate same energy to be used to build ATP. One could even say that resting potential defines fundamental metabolic energy quantum.

(c) The loading of metabolic batteries could take place by remote metabolism in very simple manner: charged particles with charge $\pm 2e$ send negative energy Josephson photon energy $E = -2eV_{rest}$ to some magnetic body and in this manner gain opposite energy as a recoil energy and is pumped to the other side of the membrane.

(d) Note that the fundamental energy quantum would be about.06 eV. Metabolic energy quantum has nominal value of.5 eV. This process would not therefore use dark variants of visible photons (decaying to bio-photons) but dark variants of infrared photons decay to IR counterparts of bio-photons. A killer test for the proposal could be a check whether IR analogs of bio-photons with these energies exist.

Absorption of photons at Josephson frequency is obviously a very primitive manner to receive metabolic energy. What about photosynthesis? Could it rely on the absorption of visible photons at Josephson frequency kicking ions to the other side of the photo-receptor membrane,

dropping back spontaneously and transferring their electrostatic energy to the electrons in the electron transport chain? This would eventually lead to the kicking of four protons (or two proton Cooper pairs) through the membrane and generation of ATP? Photosynthesis would transform solar photons as natural metabolic energy quanta assignable with near vacuum extremals to the IR metabolic energy quanta. In [K12] and accompanying JNL article it is demonstrated that this kind of scenario can be considered.

(a) TGD suggests two possible states for cell membrane corresponding to far from vacuum extremals and near to vacuum extremals for Kähler action [K24]. For the latter one the Z^0 contribution to membrane potential would dominate and the energies of charged particles defined by membrane voltage are proportional to $Q_Z g_Z V_Z$. Basically due to the large isospin of nuclei the scaling of Josephson energies is large but the energies remain below visible range. If Weinberg angle is reduced from $p = sin^2(\theta_W) = .02397$ to $p = .0295$, the electrostatic energy differences over membrane for ions are scaled up to energies of visible photons for $V = .055$ eV [K24].

(b) The following argument demonstrates that the questionable assumption about Weinberg angle for near to vacuum extremals is actually un-necessary.

(c) From **Table 12.1** one indeed learns that for $p = .0295$ and $eV_{rest} = .055$ eV the Josephson energies for Na^+, Cl^-, K^+ and Ca^{++} for near to vacuum extremal using eV as a unit are 2.2, 2.74, 3.07 and 2.31. The peak energies for red, green, blue and white light are 2.19, 2.32, 3.06, and 2.49 eV respectively. For ordinary value of Weinberg angle given by $p = sin^2(\theta_W) = .23$, the energies are below visible energies, and this motivated the hypothesis that Weinberg angle is different for near to vacuum extremals. This hypothesis can be criticized.

(d) In the earlier version of the model I however failed to notice that it is Cooper pairs of fermionic ions rather than ions that must be the charge carriers. 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 and these energies could correspond to peak energies for visible photons. Therefore there is no need to make the questionable assumption $p = .02397$ nor to assume that instead of fermionic ions one has their exotic bosonic counterparts allowed by the nuclear string model [K67]. For electron the Josephson energy would be scaled by a factor $-1+1/2p$ to $E(e) = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_(\nu) = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E(p) = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E(n) = V_{rest}/2p = 2.086 \times V_{rest}$.

Could photo-reception (`http://tinyurl.com/6z7883v`) in rods and cones and photosynthesis be initiated by the same first step - a resonant absorption of visible photon by a ionic Cooper pair at its Josephson frequency and kicking it through photosystem II (`http://tinyurl.com/ydfxrmcu`) part of thylakoid membrane, which would therefore be near-to-vacuum extremal? If thylakoid membranes are near to vacuum extremals, the Josephson energy of proton Cooper pairs would: $E_J = 2eV_{eff}$, $eV_{eff} = (3 - x) \times eV_{thr}$, $x = 1/2p$. For $eV_{thr} = .044$ eV favored by the considerations of [K12] this would give $eV_{eff} = .040$ eV. This happens to be just the nominal threshold potential for sensory receptors. After the absorption the energy of photon would be transferred to electron transfer chain in far from vacuum extremal region of the thylakoid membrane.

Remote metabolism for visible photons would mean the transfer of ion through thylakoid membrane inside photosystem II induced by sending of negative energy photon. One can wonder whether plants could make photosynthesis more effective by by emitting long wave length dark photons received by a source of visible light. Similar mechanism would make possible active vision.

12.5.7 Further Comments

The model deserves some further comments.

(a) It should be made clear that the basic assumption $f_J = f_{AC}/l = f_c/l$ is perhaps un-necessarily strong. The idea that Josephson voltages and "alternating voltages"

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 12.1: 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.

assignable to cyclotron BE-condensates are in resonant interaction requires only $f_J = (k/l)f_c$, where k/l is small rational. It is however easy to generalize the above estimate by replacing l with k/l.

(b) The above arguments lead to a possibly new mechanism producing dark photons and allowing a control of the value of $\hbar_{eff}/\hbar$ in terms of periodic perturbation of DC voltage. Also very tight conditions on system parameters, such as for allowed values of f_{AC} follow and the charge of the charge pulse follow. I have proposed also amplitude modulation as a mechanism of production of dark photons. In this case one modulates high frequency (f_h) em field with low frequency (f_l) em field and the value of h_{eff}/h is simply the ratio of frequencies: $h_{eff}/h = f_h/f_l$. The mechanism requires that the frequency ratio is integers. The two mechanisms make the same prediction but it is not clear whether one should regard them as equivalent.

(c) Especially fascinating is the consistency of the resulting picture with the vision about cell membrane and even larger structures of brain as plane capacitor -like Josephson junctions maximizing their area to maximize the values of h_{eff}/h. This would give direct quantitative grasp to evolution as increase of h_{eff}/h.

(d) The model provides a quantitative formulation of an old vision. Already more than fifteen years ago I talked about a fractal hierarchy of super-conductors and Josephson junctions [K76] of which the cell membrane is only one representative. I proposed that even the region between ionosphere and Earth's surface could be analogous to cell membrane and that lightnings are analogous to nerve pulses. It was however not possible to concretize the idea at that time. Now the situation has changed.
Kennelly-Heaviside layer of thickness about 150 km could have interpretation as the analog of cell membrane. The analogy with cell membrane as Josephson junction goes actually further. Kennelly-Heaviside layer decomposes to two layers with thickness of order 80 km: the lower one corresponds to atmosphere. 172 km corresponds to the thickness assignable to the electron Compton scale $L_e(239)$, which corresponds to the next Gaussian Mersenne prime after $L_e(167) = 2.5$ μm defining the size scale of cell nucleus. Therefore $L_e(237) = 86$ km would correspond to the thickness $L_e(149)$ of lipid layer and 176 km to the thickness $L_e(151)$ of the lipid layer associated also with Gaussian Mersenne. Kennelly-Heaviside layer would be the analog of cell membrane and Earth

interior the analog of the cell interior in accordance with early speculations [K58, K56]. One can consider an alternative interpretation based on p-adic length scales $L(k)$ rather than scaled up Compton lengths $L_e(k) = \sqrt{5}L(k)$. The p-adic length scale $L(239)$ -as opposed to scaled up electronic Compton scale $L_e(239) = \sqrt{5}L(239)$ is 78.7 km - 20 per cent smaller than 100 km. Remarkably, also M_{241} is Gaussian Mersenne and corresponds to the scale L(241) which equals to 157.4 km. The two kinds of tectonic plates (continental and oceanic) would be analogous to the lipid layers of cell membrane. Note that 78.7 km is rather precisely the thickness of the atmosphere above which there is ionosphere (see `http://tinyurl.com/lqr85j`) [F2]. The thickness of Kennelly– Heaviside layer (see `http://tinyurl.com/25ur2tl`) [F3] inside which radio waves used in terrestrial radio communications propagate, has thickness about 150 km which roughly corresponds to $L(241)$. Also the fact that continental litosphere (see `http://tinyurl.com/d96kw`) [F5] has typical thickness of 200 km ($L(239)$) whereas oceanic litosphere is 100 km thick ($L(237)$) fits qualitatively with the proposed formation mechanism of continental tectonic plates.

The first guess for the Josephson frequency would be as Schumann frequency $f_S \simeq 8$ Hz or at least a frequency which is of the same order of magnitude. From the knowledge of the magnitude of the electric field of Earth and from the value of Schumann frequency one can deduce the value of $\hbar_{eff}/\hbar$ associated with this system. The radial electric field of Earth is not constant and goes to practically zero within few kilometers. At the surface of the Earth it is about $E = 100$ V/m so that for 10 km height one has $eV_E < 1$ MeV to be compared with the membrane potential $eV_{rest} \simeq .06$ eV. The value of $\hbar_{eff}/\hbar = ZeV_E/f_S$ would be rather large of order $\hbar_{eff}/\hbar \sim 10^{19} \sim 2^{63}$.

(e) Tesla argued that the magnifying transmitter generated telluric currents, which could propagate in the scale of Earth. The skin depth for Earth estimated from the resistance which is $10^{10} - 10^{12}$ times that of copper is in the range 4-40 km and from $j = \sigma E$ it is clear that also telluric currents decay exponentially with distance travelled so that Tesla's claim cannot hold true in Maxwell's electrodynamics.

One can however ask whether the currents could propagate as dark currents along magnetic flux tubes. In this case the damping would be very small and one can imagine current circuits in the scale of entire Earth. Also Schumann resonances at dark flux tubes would have very high Q-value as opposed to ordinary Schumann resonances whose Q-value (`http://tinyurl.com/yabm8yu5`) is estimated to be about 4 so that one fourth of the energy of the mode is lost during one cycle of duration 1/7.8 seconds.

12.6 Mysteries associated with lightnings, ball lightnings and the electrosphere of Earth

Lightning and ball lightning are electrospheric phenomena involving several poorly understood aspects. Also the origin of the electrosphere of Earth is still a mystery. In the TGD framework it is possible to deduce information about magnetic and electric bodies of Earth (briefly MB and EB) by using empirical inputs and these phenomena.

12.6.1 Basic facts

The following summarizes the basic facts about ball lightnings, lightnings, and the Earth's electrosphere.

(a) Ball lightings are known to be real are not understood. Ball lightning-like phenomena can be created also artificially in microwave ovens using match. Matches contain organic material and this serves as a good hint.

(b) There is a New Scientist article, which gives a popular representation of ball lightings (`https://cutt.ly/0HkW59F`.

The theory of Cameron [D15] is mentioned in the article. The theory assumes that lightnings are essentially phenomena associated with the electromagnetic radiation field alone and neglects the fact that plasma is very probably involved. The theory relies on exact

solutions of Maxwell's equations and proposes that ball lightnings involve monochromatic electromagnetic fields which are knotted and linked making the field configurations topologically nontrivial. Both magnetic and electric field lines can be knotted.
This does not however imply topological stability since the linearity of Maxwell's equations implies that these field configurations are unstable. The finding that lifetime is long enough for microwave lengths does not conform with the fact that visible light is involved. Another theory mentioned in the article is by Boerner and proposes that lightning comes from another dimension. What this could actually mean, is of course a highly non-trivial question.

(c) The basic mystery is how ball lightning can survive for so long a time. An ordinary plasma ball is not expected to do so. This suggests that ball lightning obeys non-linear dynamics and is some kind of topological entity robust by their topological non-triviality.

(d) A very natural expectation is that ball lightning is a self-organizing system consisting of plasma which radiates. Self-organization requires energy feed. It could come as a Coulombic energy from the electric field of Earth through which part of the plasma of ball lightning has arrived.
Here one encounters a problem. The electric resistance of the atmosphere causes a dissipation of the energy so that the charged particles cannot accelerate to high energies. How could lightning avoid this?

(e) Two problems are always better than one. The second puzzle is that ordinary lightnings involve relativistic electrons and gamma rays [F7, F4] (for the TGD view of lightnins and related phenomena see [K24, K91, K12, K63, K108]). This is impossible in standard physics due to the already mentioned electric resistance of the atmosphere. Could ball lightning involve a new phase of matter, for which the dissipation is very small. Perhaps because it interacts very weakly with the ordinary matter of the atmosphere?

(f) The third mystery is that the surface of Earth carries a negative charge, which creates an electric field. This field is essential for the generation of lightning. The origin of this field is however not understood.

(g) There is also a fourth problem. Dark matter exists but there is no generally accepted theory of dark matter. All experiments trying to detect proposed candidates for dark matter particles (the particle physicist's way to solve a problem is to propose a new particle) have failed. There is of course also the mystery of life but it is better to stop here.

In the sequel a TGD based model for electrosphere is deduced by using various empirical inputs and the TGD based view about dark matter and the model of quantum biology inspired by it. A model, which allows us to understand these phenomena in the TGD framework, is developed. The model relies on the TGD based model of dark matter residing at the flux tubes of the magnetic body. The gravitational magnetic bodies of both Earth and Sun are important.The notion of the electric body of Earth as an analog of the cell membrane acting as a generalized Josephson junction is developed. Lightning and ball lightning would be associated with the analog of action potential.

12.6.2 The TGD view of ball lightning and other mysteries

What could TGD say about the mysteries associated with the Earth's electrosphere?

Dark matter in the TGD Universe

TGD predicts an entire hierarchy of phases of ordinary matter behaving like dark matter (and perhaps being the dark matter) in that they have very weak direct interaction with ordinary matter. These phases reside at the magnetic body (MB).

(a) The notion of MB distinguishes between Maxwellian and TGD based views about electromagnetism. The flux tubes of MB can carry monopole flux which makes them topologically stable. Ball lightning could involve a tangle of a monopole flux tube carrying plasma and thus highly stable topologically. In fact, practically all structures in the fractal Universe of TGD would involve this kind of tangles: also galaxies and stars.

(b) These phases are labelled by the value of effective Planck constant $h_{eff} = nh_0$, which can be larger than $h = n_0 h_0$. The estimate for n_0 is given by $n_0 = (7!)^2$.
The larger the value of h_{eff} the longer the spatial and temporal scales of quantum coherence are, and the lower the dissipation rate is. In particular, ohmic resistance is reduced. Also the very weak interactions with ordinary matter reduce ohmic resistance for charged dark matter particles.
$h_{eff}/h_0 = n$ has an interpretation as the dimension of algebraic extension of rationals assignable with a polynomial defining the space-time regions at fundamental level [L104, L105]. It measures algebraic complexity and one could even speak about universal IQ. MBs with large value of h_{eff} would naturally receive information from and control the ordinary matter and represent higher levels in the master slave hierarchy of self-organizating systems.

(c) The value of h_{eff} can be very large and one can assign it to the flux tubes mediating various kinds of interactions such as electromagnetic and gravitational, and even weak and color interactions.
Gravitational Planck constant $h_{eff} = h_{gr} = GMm/v_0$ introduced originally by Nottale [E1] is associated with flux tubes of a large mass M and particle with mass m. $v_0 \leq c$ is a parameter with dimensions of velocity and can have varying values. The gravitational Compton length is given by $\Lambda_{gr} = GM/v_0$ and does not depend on m: this reflects the Equivalence Principle. Also cyclotron energies $E_c = \hbar_{gr} eB/m$ are independent of m.
Gravitational flux tubes would play a fundamental role in the TGD based quantum gravitational view about living matter. In particular metabolic energy would be stored at gravitational magnetic flux tubes with length scales given by Earth size as energy of dark protons. The delocalization of the dark proton to the surface of Earth would reduce the magnitude of gravitational potential energy.
This gravitational potential energy would be liberated as metabolic energy in a transition $h_{gr} \to h$ implying delocalization of dark. A correct value of metabolic energy currency is predicted [L150] if dark protons appear as triplets: ATP mechanism indeed involves proton triplets. Also a new metabolic energy quantum assignable to electron triplets is predicted and there is evidence for its necessity from the fact that cilia do not have ATP machinery but certainly need metabolic energy.

Pollack effect in cellular scales

What would drive particles, say protons, from ordinary matter to the MB and how would this be visible as properties of ordinary matter? The Pollack effect is a possible answer.

(a) Pollack effect occurs in water bounded by a gel phase in presence of energy feed, for instance infrared (IR) radiation. Negatively charged regions, exclusion zones (EZs) are formed in water. They have a very high density of negative charge. As if every fourth proton of water would have left the region so that the effective stoichiometry is $H_{1.5}O$. Several exotic effects are associated with EZs.

(b) EZs love cleanness and eliminate impurities from their interior. This does not conform with the second law of thermodynamics and can be seen as evidence for the reversal of the arrow of time.

(c) As already noticed, the presence of gel phase and energy feed is needed to create EZs. This suggests that a primitive life form is in question. In biology both cell and DNA are basic examples of negatively charged regions which could be basically EZs.

The energies of particles indeed increase with h_{eff} as a rule as it is easy to verify by looking at some examples.

(a) The TGD explanation for the Pollack effect is that the energy fed to the system increases the value of h to $h_{eff} > h$ for the protons and makes them dark particles at the magnetic flux tubes MB. If gravitational MB is in question, quantum gravitation would become a key player in quantum biology. The quantum gravitational model explains besides metabolism also bio-catalysis [L150] and allows us to understand how DNA could act as a topological quantum computer [L155].

(b) The behavior of EZs suggests breaking of the second law of thermodynamics and therefore reversal of the arrow of time. In the TGD Universe the time reversal could occur in long scales at MB carrying phases with a large value of h_{eff}. The basic prediction of TGD inspired theory of quantum measurement (extending to a theory of consciousness) indeed is that the arrow of time changes in the ordinary state function reduction (SFR),"big" SFR (BSFR) as it is called in TGD. In "small" SFRs (SSFRs), which are counterparts for "weak" measurements, the arrow of time is not changed.

Pollack effect in the scale of Earth

The surface of Earth is known to be negatively charged so that Earth has an electric field.

(a) The electric field strength has a nominal value $V_E = 120$ V/m and varies in the range 100-300 V/m, as one can for instance learn from the excellent lectures of Feynman (`https://cutt.ly/OHkAWFs` or from Wikipedia `https://cutt.ly/PHkACG2`).
The number density dn/dA of unit charges e per unit area would be about $(137/4\pi)eV/m = (137/4\pi)10^8/m^2$ making one unit charge per area corresponding to the size of a large neuron about 10^{-4} m. This volume of water happens to have a mass about 1 Planck mass.

(b) The field extends to the height of about $h_E = 50$ km at which height the conductivity of the atmosphere is so high that the electric field vanishes in good approximation above this height. The voltage at this height is about $V_E = 5 \times 10^5$ V. There must be a layer of positive charge concentrated at this height and neutralizing in a good approximation the positive charge so that electrosphere would contain structure analogous o a pair capacitor plates. Note that ionosphere begins at height of a about 48 km.

(c) The origin of the Earth's electric field is not known but it is known to be relevant for life.

The fractality of the TGD Universe suggests that the Pollack effect can be realized also in the Earth scale. The dark part of the magnetic field of Earth involving monopole flux tubes could carry dark protons and possibly also other dark particles. This would create the electric field of Earth. One could see the biosphere as a living organism, Mother Gaia.

(a) If the Pollack effect takes protons to the (gravitational) MB of Earth, Earth becomes negatively charged and creates an electric field. One dark proton per size scale of a large neuron (water blog having roughly Planck mass) would be transferred to the (gravitational) MB of Earth.

(b) The energy of a unit charge received as it travels from the height of $h_E = 50$ km to the surface of Earth without ohmic resistance of 5×10^5 eV, which corresponds to electron mass. Electrons travelling from Earth upwards would gain relativistic energy in this field. Protons travelling downwards would gain the same energy. The photons radiated by accelerated electrons and protons would have gamma ray energies. This would explain the association of relativistic electrons and gamma rays to lightning.

(c) Most of the screening positive dark charge should reside at the height of about $h_E \sim 50$ km. The magnetosphere of Earth has a much larger size of about $10R_E$ at the day-side of Earth. This suggests that the densities of the dark charged particles (at least protons and electrons) sum up to zero at higher heights.
The natural option is based on the approximation that the space above h_E is a perfect conductor. In a perfect conductor the surface charge indeed prevents the penetration of the external electric field inside it.
The dark protonic charge from hydrogen bonds and possibly also dark electronic charge would basically screen the electric charge of Earth at higher heights of order Earth radius.

(d) What could the dark positive charge at the height h_E consist of? One could consider dark protons but also dark ions at the oppositely charged boundaries of the conductor. Dark ions play a key role in the TGD based view of quantum biology. They could be metal ions for which the valence electrons are gravitationally dark and at similar U-shaped vertical flux tubes as the dark protons of H bonds [L150].

Why just the height h_E?

(a) p-Adic length scale hypothesis $p \simeq 2^k$ [K59] favours Mersenne primes $M_k = 2^k - 1$ (k is prime) and their Gaussian analous $M_{G,k} = (1+i)^k - 1$. Could $h_E = 50$ km correspond to Gaussian Mersenne? The answer is negative. The corresponding p-adic length scale is proportional to $\sqrt{p} \propto 2^{k/2}$. The twin pair $(k_1, k_2) = (239, 241)$ defines a pair of Gaussian Mersennes. $M_{G,151}$ corresponds to cell membrane thickness $L(151) = 10^{-8}$ m and $L(239)$ is scaled by a factor $2^{44} \simeq 1.6 \times 10^{13}$ to $L(239) \simeq 160$ km, that is $3h_E$, $h_E = .5 \times 10^5$ km.

(b) The idea that Gaussian Mersennes define fundamental lengths is too beautiful an idea to be given up too easily. The ionosphere extends from 48 km to about 960 km. Thermosphere extends from 90 km to 500 km.
Could one think of a conductor-like structure with thickness $L(241) = 320$ km with boundaries at $h_E = 50$ km and $L(241) = 320$ km extending from $h_E = 50$ km to $h_{E,1} = 410$ km and having a vanishing total charge so that above this distance Earth would look negatively charged and carry electric field, whose strength would be scaled down from its value at the surface of Earth by a factor $(R_E/(R_E + h_{E,1})^2 \sim 1$.

(c) One can argue that this field would have been observed long ago so that the conducting region must extend much farther. Despite this objection, one can ask whether these layers could exist and correspond to membrane-like preferred extremals, which are minimal surfaces in $H = M^4 \times CP_2$. Note that the E^3 projection is not minimal surface but analogous to a soap bubble [L141]. Also the cell membrane would be accompanied by this kind of pair of surfaces and magnetic flux tubes would traverse it.

(d) TGD predicts that any astrophysical object necessary has a non-vanishing but arbitrarily small Kähler charge, which is accompanied by electromagnetic charge. The reason is that a long range gravitational field defined by the induced metric unavoidably implies a long range Kähler electric field.

(e) One can argue that this electric field would have been observed so that the conducting region must extend much farther. Despite this objection, number theoretic intuitions give the right to ask whether these layers could exist and correspond to membrane-like preferred extremals, which are minimal surfaces in $H = M^4 \times CP_2$. Note that the E^3 projection is not minimal surface but analogous to a soap bubble [L141]. Also the cell membrane would be accompanied by this kind of pair of surfaces and magnetic flux tubes would traverse it.

(f) If dark ions of opposite charges (perhaps as pairs of a dark metallic ion and valence electrons) reside at the proposed layers with the distance $L(241)$, they could correspond to dark ionic matter that I have assigned with the MB of Earth. As a matter of fact, one could say that they reside in the electric body of Earth defined by the boundaries of this conductor. Could this pair define the analog of the double lipid-layered cell membrane and could the Earth itself define the analog of a cell nucleus? DNA is negatively charged and is responsible for the negative charge of the cell nucleus and perhaps of the entire cell. What could this analogy suggest in the case of Earth?

In the TGD Universe, one can ask whether the Earth is a living organism, Mother Gaia as an analogy of a monocellular organism but in the scale of Earth.

(a) The capacitor plates would define the analog of a cell membrane having membrane potential 5×10^5 eV, which is 10^7 times higher than the membrane potential $V \sim .05$ eV and corresponds to electron rest mass. Also monocellulars can exhibit action potential and lightning would be its analog. Ordinary cells form dark (generalized Josephson junctions). For them ohmic currents are replaced with oscillating Josephson currents with Josephson frequency $f_J = eV/h_{eff} \simeq m_e v_0/GMm$.
One can also imagine a gravitational Josephson current defined by the gravitational potential of the Earth. In this case the energy scale is about eV. In the electric case it is 10^7 times higher.

(b) For $M = M_E$, $v_0 = c$ and $m = m_p$ this would give $f_J \simeq 10^5$ Hz, which is not far from the cyclotron frequency of electron in the endogenous magnetic field $B_{end} = .2$ Gauss deduced from Blackman's findings [J8] and identified as the monopole flux part of the Earth's magnetic field B_E with the nominal value .5 Gauss.

(c) Also solar gravitational MB is important in the model and the model of photosynthesis and ATP involves it in an essential manner [L150]. For Sun with $M_S \simeq 3 \times 10^5 M_E$,

$v_0/c \simeq 2^{-11}$ and $m = m_p$, Josephson frequency would $f_J \simeq 1$ Hz. This is the average value for DNA cyclotron frequency in B_{end}, which only weakly depends on the length of the DNA strands since the nucleotides have a negative unit charge.
Since the cyclotron transitions would be associated with dark ions with $h_{eff} = h_{gr,Earth}$ and f_J would correspond to Josephson radiation associated with $h_{gr,Sun}$, it would seem that Josephson radiation induces cyclotron transitions. This would be communication between solar and terrestrial levels of the dark matter hierarchy? Could solar level control the terrestrial level?

Models for lightning and ball lightning

The model for the ball lightning would be as follows.

(a) Lightnings would involve the transfer of dark matter to the surface of Earth and they could arrive to the surface of Earth along gravitational flux tubes. Just like action potential, lightning would correspond to a local breakdown of superconductivity. Ball lightning could be born at flux tubes sy heights below h_E and generate plasmoids as primitive life forms.

(b) The large value of h_{eff} and topological stability of monopole flux tubes would explain the long life time of ball lightning.

(c) The self-organization of living matter would produce via the Pollack effect plasmoid-like negatively charged systems in microscales. Ball lightning could be seen as an analog of a cell. It would also have the counterpart of the cell membrane and a good guess is that its thickness is scale for .5 m sized ball lightning to .5 cm which happens to be one half of the Scwartshild radius of Earth which defines the gravitational Compton length. Whether ball lightning is negatively charged can be tested if it can be produced in a microwave oven.

Is the proposal consistent with the model of metabolism based on quantum gravitation?

One can worry about the consistency with the dark gravitational model of metabolism [L150].

(a) The quantum gravitational model of metabolism gives an estimate for the height of the metabolic dark protons. If the dark protons at a U-shaped flux tube correspond to a stationary orbit in the gravitational field of Earth, the height from the Earth's surface would be about $h_g = 1.5R_E$. For proton triplets one obtains the correct value of the metabolic currency. The strong electric field near the surface of Earth would correspond to a rather short length scale as compared to this scale. The ratio $h_E/h_g \simeq 5 \times 10^{-3}$ is rather small. The gravitational potential energy difference is scaled roughly by this factor downwards so that the protons at this height cannot liberate metabolic energy quantum as gravitational potential energy.
TGD assigns to electrons metabolic energy quantum which is by factor m_e/m_p smaller than the standard metabolic energy quantum by factor of order 1/10 smaller than the protonic gravitational energy liberated at height h_E.
Most of the screening dark protons would be at a height which is much smaller than the height at which the gravitational potential energy is of order .5 eV for metabolic energy currency. This is possible since the scale of MB of the Earth is about $10R_E$ at the day-side.

(b) The electric field is in good approximation given as a gradient of potential and the voltage between points A and B is same alon all space-time sheets. Therefore the voltage should be the same also along the gravitational flux tubes if they connect A and B. Does this mean that gravitational dark protons coming from higher heights than 50 km receive huge energy of about electron mass m_e.

The metabolic dark protons at the gravitational flux tubes should be able to avoid this electric field: otherwise they would have energy of order m_e. How? One can imagine 4 options.

(a) The proposal of [L150] is that the transformation $h_{gr} \to h$ for dark protons involves a reconnection of the gravitationally dark flux tube with flux tube having much smaller value of h_{eff} and also accompanying dark hydrogen bond. If these flux tubes extend to a height somewhat larger than $h = 50$ km, the acceleration could be avoided by reconnection and staying at this height. The gain of metabolic energy communicated to the surface of Earth by dark photons would be essentially the same. The naive estimate for the value of h_{eff} for these flux tubes would be $h_{eff}/h_{gr} \sim h_E/R_E \sim 1/100$.

(b) The presence of solar gravitational MB was proposed in [L150]. In this case the gravitational Compton length would be $\Lambda_{gr} = GM_S/v_0$, $v_0 \simeq 2^{-11}$. This would correspond to the scale of 6×10^6 m, to be compared with Earth's radius $R_E = 6.4 \times 10^6$ m! Also in this case the reconnection would make it possible to avoid the acceleration in the electric field.

(c) The model of genetic code also requires both dark protons and dark neutrons [L162, L150]. Dark neurons are possible if strong and weak interactions are dark and thus are not screened below the Compton length of the bosons mediating them. This means a scaling of their typical length scaled up by h_{eff}/h: for weak bosons and for h_{gr}, the scale would be GM/v_0 and about .45 cm for $M = M_E$ and and about R_E for $M = M_S$.
The dark nucleon sequences at the flux tubes would be dark nuclei, which in the TGD based model are indeed string-like entities [K67]. Dark neutrons could propagate through the electric field without acceleration. Dark weak bosons would be effectively massless below the scaled up weak scale and this could explain chiral selection in living matter, which is very difficult to understand in the standard model.

(d) If the gravitational portions of the flux tubes through the analog of the cell membrane act as Josephson junctions, the energy would not be dissipated as for Ohmic currents. There would be only a rapidly oscillating current with Josephson frequency. For the solar gravitational flux tubes the oscillation frequency would be about 1 Hz. It is not clear to me whether this could solve the problem.

12.7 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 [D13].

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 [L150, L145], and the TGD inspired model of nerve pulse [L182].

12.7.1 TGD view of lightnings

The background for the TGD based model of lightnings and ball lightnings is provided by the TGD view of magnetosphere [K58, K56] [L125] 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 [L175, L176] (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 [K85] and its up-to-date version [L182] 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 [K58, K56] [L125]. 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 [L175, L176].

(a) 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.

(b) 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.

(c) 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 [L182] relies on the Pollack effect inducing a charge separation between cell interior/exterior and its MB.

(a) Pollack effect [I63, L27, I128, I99] 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.

(b) 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) [K117], predicting that the arrow of time changes in the ordinary state function reductions, can explain this.

(c) In the nerve pulse generation, the reverse Pollack effect would occur and neutralize the negative charge of the cell interior locally [L182]. 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.

(d) 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 [L182]. 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?

(a) The fractality of the TGD Universe inspires the proposal that the Earth's biosphere and its MB [K58, K56] [L125, L175, L176] 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.

(b) 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.

(c) 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 [K85] [L182].

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 [L182].

(a) 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 [K85].

(b) 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.

(c) 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.

(d) At the gravitational MB, assumed to be an onion-like structure consisting of nearly spherical layers [L175, L176], 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.

(e) 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! [L182].
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?

(a) 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.

(b) 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.

(c) 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.

(a) 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.

(b) 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.

(c) 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 [L135], 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 $L(239)$.

12.7.2 Ball lightning in the TGD framework

Could one understand the generation of ball lightning in this framework?

(a) Suppose that in the normal situation the Pollack effect [I63, L27, I128, I99] 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.

(b) 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.

(c) 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 [L150, L145].
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 [K38, K39] 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 [L170, L169], 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?

(a) 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 [L169], is that the conscious computer is based on the representation of bits in terms of Josephson junctions.

(b) 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.

12.8 Tesla's Work, Biology, And TGD

If TGD world view is correct, remote metabolism could also have technological implications. Three different applications mimicking biology come in mind. The communication with geometric past by sending negative energy photons and receiving positive energy photons - as memory recall and remote sensing; the initiation of motor actions by sending negative energy signal to geometric past; and remote metabolism. Zero energy ontology justifies these ideas.

Energy is the bottleneck of recent day technology. Nuclear energy has well-known problems. Also the use of, say, oil as a fuel produces environmental problems and for long travels - in particular space travel - the needed amount of fuel poses an insurmountable problem. The storage of energy as electric energy has also its difficulties due to the fact that the lifetimes of accumulators are very limited.

Tesla had surprisingly far reaching vision about the means of generating and transferring energy in the future society. Tesla speculated about an analogy with biology: in future technology the energy user would extract energy from environment and do this only when it needs the energy. Tesla also believed that there exist unidentified energy sources. This does not imply their identification with zero point energy (ZPE) as often erratically claimed - ZPE emerged as an outcome of quantum field about which Tesla knew nothing. Tesla also speculated on a connection to biology.

To me the most amazing and perhaps most important finding reported by Tesla is what he called "cold electricity" and as a child of his time interpreted it as an evidence for aether

particles and scalar photons. What is amazing is that in TGD framework the reported properties of cold electricity and aether particles suggest an interpretation as Cooper pairs of dark electrons and dark photons (recall that we *know* that dark matter is there!). If this is really the correct interpretation, dark matter would have been discovered more than century ago!

In the sequel I will discuss a simple formula expressing the conditions for the transition to a phase that Tesla called "cold electricity", identified in TGD framework in terms of dark matter - and study its generalization to the case of cell membrane allowing to deduce formulas relating cell membrane critical potential and p-adic length scale assigned to given dark particle. These formulas are of course only guesses based on general principles and on available numbers. If the proposed general principles are not correct, one can forget the formulas!

12.8.1 Tesla's Work

In this section Tesla's work about energy transmission and cold electricity are briefly discussed. After that TGD inspired interpretation of the findings is discussed.

Tesla's vision about energy transmission

Probably already Tesla (see `http://tinyurl.com/yysaqzm`) realized the deep problems related to energy and Tesla's technology based on alternative currents initiated by the discovery of AC magnetic motor became the basis of the modern society and the transfer of information by radio waves the standard.

Tesla's vision was that not only information but also energy could be transmitted as radiation and this served as his motivation in transmitter experiments. The idea (`http://tinyurl.com/28nbr`) [H1] was that the energy beam sent to what is now known as Kennelly-Heaviside layer is echoed back and received by the user. The objection against the transfer of energy by radiation is obvious. In Maxwellian world the radiation from energy source propagates to all directions and the power density decreases as $1/r^2$ with distance. Only a small fraction of radiative energy can be used.

One can of course consider a situation in which geometric optics applies reasonably well: this requires however that the wavelength used is small as compared to the size of the antenna. For 200 kHz corresponding to the highest frequency used by Tesla the wavelength is about 1.5 km. For smaller wavelengths one cannot anymore assume that the radiation is reflected from the upper boundary of Kennelly-Heaviside layer.

To develop this vision Tesla studied so called Tesla transmitters (`http://tinyurl.com/y778g5sg`) and magnifying transmitters (`http://tinyurl.com/y7yybrpf`) [H1], which instead of serving as voltage transformers acted as amplifiers: the primary circuit acted as a resonant driving force so that an energy transfer to the secondary was achieved. These circuits act as both receivers and antennas. The circuits applied dynamic switches based on the di-electric breakdown of the surrounding air and generated in the secondary di-electric breakdowns through surrounding air to surprisingly long distances. Rather interestingly, the duration of resonant period after di-electric breakdown putting the switch on was few milliseconds which is the time scale associated with nerve pulse. I do not know whether anyone has really explained this co-incidence. Also the frequency range studied was 20-100 kHz which corresponds to biological time scales. Tesla discovered in his experiments X rays assignable to the high voltages generated in the Tesla transformer.

Tesla also generated radiation propagating through the Kennelly-Heaviside layer (`http://tinyurl.com/25ur2tl`) - not yet discovered at that time - making possible radio transmissions: Marconi received Nobel prize for radio sender but Tesla in fact discovered the phenomenon first as was admitted after Tesla's death. Tesla also found the surface of Earth acts as a conductor with resistance roughly 10^{10} times higher than that of Copper. Tesla also discovered Schumann resonance on basis of his measurements. In my opinion the large scale effects related to di-electric breakdown discovered by Tesla are not easy to understand in the framework of Maxwell's electrodynamics and might involve new physics. It is a pity that they are seen only as an entertainment nowadays.

Cold electricity

Tesla's findings [H11, H2] (see the book by Lindeman at http://tinyurl.com/krobpfu and the article by Akai at
http://tinyurl.com/yd2av3xs.html) led him to propose the existence of "cold electricity" running as a visible current along the surface of the Tesla coil in a local direction orthogonal to the wire of the coil and consisting of charge carriers not detectable by ordinary amp-meter but generating ordinary electrons at the target.

Cold electricity was not accompanied by dissipation. For instance, the vacuum tube serving as a diode (conducting current only in single direction) was not heated by the cold currents although it generated light. In other words, the currents in question were not ohmic. This brings in mind super-conductivity not yet known at the time of Tesla's experiments. Cold electricity was thought to appear as a result of a "traffic jam" with very strong local electric field leading to a generation of high electronic surface charge densities. This suggests that a high density of electrons is necessary for the cold electricity to appear in a phase transition-like manner.

Cold electricity gave rise to a force parallel to its direction of propagation. As a child of his time Tesla identified dark electricity as aether particles. Tesla assigned to the cold electricity also scalar waves - longitudinal photons - manifesting as light emitted in dielectric breakdowns associated with air gap of primary coil and secondary coil of Tesla transmitter. Longitudinal polarization explained the force in the direction of motion of the scalar waves. Another possibility is that the momentum of cold currents transforming to that of matter gave rise to this force.

Tesla estimated the velocity of the aether particles and concluded that it was superluminal. Tesla claimed also the that energies and the voltages at the secondary coil were too large to be explained in terms of ordinary circuit theory: the discrepancy between the observed value of the voltage for bifilar coil was by a factor about 9 percent higher than predicted (http://tinyurl.com/ybocsta5) [H10, H9]. This might be understood if the ordinary ohmic dissipation for the cold currents was absent so that the energy of charge carriers was transformed to kinetic or electric energy as a whole. Tesla speculated with an additional energy source as an explanation of the strange energetics.

Cold electricity could be perceived as various bodily sensations for pulse lengths not much shorter than nerve pulse duration of order milliseconds. The accompanying light required very long exposure time to become visible in photos. This would suggest exotic photon-like particles were involved and had to transform to ordinary photons in order to become visible for camera. Human eye was however sensitive to this light.

What was remarkable that the time scale for the di-electric breakdown was measured in milliseconds. This happens to be the time scale of nerve pulse duration associated with the electric field of cell membrane higher than the critical value of electric field for dielectric breakdown in air. This motivates the application o f TGD inspired view about quantum biology in order to understand the findings of Tesla.

12.8.2 Scalar Waves Of Tesla In TGD Framework

The scalar waves or so called non-Hertzian waves of Nikola Tesla belong to the fringe region of science. Many proponents of free energy believe that scalar waves might provide a basis for a new energy and communication technologies. Tesla himself was isolated from the official science and found no place in text books because his hypothesis about scalar waves did not fit within the framework of the Maxwell's electrodynamics. Personally I justified my personal prejudices against scalar waves by the observation that the formulations for the notion of scalar waves that I had seen seemed to be in a conflict with the cherished gauge invariance of gauge theories. The discussions with a Finnish free energy enthusiast Juha Hartikka however led me to reconsider the status of the scalar waves.

The surprise was that the non-Hertzian waves of Tesla might be possible in TGD framework. The most plausible explanation relies on many-sheeted space-time.

(a) TGD allows so called massless extremals (MEs, topological light rays) as non-linear generalization of Maxwellian plane waves. They are characterized by light-like wave vector and polarization vector orthogonal to it and these vectors can also depend on space-time position [K20]. The most general wave is a pulse with arbitrary profile moving along ME with light-velocity along them and preserving its shape.
Since TGD space-time is many-sheeted one can take two waves of this kind on top of each other in the sense that their M^4 projections intersect in some region of M^4. The effective space-time is defined by a piece of Minkowski space with effective metric which is sum of M^4 metric and deviations of the metrics of sheets from M^4 metric. Effective gauge potentials are sums of the induced gauge potentials. For two MEs the potentials at the two sheets and if the wave vectors can be chosen to be in opposite direction in which case one obtains an effective standing wave with non-vanishing net energy but vanishing 3-momentum and classical spin. Since MEs can carry light-like charge current the resulting system carries non-vanishing charge density and vanishing current Fourier transforms of the pair give rise to massive spinless states having identification as scalar waves possibly carrying em charge.
In TGD framework classical gauge boson fields of standard model correspond two-sheeted structures - perhaps pairs of MEs connected by wormhole contact pairs having interpretation as gauge boson. One can consider the possibility that the classical space-time correlate for gauge bosons massivation at the level of MEs is this kind of pair of space-time sheets. For massive gauge bosons the wave vector directions of the two sheets would be opposite in the rest system and spin would be vanishing.

(b) The original proposal could have been inspired by the electric-magnetic duality of TGD suggesting a large number of solutions of field equations representing constant energy density configurations of electric field assignable to bio-electrets, which would be in a well-defined sense dual to the magnetic flux tube structures with analogous properties. Also classical gravitational fields generated by classical field energy could be important in the living matter. One must however take this proposal with a big grain of salt since there is no proof for the actual existence of this kind of solutions. Furthermore, one can obtain TGD counterparts of scalar waves as pairs of MEs.

12.8.3 Relating Tesla's Work To TGD Inspired Quantum Biology

Skeptics can of course argue that if Tesla were right, his claims would have been verified long time ago. Here I disagree. Dark matter represents the deepest puzzle of modern physics, and all attempts to find dark matter identified as exotic particles of main stream quantum field theories have failed. This suggests that some assumption about the nature of dark matter is badly mistaken. Tesla's experiments tested Maxwell's electrodynamics in extreme situations - typically high voltage pulses generated in switching on of a circuit such as occur in dielectric breakdown over air gap. Interestingly, also cell membrane - another physics mystery - has a very high resting potential generating an electric field stronger than that inducing a dielectric breakdown in air. These situations are different from the extreme situations encountered in high energy elementary particle physics: long wave lengths and low frequencies are combined with high voltages, and this makes possible for the hierarchy of effective Planck constants to make itself manifest if it exist.

My TGD inspired educated guess indeed is that the hierarchy of dark matter phase labeled by the value of effective Planck constant implying macroscopic quantum coherence might have made itself manifest in the experiments of Tesla.

Cold electricity as dark matter in TGD sense

It came as a surprise to me that Tesla's findings - described in [H11, H2] - could be seen as first experimental indications for dark matter in TGD sense.

Consider first dark photons as counterparts of scalar waves of Tesla.

(a) Scalar waves could correspond to dark variants of ordinary photons with a high value of effective Planck constant: later an estimate as the ratio $h_{eff}/h = ZeV/f_{AC}$ of Josephson

frequency and AC frequency will be discussed. In TGD inspired biology bio-photons result in the transformation of dark photon of same energy to ordinary photon. The low intensity of bio-photons can be explained in terms of low rate for this process. This could also explain why a long exposure time was required to make the light emitted in Tesla's experiments visible. If this interpretation is correct, living matter would be an optimal detector of dark matter so that subjective experience would provide the most straightforward proof for the existence of dark matter whereas its detection by using conventional detectors would be more difficult!

(b) I have earlier considered the possibility of obtaining scalar photons in TGD framework [K41], and the model of gauge bosons as pairs of fermion and anti-fermion at opposite ends of wormhole contact together with p-adic mass calculations [K69] suggests (one might even argue "predicts")the existence of longitudinal photons with very low mass. They need not be relevant for understanding Tesla's findings if the transfer of dark matter momentum is able to explain the longitudinal force reported by Tesla.

(c) Massless extremals (MEs)/topological light rays represent TGD counterparts for Maxwellian radiation fields. Their special feature is that they can carry light-like current and therefore also charge. Local polarization ϵ and light-like momentum vector k are orthogonal to each other ($\epsilon \cdot k = 0$), and the expression for the current in terms of the induced gauge field demonstrates that non-Abelian character of field makes possible charge current. In the Maxwellian case ϵ should be non-orthogonal to k. Hence charged MEs cannot correspond to Tesla's scalar waves. As in standard model, *all* particles look massless in sufficiently short length scales in TGD Universe, and all particles - including also electron - should have MEs as space-time correlates. MEs would therefore naturally correspond to dark electrons behaving like massless particles below Compton length scale of scaled up by h_{eff}/h.

In TGD framework Cooper pairs of dark electrons could thus serve as counterparts of Tesla's aether particles.

(a) In TGD framework cold electricity could correspond to Cooper pairs of super-conducting dark electrons with a high value of effective Planck constant. This would explain the non-ohmic character of dark currents. If the value of h_{eff} is same for dark photons and dark electrons (this is not necessarily true), the Compton wave length of dark electrons would be by a factor E_{photon}/m_e smaller than that for dark photons. For a photon energy of 2 eV this would give a reduction factor of order 4×10^{-6}. This wave length is still macroscopic (of order of 1 m) for the needed values of $h_{eff}/h = n \sim 10^{13}$. The large value of the Compton length implies that the overlap criterion for electron wave functions is satisfied so that the formation of electronic Cooper pairs is possible and lead to a generation of supra currents which do not dissipate. The absence of ohmic dissipation could explain why the vacuum diode serving as a diode was not heated and also why energetics could not be understood in terms of ordinary circuit theory. One cannot of course exclude the possibility of remote metabolism as an additional energy source.

(b) If supra currents are formed, they give rise to a path of smallest resistance so that by standard circuit theory of by hydrodynamical analogy the ohmic current along highly resistive winding of the Tesla coil is effectively replaced with the supra current flowing along its surface.

(c) One must make a distinction between supra currents which can run even without any potential difference and oscillatory Josephson currents running in presence of voltage. The first guess is that the supra current runs along the surface of the coil and possible Josephson current runs between the coil and ground and is assignable to the sparks generated by the coil. The generation of supra currents and Josephson currents would be favored by the formation of very high electron densities at the locations of the coil in which the normal value of electric field was very high. Using axon as an analogy, the supra currents would flow along axon and Josephson currents between the lipid layers of the axon.

In the case of DC voltage the emerge of Josephson current with frequency determined by the DC voltage looks natural. For AC voltage the first guess is that dark Josephson current oscillating with the AC frequency (or its harmonic or sub-harmonic as will be

proposed later) is established. This however requires a constant shift V_J of the Josephson voltage so that only current would remain strictly sinusoidal. V_J might explain why the observed voltage in the secondary coil of Tesla transformer is roughly 10^3 times higher than the estimated one. V_J could reflect the proposed accumulation of charge ("traffic jam") interpreted as a breakdown of the conductivity of the coil and its transformation to a capacitor carrying a constant charge. The claimed loss of the conductor property for the coil for a time interval of few milliseconds could correspond to the generation of supra current along coil and V_J between coil and ground generating Josephson current and direct Ohmic currents.

(d) If super-conducting space-time sheets emerge as dark space-time sheets identifiable as n-furcations of space-time sheets at quantum criticality and if each sheet carries a Cooper pair of electrons one has the analog of Bose-Einstein condensate. One can assume that the area S of the critical region of the surface of conductor is that of the partonic 2-surface. The guess is that at criticality the electric flux decomposes into sum of smaller electric fluxes over the sheets of n-furcation such that the small fluxes are equal to charge $2e$ of the Cooper pair.

Using $2e$ as a unit the charge the electric flux over the partonic 2-surface at criticality equals to the value of $h_{eff}/h = n$ identifiable as the total number of Cooper pairs so that one obtains an estimate for Planck constant in terms of the critical electric flux:

$$\frac{E_{cr}S}{2e} \quad = \quad n = \frac{h_{eff}}{h} \quad . \tag{12.8.1}$$

This allows a pseudo-continuum of critical fluxes.

(e) It would seem natural to assume "traffic jam" at some critical value of voltage between the ends of the coil implies Bose-Einstein condensate-like state of large h_{eff} Cooper pairs, Josephson currents, and supra currents. In principle this critical electric field has nothing to do with the critical field E_d for the di-electric breakdown of air. The needed phase transition would be forced by the "traffic jam" reducing the ordinary conductivity along the wire of the coil. The traffic jam would occur for some critical voltage V_{cr} between the ends of the coil.

i. One especially interesting value of voltage corresponds to the Compton energy of electron:

$$eV_{cr} = m_e \simeq .5 \ \text{MeV} \quad . \tag{12.8.2}$$

Also higher voltages than this were encountered in Tesla's experiments. This condition is non-local condition. One should not confuse V_{cr} with V_J, which however can be assumed to emerge in the phase transition.

Later a justification for the condition will be considered. It is also encouraging that in Modanese-Podkletnov effect [H12] involving a capacitor for which the second plate is high T_c super conductor, radiation pulses allowing no interpretation in standard physics framework are generated above the proposed critical voltage $eV_{cr} = m_e$: the TGD inspired explanation of the effect is discussed in [K107].

ii. Combining this condition with Eq. 12.8.1 one would have

$$E_{cr} \quad = \quad \frac{V_{cr}}{L} \quad . \tag{12.8.3}$$

Here L the total length of the wire of the coil if the electric field is constant along the wire. Hence di-electric breakdowns would occur as an undesired side effect due to the very strong fields forced by the Eq. 12.8.2. In the case of cell membrane this side effect is used for neural communications using nerve pulses. Conditions of Eqs. 12.8.1, 12.8.2, and 12.8.3 would allow to fix the model to a rather high degree. Already earlier additional assumptions correlating Josephson frequency, AC frequency and the geometric characteristics of the system were considered.

iii. In air the critical field for di-electric breakdown is $E_d \simeq 3$ MeV/m. For higher field strengths a complete di-electric breakdown (meaning that air becomes a conductor) takes place. E_d gives for 17 cm long coil $eV \simeq m_e$ so that one can understand why

dielectric breakdowns tend to occur unless coil is longer than this. Also dielectric breakdowns between subsequent turns of the coil are possible and can be seen as a nuisance. The estimate $E_{cr} = E_d$ together with the condition 12.8.1 gives for $S \in \{1\ \mu\text{m}^2, 1\ \text{cm}^2, 1\ \text{m}^2\}$, $n \in \{3, 3 \times 10^8, 3 \times 10^{13}\}$. Note that the size scale of the cell nucleus defines the smallest area for which the dielectric breakdown becomes possible.

iv. The millisecond duration of the current is same as for nerve pulse. Nerve pulse however occurs when the resting potential is reduced *below* the critical value so that the two phenomena do not obey identical physics. The current however decreases as a function of the voltage above criticality (negative resistance): does this mean that oscillating Josephson currents become dominant charge carriers above criticality and that for cell membrane this dominance is taken to extreme meaning that ohmic currents are practically absent?

v. One cannot completely exclude the presence of Josephson currents also below V_{cr} but due to the absence of V_J they would not contain the dominating purely sinusoidal component but would have the form

$$J_0 sin(\frac{f_J}{f_{AC}} cos(2\pi f_{AC} t)) \ , \quad f_J = \frac{ZeV}{h_{eff}} \ ,$$

and periodicity defined by f_{AC}. The sine term would oscillate between values

$$\pm J_0 sin(\frac{f_J}{f_{AC}}) = \pm J_0 sin(\frac{1}{l}) \ , \ l = 1, 2, ...$$

if the condition $f_J = f_{AC}/l$ holds true.

(f) The cold currents induce electronic effects - generation of ordinary electrons - at the target. This can be understood if a phase transition to ordinary matter occurred when the criterion for the presence of the multi-furcation is not satisfied anymore. An explosion of a copper wire as it received cold electricity was reported by Tesla. This could be understood if the proposed criticality criterion was not satisfied so that the dark current was transformed to ohmic current heating the copper wire.

(g) Tesla reported that dark electricity flowed with superluminal velocity and even determined this velocity. This is in principle possible in TGD Universe: sub-manifold gravity implies that the light velocity determined operationally from the time for the signal to travel between two points along light-like geodesics defined with respect to the induced metric depends on space-time sheet. In TGD inspired cosmology this light velocity is lower than the light velocity empty Minkowski space (geodesics of M^4 instead of those of space-time surface X^4). If the dark space-time sheets are nearer to M^4 than ordinary space-time sheets, the effective super-luminality follows.

(h) Cold currents were not seen by amp-meter but caused subjective sensations and were visible. This conforms with TGD view about the role of dark matter in biology.

This scenario leads to concrete (almost -) predictions.

(a) If amplitude modulation is the mechanism generating dark photons, the values of Planck constants involved should come as ratios of frequencies involved: only integer ratios for the frequencies can produce dark photons.

(b) The energies of ordinary photons generated form a continuum such that highest frequencies correspond to frequencies assignable to photons with energy of order eV_{max}, where V_{max} is the highest voltage generated by the transmitter. Therefore the energies can be in X-ray region (keV region) and even in MeV region. The frequencies of radio waves used were in the range 20-100 kHz so that the range of values of effective Planck constants can be estimated as frequency ratio if amplitude modulation is the mechanism producing dark photons.

(c) There is also the amplitude modulation of radio frequency by a frequency associated with the periodic switching of the current through the air gap caused by the di-electric breakdown. This modulation could transform the radio wave photons to dark photons with same energy but frequency considerably below kHz and these dark fields could in turn modulate the ordinary higher energy photons to dark ones so that one would obtain dark photons with frequencies below kHz and energies up to the eV_{max}.

Isn't $eV_{cr} = m_e$ condition rather ad hoc?

The first objection against the condition $eV_{cr} = m_e$ is that it looks rather ad hoc. The study of Dirac equation shows that for $V > V_{cr}$ the sign of the energy of electron changes from positive to negative so that the roles of electron and positron change. One can argue that something dramatic must happen in this kind of situation and the phase transition transforming electrons to their dark counterparts is good candidate in this respect.

An analogous situation was expected to result in atomic physics of very heavy atoms as the energy of electron changes sign in the strong electric field of heavy nucleus. It however turned out that something different takes place. In heavy ion collisions exotic pion-like states decaying to electron and gamma pairs with energy very near to $2m_e$ was observed and this led to a TGD inspired model as lepto-pions identified as bound states of colored excitations of electron [K108]. Darkness in TGD sense had to be assumed since otherwise they would be produced in the decays of weak bosons. Could something similar happen also now?

In zero energy ontology (ZEO) the natural assumption is that the scale of causal diamond (CD) is determined from the condition that the quantity $E - ZeV$ preserves its sign. This would give $m_e = eV_{cr}$ condition for the state at rest. The standard quantization condition analogous to the quantization of magnetic flux but applied to 2-surface with Minkowskian signature has the following equivalent forms:

$$\begin{aligned} \frac{ZeVT}{h_{eff}} &= n \ , \\ \frac{ZeV}{h_{eff}} &= nf \ , \ f = \frac{1}{T} \ . \end{aligned} \tag{12.8.4}$$

The time interval T corresponds naturally to the time scale of CD (temporal distance between its tips). The condition for $n = 1$ is consistent implies the quantization condition proposed in previous section and motivated by the model of dark EEG:

$$\frac{ZeV}{h_{eff}} = \frac{f_{AC}}{l} \ . \tag{12.8.5}$$

The reason is that f_{AC} in general is harmonic of f: $f_{AC} = lf$, $l = 1, 2, ...$ Recall that the identification of f_{AC} as cyclotron frequency for some charged boson is natural and requires that ions for which cyclotron frequencies (atomic weights in good approximation) are not multiples of each other cannot appear on the space-time sheet corresponding to same CD. One cannot however exclude the possibility that space-time sheets continue outside the CD and therefore the possibility that same space-time sheet is contained partially to sub-CD of CD.

An objection against $eV_{cr} = m_e$ condition from biology

One can invent another objection against the identification $eV_{cr} = m_e$. For cell membrane the critical membrane potential for nerve pulse generation is.055 eV rather than.5 MeV so that the criticality condition would not apply in this case. Does this mean that electronic super-conductivity is not possible? Should one give up the criticality condition or generalize it appropriately in this case?

The correct solution of the problem comes from the answer to the question "What happens as voltage becomes higher than the critical value V_{cr}?". The conjecture is that h increases to $h_{eff}/h = n$ and n-furcation replaces space-time sheet with its n-sheeted covering. But what does this mean physically?

To answer it is best to make first clear what we want and see whether we can get it.

(a) We want criticality condition in the form $eV_{cr} = m_e/n$ with such an n that V_{cr} corresponds to cell membrane resting potential. Therefore mass is scaled down by $1/n$. Somehow particle splits to n fractions so that the total quantum numbers, in particular mass, remain unchanged.

(b) We want p-adicity. Since p-adic length scale hypothesis allows besides standard mass corresponding to the p-adic prime $p \simeq 2^k$ characterizing the particle also mass values scaled by powers of $\sqrt{2}$, the natural guess is that p-adic length scale is increased by a factor $n = 2^{\Delta k}$.

(c) We want a connection with dark matter in TGD sense: $h_{eff}/h = n$ should hold true for the resulting state. The resulting state must be interpreted as a many-sheeted structure defined by n-furcation and all quantum numbers are fractionized so that a given sheet carries q/n if total quantum number is q. A longstanding issue has been what this fractionization could mean.

By Maxwell's equations stating that potential difference is same along any path with same end points, the potential along each sheet is the same $eV_{cr,new} = M/n$. The new version of the criticality condition $eV_{cr,new} = M/n$ for single sheet of the n-fold covering is the analog of the original condition $eV_{cr} = M$ for single sheeted space-time surface. This interpretation also allows to understand the formula $E_c = h_{eff}ZeB/M$ for cyclotron energy as a formula for single sheet of covering carrying mass M/n and charge Z/n. The charge-to-mass ratio Z/M remains unchanged but summation over sheets yields the factor h_{eff}/h to the formula of E_c. Hence everything is consistent with the original motivation for dark matter hierarchy.

(d) One can imagine two alternative mathematical realizations. The dark particle could correspond to a tensor product of n fractional tensor factors or to a direct sum with a complete de-localization of single fractionalized particle to various branches. For a de-localized fractional single particle state the total quantum numbers would be equal to q/n rather than the desired q whereas for tensor product of fractional single particle states the total quantum numbers are q as desired. Therefore tensor product option seems to be the correct one. The fractionized particle is analogous to a full Fermi sphere with all fractional single particle states filled.

(e) One can consider also states for which any number $1 \leq m \leq n$ of single particle states are filled. $m = 1$ corresponds to the option with a complete de-localization and $m = n$ to the states proposed above. I have earlier proposed [K78] that this kind of states - I have called them N-atoms, N-molecules, etc... - might allow to understand emergence of symbolic dynamics in living matter. Fractional second quantization for n-furcations of space-time sheet seems naturally lead to to these kind of states. These states allow a natural conjugation operation. A state with m sheets with each of them containing fractional particle contains holes at the remaining $n - m$ empty sheets. By replacing holes with particles and particles with holes one obtains a conjugate state. The wild proposal is that the pairing of states and their conjugates by entanglement with maximal entanglement entropy defines the molecular analog of sex. State function reduction would automatically lead to this kind of states having negentropic number theoretic entanglement and Negentropy Maximization Principle [K64] would stabilize them.

This picture is highly predictive. From the knowledge of the membrane critical potential one can calculate the value of h_{eff} and from the integer quantization of $h_{eff}/h = n$ gets constraints on the possible values of membrane potential: this constraint is unfortunately rather weak since the values of n are rather large. Situation changes if the values of n correspond to powers of 2: $n = 2^{\Delta k/2}$ so that the mass of the dark particle at given sheet of covering equals to the mass predicted by p-adic mass calculations but in p-adic scale $k_{eff} = k + \Delta k$. Note that Δk must be an even number unless one replaces the condition with the approximate condition $n \simeq 2^{\Delta k/2}$. This hypothesis might mean that the p-adic physics associated with the sheet of covering indeed corresponds to $p \simeq 2^k_{eff}$. The hypothesis predicts the p-adic prime associated with the cell membrane and also restricts strongly the value of the threshold potential of the cell membrane.

(a) In the case of electron p-adic length scale hypothesis predicts the value of the threshold potential: $V_{crit}/V_{cr} = V_{crit}/m_e = n = 2^{\Delta k/2}$. For $\Delta k = 46$ one obtains $eV_{crit} = .060$ eV not too far from the nominal value .055 eV of the threshold potential. The Compton length of scaled up electron would correspond to $k = 127+46 = 173$, which is 20 μm - a size scale of cell - and longer than the scale $L_e(167)$. Note that the ratio $L_e(173)/L_e(151) = 2^{11}$ is approximately the same as the ratio of proton and electron masses. I have also

introduced an ad hoc hypothesis that powers of 2^{11} represent preferred values of h_{eff}.

(b) For biologically important ions one can find the values of membrane critical potential for which n is power of 2. Since the mass of the ion is in good approximation proportional to mass number in good approximation it is easy to get reasonable estimates for the effective (or maybe real) p-adic length scales associated with ions and for the precise value of the threshold potential. The values of k_{eff} and electrostatic energy E in threshold potential are given in Table 2 below.

(c) This picture might allow to understand why nerve pulse is generated when the membrane potential is reduced *below* V_{crit}. The earlier vision about resonant interaction between dark variants of elementary particles and their p-adically scaled up versions with ordinary value of Planck constant and scaled down mass [K56] assumes that dark scaled up Compton length nL_c equals to the p-adically scaled up Compton length: this quantizes the values of $h_{eff}/h = n$ to powers of 2. In the case of electron this gives $n = 2^{\Delta k} = 2^{23}$. The reduction of the membrane potential below the critical value would transform dark electrons to ordinary electrons. Same applies to dark ions. If this is the case, the ordinary ohmic conduction would set on and lead to a generation of nerve pulse as a phenomenon analogous to di-electric breakdown. This picture could make sense also for the neutrino option. What is remarkable that ZEO and dark matter in TGD sense would be essential for understanding the highly non-intuitive fact that cell membrane system becomes unstable as membrane potential is reduced in magnitude.

(d) One can try to determine the order in which different charged particles make a transition to non-superconducting phase during nerve pulse from the ordering of the values of E as $(e, p, Cl^-, K^+, Ca^{++}, Na^+)$. The inward flux of ions however begins with Na^+ ions and the outward flux with K^+ ions. That Na^+ rather than K^+ flow initiates nerve pulse is not a catastrophic prediction: the transition to a non-superconducting phase initiates the dissipative ion flow only if the concentration of non-super-conducting ions on the other side is low enough (not true in the case of K^+ in the beginning of the action potential).

(e) Voltage gated ion channels are assumed for all ions. Nerve pulse can be also initiated by voltage dependent calcium channels, and in this case its duration is about 100 ms instead of few milliseconds. The TGD counterparts for the ion channels should exist and the following correspondences are suggestive.

- Voltage gated ion channel characterized by channel protein $\leftrightarrow$ n-furcated dark space-time sheet with n depending on ion.
- Closed/open ion channel $\leftrightarrow$ the magnitude of the membrane potential above/below the critical potential.

Voltage gated ion channels would correspond to dark regions of the cell membrane assignable to proteins rather than to the entire membrane as implicitly assumed hitherto. Metabolic economy (minimization of dissipation) would encourage an analogous interpretation in the case of ion pumps. Ionic pumps (`http://tinyurl.com/y7wq3w7c`) use the energy provided by ATP or the electrostatic energy $E = ZeV$ (depending on ion only via its charge) provided by the passive transfer of another ion through the cell membrane - the members of the ion pairs might be connected by a magnetic flux tube! The basic mechanism for pumps would be emission/absorption of negative/positive energy Josephson photon kicking the ion or ion Cooper pair to the other side of the membrane and thus same as in the generation of ATP. Quantal ionic pumps dissipate much less than expected, and Ling's approach postulating the absence of pumps is partially inspired by this observation.

There are also questions to be answered. The estimated value of n is same for K^+, Na^+, Ca^{++} so that one might expect them to reside at same n-sheet. Why the channel proteins are different? Do different ions correspond to different cyclotron Bose-Einstein condensates? Could cyclotron frequencies be same or related by powers of two so that local magnetic field strengths would be different and ions should correspond to disjoint parts of magnetic body.

It seems that k_{eff} could characterize genuine p-adicity that is p-adicity in the same sense as ordinary particle obeys it.

Ion	H^+	Na^+	Cl^-	K^+	Ca^{++}
$\frac{A}{z}$	1	23	35	19	20
E/meV	54.6	38.0	50.0	46.0	44.0
k_{eff}	175	189	191	189	189

Table 12.2: The values of the threshold potential and effective p-adic length scales $k_{eff} = k + \Delta k$ predicted by assuming $h_{eff}/h = n = 2^{\Delta k}$. A and z denote the mass number and charge of the ion. For electron one has $k_{eff} = 173$ (prime) and $E/meV = 60$. Na^+, Ca^{++} and K^+ all correspond to same p-adic length scale $k_{eff} = 189$ (p-adic length scale of 5 mm) if the ion is assumed to correspond to $k = 113$ for atomic nuclei. Another posssibility is $k = 137$ (atomic length scalle) giving $k_{eff} = 213$ (p-adic length scale of 20 meters) and should be assigned with the magnetic body.

(a) I have proposed earlier that dark and possibly also p-adic copies of electroweak physics and color interactions are present in living matter for the p-adic length scales corresponding to Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$. $k = 151, 157, 163, 167$ defining four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L_e(k)$ in the range [$L_e(151) = 10$ nm, ..., $L_e(167) = 2.5$ μm] [K56]. Weak bosons behave as massless particles below these p-adic length scales for both p-adic and dark copies. The presence of these copies of weak physics is suggested by the large parity breaking effects in living matter (chiral selection), which are still poorly understood.

(b) The hypothesis implies a large number of satellite p-adic length scales if one assumes that dark variant of particle can transform to ordinary variant of the particle characterized by a given dark scale characterized $n = 2^{\Delta k}$.

(c) The recent conjecture modifies this hypothesis to a statement that given sheet of n-furcation with fractionized quantum numbers - in particular mass - obeys effective p-adic topology characterized by $k_{eff} = k + \Delta k$. In particular, the exotic weak and color physics with massless weak bosons and non-confined color below the p-adic length scale k_{eff} could be obeyed at given sheet of the covering.

Neutrino super-conductivity and cognition

The idea that neutrinos are highly relevant for cognition [K84] is rather attractive in TGD framework. One of the oldest ideas of TGD inspired biology is the notion of cognitive neutrino pair identified as pair of neutrino and antineutrino at opposite throats of wormhole contact, which I have however gave up as unrealistic. In the recent formulation this state would correspond to a superposition of photon and Z^0 boson coupling only to neutrinos. In standard model framework the idea about the relevance of neutrinos for biology is of course complete nonsense, but p-adic length scale hierarchy and TGD view about dark matter allows to consider this idea at least half-seriously. The observed large breaking of parity symmetry in living matter (chiral selection) indeed encourages to ask whether the p-adically scaled counterparts of weak gauge bosons could appear in the length scales of living matter.

There is also second wild idea. In [K24, K40] I have considered the possibility that the cell membrane can exist in two states: the first state is far from vacuum extremal and electromagnetic fields dominate whereas the second state is near to vacuum extremal and also classical Z^0 fields are important. The latter option would mean maximal sensitivity to perturbations highly desirable for cells serving as sensory receptors. This leads to a modification of the model of cell membrane resting potential and rather realistic looking estimate for the frequencies for which the retinal sensory receptors have maximum response.

(a) For near to vacuum extremal option induced Kähler form is very small and in good approximation electromagnetic and Z^0 potential energies for e, ν, p and n relate to the treshold value of the electromagnetic potential energy via

$$\begin{array}{lll} E(X) = Y(X) \times eV_{crit} \ , & & \\ Y(e) = (-1+x) \ , & Y(\nu) = 2-x \ , & Y(p) = 3-x \ , \quad Y(n) = x \ , \\ x = \frac{1}{2p} \ , & p = sin^2(\theta_W) \ . & \end{array} \tag{12.8.6}$$

These formulas generalize to ions and allow to calculate the values of V_{crit} for near vacuum extremals from the condition $m(X) \times 2^{-\Delta k} = E(X)$, $X = e, p$ or for an ion with given value of A/z (A is mass number and z is degree of ionization). The modified threshold potential is given by $eV_{crit} \to eV_{crit}/Y(X)$ when $Y(X)$ is near unity. The expressions of $Y(X)$ are deduced in [K24].

(b) The earlier model [K24] made the questionable assumption that for near to vacuum extremals the value of the Weinberg angle is $p = .0295$, which is considerably smaller than the value $p = .23$ assumed for the phase far from vacuum extremals [K24]. This assumption was motivated by the condition that the energies of biologically important ions gained in membrane potential correspond to three peak energies associated with visual receptors. It has however turned out that the ordinary value of Weinberg angle can be assumed without losing this prediction if one assumes that Cooper pairs of ions Na^+, K^+, and Cl^- rather than ions themselves are the charge carriers. For $p = .2397$ one obtains $(E(e), E(\nu), E(p), E(n)) = (1.085, -0.0859, 0.914, 2.086) \times V_{rest}$. Except for neutrino, the scaling factors are rather near powers of 2. Note that for proton the scaling factor is in good approximation two.

(c) Dropping of two proton Cooper pairs in the production of ATP would liberate total energy of about $4 \times .055 = 0.22$ eV. The problem is that this is roughly one half of the metabolic energy quantum. If two proton Cooper pairs and two neutrino Cooper pairs are dropped, the liberated energy is of the order of the nominal value of the metabolic energy quantum. Could it be that the step producing ATP takes place in the region of cell membrane near to vacuum extremal and that also two neutrino Cooper pairs are involved in the process? Note that this discrepancy is encountered also in in standard thermodynamical approach and can be overcome by assigning a gradient of chemical potential to the cell membrane. In quantum approach one cannot use this kind of argument.

If one accepts this picture, neutrino super-conductivity with neutrino Cooper pairs as carriers of Z^0 current becomes in principle possible and is even favored by energetics. I have earlier considered the possibility that neutrinos play a key role in cognition but gave up the proposed realization as unrealistic. In the recent situation one must however reconsider a new variant about the idea of cognitive neutrino Cooper pairs. A nice feature of this notion is that cognition would be shielded from electromagnetic perturbations from environment.

(a) One can apply the condition $E(\nu) = m_\nu$ to see whether it is consistent with the electron and neutrino masses predicted by p-adic mass calculations in the lowest approximation [K59]. For neutrinos one can identify two options giving $m_\nu \propto \sqrt{s_\nu}$, $s_\nu = 4$ or $s_\nu = 5$. For electron one has $m_e \propto \sqrt{s_e}$, $s_e = 5$. For $s_\nu = 5$ masses are identical for same p-adic length scale. For $s_\nu = 4$ one has $m_\nu = 2/\sqrt{5} m_e = .89 m_e$ in the same p-adic mass scale.

(b) Assume the recent Wikipedia value $p = .23970$ for the Weinberg angle. For electron $\Delta k = 46$ giving $k = 173$ (prime) predicts $V_{eff} = 2^{-23} m_e/(-1+x) \simeq .0561$ eV differing by 2 per cent from the nominal value.055 eV of the threshold potential for neurons.

(c) For $s = 5$ neutrino $\Delta k = 54$ gives $k = 181$ (prime) and $V_{eff} = 2^{-27} m_e/(2-x) \simeq .044$ eV differing by 10 per cent from the nominal value .040 eV of the threshold potential for photoreceptors in retina. Interestingly, one has $E(p) = eV_{eff}(p) = .040$ eV. These observations provide support for the idea that ordinary neurons/visual receptors correspond to far from/near to vacuum extremals, for the p-adic length scale hypothesis, and for the criterion $m = eV_{eff}$. Note that the p-adic mass scales for neutrinos and the light variant of electron are longer than those associated with Gaussian Mersennes. This is the case also for the ordinary weak bosons.

These considerations allow to take at least half-seriously the possibility that cell membranes correspond to near to and far from vacuum extremals depending on whether the membrane corresponds to neuron (cognition) or sensory receptor (sensory experience) and that electrons are light and dark for the far from vacuum extremals and neutrinos are light and dark for the near vacuum extremal.

Magnetic body and topological light rays from the point of view of energy storage and transfer

As noticed, in Maxwell's theory the dispersion of EM waves is problematic from the point of view of energy transmission unless geometric optics applies. In TGD Universe topological light rays possibly associated with magnetic flux tubes make possible precisely targeted communication and this difficulty might be circumvented. Remote metabolism possible in zero energy ontology also involves these structures and brings in additional flexibility.

The system using energy could store it temporarily at its magnetic body and transform the energy of cyclotron BE-condensate into various forms of energy assignable to visible matter. Tesla's vision was that energy transfer could take place in planetary scale by reflecting what he called longitudinal scalar waves from the upper boundary of Kennelly-Heaviside cavity. One can even imagine that the part of the magnetosphere associated with atmosphere, ionosphere, the part of magnetosphere rotating with Earth, or even entire magnetosphere could serve as an energy reservoir from which one could receive energy somehow. One can even ask whether solar radiation automatically takes care of the loading of these energy reservoirs. If so, the only problems to be solved would be how to control the magnetic body of the system using energy and generation of negative energy photons. One can also consider the option in which the magnetic body of the system is loaded by irradiating it with dark photons at cyclotron frequencies.

I have proposed that the generation of dark photons with given integer value of $\hbar_{eff}/\hbar = n$ is possible by performing amplitude modulation of high frequency radiation with frequency f_h using low frequency radiation such that the frequencies are related by $f_h = n \times f_{low}$. I have not been able to give a convincing justification for this proposal. This would generate dark photons with large value of $\hbar_{eff}/\hbar = n$. An open question is whether it automatically also generates dark magnetic flux tubes with accompanying the dark photons or whether they must be generated by a phase transition increasing $\hbar_{eff}$. In previous section a mechanism utilizing very strong electric fields and high voltages to generate dark Cooper pairs and dark photons as Josephson radiation from AC current system was discussed.

Lightnings, ball lightnings, and plasmoids as primitive life forms?

If one takes seriously the idea that Earth's electric field (see `http://tinyurl.com/y8wsggpq`) $eE_E = 100$ eV/m played the role of the electric field associated with cell membrane during the prebiotic period and also requires that the condition $eV_{cr} = .5$ MeV for the establishment of dark supra currents along helical structures, one must conclude that the minimal length of this kind of structure is about $L = 5$ km if the electric field remains constant as function of radial distance. A typical cloud-to-ground lightning flash indeed begins at this height. This would suggest that lightnings are generated when the criticality condition is satisfied.

E_E however weakens with height and the voltage associated with E_E reaches maximum $eV_E = .3$ MeV at height of 30-50 km. This is rather near to $eV_{cr} = .5$ MeV: perhaps lightning is generated when this maximum increases locally above $V_{cr} = m_e = .5$ MeV. This would mean that lightnings are initiated at much higher heights than thought and by above considerations could involve dark supra currents. This conforms with the recent observations that lightnings produce gamma rays and electrons with anomalously high energies (see `http://tinyurl.com/y8wsggpq`).

For the electric field $eE = 3$ MeV/m corresponding to di-electric breakdown in air perhaps assignable locally to the lightning the length would be $L = 18$ cm. I have proposed that plasmoids consisting of plasma and magnetic fields could correspond to primordial life forms. A charged helical structure carrying current and associated magnetic field defining its magnetic body would serve as a candidate for a plasmoid. Plasmoid and "ground" would define the "plates" of a capacitor-like system. If this view is correct, $L = 18$ cm is the minimum size scale of plasmoids (say ball lightnings).

12.8.4 How Could This Picture Relate To Biofield Research?

Various biofield therapies (healing by touch, remote healing, using electromagnetic fields, etc) rely on the observation that weak electromagnetic fields have effects on living matter and the assumption that this can be used for healing purposes. The article "Biofield Research: A Round Table Discussion of Scientific and Methodological Issues" [J3] gives an overall view about the challenges encountered. Biofield therapies represent alternative and complementary medicine and the attitudes of the mainstream are still very hostile. Bio-electromagnetism is a well-established branch of science studying effects of various kinds of electromagnetic fields on living matter and brain. Interestingly, Tesla is the father of the oldest healing method based on pulsed magnetic field generated by Tesla coil. This method is also accepted by standard medicine. The pain relieving effects of this treatment is still poorly understood. Furthermore, the work of the pioneers of bio-electromagnetism like Blackman and Adey revealed that ELF electromagnetic radiation have essentially quantal effects on brain in frequency-amplitude windows and that the field values involved are extremely small: of order 1-10 V/m in typical experiments [K40]. These effects are also poorly understood.

A further idea not accepted by mainstream medicine is the notion of "subtle energy". The concept is often used in a metaphoric sense and it is not clear whether its meaning is nearer to that of information. A more precise meaning for subtle energy could be as some yet unknown form of metabolic energy. Note that in TGD framework metabolic energy is accompanied by negentropic entanglement and conscious information at some level of the self hierarchy.

In the round table discussion some basic theoretical problems of biofield research were summarized. What happens to the physiology of the healer during healing? What are the receptor systems and transduction mechanisms in the healee? What is transmitted between healer and healee?

TGD allows to consider a possible answer to the latter two questions [K40]. The work of Blackman and others encourages the hypothesis that the effects on vertebrate brain are quantal and correspond to cyclotron frequencies for Ca^{++} ions in magnetic field which is 2/5 of the Earth's magnetic field (.3 Gauss). For the ordinary value of Planck constant quantal effects are definitely ruled out - the energy of photons would be ridiculously small when compared with thermal energy. This could be used as a justification for the hypothesis about hierarchy of effective Planck constants $h_{eff}/h = n$ following from the basic structure of TGD, and whose applications are discussed also in this article. If the thickness of the magnetic flux tube can be controlled as one particular magnetic motor action, also the local magnetic field can be varied in certain limits, and the outcome is a narrow frequency window.

The understanding of the amplitude windows for external electric field, call it E, is more difficult and has been a longstanding challenge. This article suggests the reduction of amplitude window to a window for Josephson energy. Denote by θ the angle between the plane of plates of Josephson junction and E. The energy gained by electron as it moves the distance d between the "capacitor plates" of a Josephson junction is $eV = eEdcos(\theta)$. It is also to the energy received by dark electron as it receives Josephson photon with energy equal to the electrostatic energy $eV = eEdcos(\theta)$. One can argue that the momentum gained by the electron in the absorption of Josephson photon and thus also that of Josephson photon must be in good approximation tangential to the membrane layer inside which it is confined. Since the momentum of the Josephson photon is orthogonal to its polarization, $cos(\theta)$ must be rather near to $cos(\theta) = 1$.

(a) The first proposed quantization formula proposed in this article is that Josephson frequency $f_J = ZeV/h_{eff}$ is sub-harmonic of cyclotron frequency: $f_J = f_c/l$, $l = 1, 2, ..$, with cyclotron frequency f_c identifiable as the frequency of irradiation. This formula relates the voltage V assignable to the radiation amplitude to its frequency equal to f_c.

(b) Josephson junction corresponds to a two-layered structure such that the electrostatic energy in the voltage between the outer surfaces of the structure corresponds to electron mass scaled by the value of Planck constant $h_{eff}/h = n = 2^{\Delta k}$: $eV = m_e/2^{\Delta k}$. This works nicely for cell membrane and the cautious proposal is that it works more generally.

(c) A resonant interaction between "large" Josephson junctions and cell membranes is needed and becomes possible by the exchange of Josephson photons if the Josephson energies

eV and the value of h_{eff}/h - that is Δk are same for the two systems. This gives a quantization condition for the thickness of the "large" Josephson junction using the value of electric field $E = x$ V/m with x in the range $[1, 10]$: $eV = eEdcos(\theta) = eV_{crit} = .055$ eV giving $dcos(\theta) = 5.5/x$ cm. $x = 1$ corresponds to $cos(\theta) = 1$ giving that the thickness of the Josephson junction is is 5.5 cm: this is roughly the scale of brain hemisphere. Variation of the angle θ gives frequency window via $cos(\theta) = 1/x$. At least two frequency windows are reported and correspond to $x \in [1/2, 1]$ and $x \in [1/10, 1]$. Already in the first case the range for θ would be 60 degrees. It seems that several values of d in the range of $[.55, 5.5]$ cm are required in both cases. They could correspond to p-adic length scales $L_e(k)$ in the range $k \in [181, 183]$ for the first case and $k \in [177, 183]$ for the latter case.

(d) Cell membrane as Josephson junction is only a macroscopic description of the situation. Membrane proteins defining channels and pumps are very natural candidates for a more precise microscopic description of Josephson junctions at cell membrane scale. Ca^{++} channels would be especially interesting in this respect since Ca^{++} is a boson and can form Bose-Einstein condensates as such. The natural question is what are the microscopic counterparts of Josephson junctions in longer length scales.

What would be transmitted between the healer and healee could be dark photons and possibly also dark electrons and even ions. The ability to generate negentropy would be also transmitted and perhaps a better manner to think about the situation is to regard healer and healee as a single system as long as the flux tube connections generated by reconnection of flux tubes are present. Also remote metabolism in which healee emits negative energy Josephson photons received by healer can be considered.

12.8.5 Tesla Coils From TGD View Point

In the sequel coils considered by Tesla are reconsidered from TGD viewpoint and an attempt to understand in more detail the phase transition to dark matter as a phenomenon accompanying resonance is made.

Is the model for the resting potential really consistent with the interpretation of Tesla's experiments?

Is the proposed picture consistent with what happens in Tesla's experiments, where very high voltages somewhat above $eV_{crit} = m_e$ were created? In living matter the voltage values are much lower and this determines the value of $n = 2^{\Delta k/2}$. Does this mean that one has $n = 1$ in Tesla's experiments? This would be rather disappointing but could quite well make sense for the coil-Earth system regarded as capacitor. In both situations very strong electric fields are encountered and the idea about large value of n is very attractive.

The solution ansatz assumes generation of light fractional electrons as in the case of cell membrane and starts from from the idea that the subsequent turns of Tesla coil are analogous to the lipid layers of cell membrane and define Josephson junctions. The observed radiation assigned to dark currents could also correspond to Josephson radiation.

(a) Since electric voltage propagates with finite velocity of order light velocity along the coil, there is a potential difference between corresponding points of two subsequent turns of the coil. Could it be that super-conductivity sets on and oscillatory Josephson currents flow between the two subsequent turns and the observed light emission can be assigned with dark currents is Josephson radiation? The electric field is very strong at points where charge accumulates and one expects phase transition. Since the maximal value of the oscillating potential difference between subsequent turns above critical voltage $eV_{cr} = m_e$ is smaller than eV_cr, a scaling of electron mass downwards is however expected to occur by the proposed criterion for cell membrane: $m_e \to m_e/n$, $n \simeq 2^{\Delta k/2}$, $n = h_{eff}/h$. Electrons would become light.

(b) To estimate n one can use a simple estimate for the voltage as function of time and angle variable ϕ along the helical coil of radius R given by equations $z = KR\phi$, $\rho = R$.

The distance along coil given by $s = \sqrt{1+K^2}R\phi$. One can express K as the ratio of height to the total length s_{tot} of the coil: $K = h/s_{tot}$. The voltage is given by $V(t,\phi) = V_0 sin[\omega_{AC}(t - \sqrt{1+K^2}R\phi/c)]$. The voltage difference between points of subsequent turns with values of ϕ differing by 2π is $\Delta V \simeq (\partial V/\partial\phi)2\pi = (\partial V/\partial t)2\pi R\sqrt{1+K^2}/c$. Josephson current is given by

$$J = J_0 sin(\frac{\int dt \Delta V}{h_{eff}}) = J_0 sin[\frac{2\pi}{f_0}\frac{1}{h_{eff}}V(t)] \quad , \quad f_0 = \frac{c}{R\sqrt{1+k^2}} \quad . \tag{12.8.7}$$

(c) Near zeros of V one has in the first approximation $V(t) = V_0\omega(t - t_{max})$ and Josephson current behaves as

$$J_0 sin[\omega_{eff,J}(t - t_{max})] \quad , \tag{12.8.8}$$

where

$$\omega_{eff,J} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \frac{1}{h_{eff}} \tag{12.8.9}$$

defines the analog of Josephson frequency for effective voltage

$$V_{eff} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \quad . \tag{12.8.10}$$

If one applies the earlier argument this would mean that the critical voltage $eV_{cr} = m_e$ is scaled down to $V_{eff,cr} = (2\pi)^2 \frac{f_{AC}}{f_0} m_e$ and that electron becomes dark electron with p-adically scaled down fractional mass at each sheet of multi-furcation.

(d) Using the proposed formulas $h_{eff}/h = n = 2^{\Delta k/2} = V_{cr}/V_{eff,cr}$ one obtains the estimate $n = (2\pi)^{-2}\frac{f_0}{f_{AC}}$. For $R = .1$ m and f_{AC} in the range $[20, 10^2]$ kHz one would have n in the range $[380, 76]$. The condition $n = 2^{\Delta k/2}$ restricts the range to even powers of 2: $\Delta k = \{16, 14, 12\}$. The corresponding p-adic scales would be $L_e(k)$, $k = 127 + \Delta k$ giving $k = 143, 141, 139$. $k = 139$ corresponds to atomic length scale and $k = 143$ to $4 \times L_e(139)$.

(e) The surface density of electronic charge carriers should be few electrons per surface area defined by $L_e(k)$. This condition looks reasonable since electron density is about one electron per atomic volume. On the other hand, from the critical value of electric field in air the charge density would be only few electron charges per μm^2 (cell size scale). Electrons should indeed separate to its own dark phase at n-sheet. This would also lead to high charge density for ions inducing dielectric breakdown.

What traffic jam in Tesla coil could mean?

What "traffic jam" or its analog could mean from the circuit theory point of view and how the traffic jam could be resolved in TGD framework?

1. First trial

In the following a simple manner to illustrate the idea in terms of effective description of coil as L, C, and R in series is discussed first.

(a) It is essential that in the experiments of Tesla both primary and secondary coils were in resonance with the same resonance frequency so that primary coil acted as driving force for the secondary and in the resonance created the situation possibly forcing the new physics to emerge via a phase transition to dark matter phase. Primary feeds the secondary with a sinusoidal input at resonance frequency. Modelling the secondary as a circuit with L, C, and R in series, one obtains simple second order differential equation for its behavior

$$\frac{Ld^2I}{dt^2} + R\frac{dI}{dt} + \frac{I}{C} = \frac{dV_{ext}}{dt} \equiv g(t) = Asin(\omega_0 t) \tag{12.8.11}$$

The right hand side represents the voltage assignable to the primary. For L, C, R in parallel one must express effective R, C, L using the real R, C and L using the formula

for $1/Z$ as sum of $1/R, 1/C, 1/L$. Resonance frequency transforms however from $1/\sqrt{LC}$ to $\sqrt{R/L}$ in parallel case at the limit of vanishing R. $R = 0$ in complete resonance for series is replaced with $R = \infty$ for parallel case (the current does not flow at all through R so that the outcome is pure L, C circuit).

(b) Solutions are sums of two solutions of homogenous equation and a special solution of inhomogenous equation. Solutions of the homogenous equation reduce to linear combinations of two exponent functions

$$I_{\pm}(t) = exp(-\Omega_{\pm}t) \ , \ \Omega = \frac{-R}{2L} \pm i\omega \ , \ \omega = \sqrt{\frac{1}{LC} - (\frac{R}{L})^2} \ . \tag{12.8.12}$$

(c) The solutions of inhomogenous equation can be obtained by the variation of coefficients for homogenous solutions that is in the form $I^1_{\pm} = C_{\pm}(t)I_{\pm}(t)$ and are given by

$$I^s_{\pm}(t) = \int_0^t \frac{g(t)}{L} I_{\pm}(t)dt \times I_{\mp}(t) \ . \tag{12.8.13}$$

The outcome from the exponentials is a combination of trigonometric functions and constant functions, which vanish at origin. The resonance corresponds to $\omega = \omega_0$ and means that the exponential decay for the special solutions is compensated by the energy feed. At the limit $R/L \to 0$ the amplitude of $I_{\pm}$ divergences and the solution for R/L is combination of trigonometric functions multiplied by t so that the envelope of the solution increases linearly.

(d) Physically the resonance means that the charge of the capacitor oscillates with amplitude, which becomes very large at resonance $\omega = \omega_0$ (the amplitude is proportional to L/R at resonance for the series case): note that large inductance makes the resonance stronger. The charge of the coil begins to fluctuate with a large amplitude. To estimate the charge notice that in a reasonable approximation the current has same phase along the coil. The reason is that the voltage represents a signal propagating with almost light velocity along the coil and the phase change $\Delta\phi = \omega T = \omega L/c \sim 10^{-3}$ and therefore rather small. Charge is given by $Q(t) = \int I(t)dt$ in good approximation (current all points of coil is in the same phase).

(e) Near resonance the amplitude of charge oscillations becomes very large and the system must become unstable. Something must happen. TGD inspired proposal is a transition containing plasma phase and dark matter and dark magnetic flux tubes as a counterpart of Tesla's cold currents.

Second trial

Second trial is inspired by catastrophe theory.

(a) Voltage and frequency would be the control variables and $|Z|$ could be taken as behavior variable if cusp is assumed to model the situation. There would exist a critical frequency interval inside which two phases are possible. The first phase could be ordinary and second phase could correspond to di-electric breakdown generating plasma and dark currents flowing along dark magnetic flux tubes. This is just one possibility but perhaps the most realistic one. The transition to the phase containing plasma and dark currents takes place at certain frequency above certain critical voltage and frequency range becomes wider as the voltage increases. Plasma can be assigned with the capacitor defined by the di-electric surrounding the coil and the super conducting dark phase with the dark magnetic body of the coil itself. Both are generated at say "the lower" sheet of the cusp. The critical voltage corresponds locally to surface charge density (essentially normal component of electric field at the surface of the conductor) above which di-electric breakdown takes place.

(b) The end points of the frequency interval correspond to effective resonances since a sudden transition between the two phases takes place as one approaches the apparent resonance frequency either from below or above. For genuine resonance would result from both sides and hysteresis is basic prediction of this model. L, C, R change in discontinuous manner inducing discontinuous change of Z. In particular, the phase changes suddenly

and discontinuously so that resonance interpretation is suggestive but would be wrong. Catastrophe theory with $|Z|$ as behavior variable predicts discontinuity of $|Z|$ at the transition.

(c) The phases have electric *resp.* magnetic character, and would be in certain sense duals of each other. In second phase dissipation is small and therefore also $|Z|$ is small whereas in the second phase dissipation is larger and $|Z|$ is large. Whether resistance increases or decreases in the transition to dark plus plasma phase depends on the proportion of the two phases involved.

(d) In this picture one does not have genuine resonances but pairs of dual phase transitions. Unfortunately, the testing of this proposal is not easy since the impedances are measured assuming linearity and using rather weak voltages around 1 V whereas plasma phase and cold currents are generated at voltages, which are above kilovolt scale. Intriguingly, the resonances appear in this kind of situation as pairs, and it is possible to reproduce them by a suitable circuit model. It does not look too plausible that small amount of dark phase and plasma could be present at so low voltages but one must have an open mind in this respect.

(e) It is possible to obtain also a connection to real resonances since in the vicinity of the resonance frequency the criterion for the formation of plasma is expected to be satisfied for high enough voltage. If the value of surface charge density is what matters then the frequency dependent real part of the charge of the coil defined as integral of the current $I = V/Z$ near resonance determines the threshold for the generation of the plasma and dark current. The total charge per area of the coil must be above certain critical value corresponding to the critical electric field at which di-electric breakdown occurs. This threshold condition defines the boundaries of the region of (V_0, ω) plane inside which the two phases can be present. The phase transition between ordinary and plasma containing phases takes place at its boundaries. Cusp catastrophe would correspond to a frequency interval around resonance.

Could one detect the generation of dark matter in the behavior of frequency dependent impedance?

The generation of dark matter would involve also the emergence "dark magnetic flux tubes". Dark magnetic flux tube would correspond topologically to the analog of n-sheeted covering space for $n = h_{eff}/h$. Ohmic currents would be replaced with dark supra currents flowing along dark magnetic flux tubes and correspond to Tesla's cold electricity. The generation of strong electron densities and thus strong electric fields at the surfaces of the conductors - in particular coils - is the prerequisite for the phase transition to dark electronic superconductivity. This would manifest itself as local dielectric breakdowns as in the experiments of Tesla. Resonances mean strong ohmic currents and the phase transition could accompany resonances for sufficiently high voltages.

If the dark magnetic fields correspond to separate space-time sheets carrying dark electron Cooper pairs, there is a temptation to conclude that the presence of the dark currents ("cold electricity" of Tesla) is not seen in the description of circuits using ordinary circuit theory applying only for the visible matter. In particular, one can argue that the contribution of the induced dark magnetic fields to the inductance characterizing visible matter becomes vanishing. In the framework of circuit theory this would look like a transition to a state in which the visible part of system - say coil - behaves like a capacitor. Here one must make distinction between two meanings of capacitance: could behaves like a charge reservoirs defining together with ground a capacitor like system or could itself becomes analogous to a pair of capacitor plates. If the second end of the system is grounded, these two views seem to be more or less equivalent.

(a) In circuit theory description this kind of transition would be analogous to a resonance since it involves a change of the sign of the phase of the frequency dependent impedance $Z(\omega)$ when the reactance $X(\omega)$ in the expression of impedance

$$Z = R + iX \quad , \quad X = \omega L - \frac{1}{\omega C}$$

vanishes. Note that system is modelled as R, C, and L in series. R, C, and L are assumed to be slowly varying functions of frequency ω and provide effective reparameterization for the frequency response of a complex system.
Also modelling as R, C, and L as parallel is possible and means that inverse of Z is sum of inverses of various contributions. This means a reparameterization giving:

$$\omega_{\pm} = -i\frac{1}{2RC} \pm \frac{1}{2}\sqrt{-(\frac{1}{RC})^2 + \frac{4}{LC}} \ .$$

One can say that these resonances are duals of each other and related by $R/L \leftrightarrow 1/RC$. One can say that the roles of inductance and capacitance are changed in the parallel coupling. Note that at the limit $R \to 0$ in parallel case second resonance frequency approaches to $\omega_+ = \sqrt{\frac{R}{L}}$. Note that the limit of very large R gives $\omega_{\pm} = \pm 1/\sqrt{LC}$. The interpretation is that the current does not flow through R and one obtains pure L, C resonance.

(b) The resonances of course have interpretation in terms of ordinary circuit theory thinking and possible phase transitions to dark phase only accompany the resonances. The turns of the coil are insulated from each other and same applies to the primary and secondary of a transformer like system as well as components of a system consisting of several coils. The insulation is obtained by using di-electric which polarizes so that one obtains effectively capacitor like systems since insulating material develops a polarization as a reaction to the charge of the coil. One has effectively L and C in parallel. This gives rise to a resonance frequency. Since C behaves like surface area per distance between the plates, and L is proportional to the length of the coil, the resonance frequency decreases with the size of the coil.
Resonance interpretation in strong sense requires also that the values of the phase are near to $\pi/2$ for the inductive phase and $-\pi/2$ for the capacitive phase for R, C, L in series. For R, C, L in parallel the roles of L and C are changed. The strength of the resonance depends on how large the change of the magnitude of the phase angle of Z is. One has two kinds of resonances depending on the sign of the change of the phase angle as ω increases. For R, C, and L in series the transition from capacitive to inductive phase - Φ decreases - would correspond to series resonance in ordinary circuit theory, where capacitance dominates at low frequencies for series configurations. Increase of Φ could be called "antiresonance". Parallel resonance would correspond to the increase of Φ as function of ω and decrease for "antiresonance". In the following I will speak only about resonances. The resonance with a phase transition decreasing/increasing Φ is expected to be followed by a reverse transition increasing/decreasing it in the case that Φ is near $\pm\pi/2$ between resonances (this requires small enough real part of Z).

(c) For coils these two kinds of resonances are expected to correspond to different kinds of phase transitions.

i. An obvious and directly observable phase transition occurring at resonance is the generation of plasma phase in di-electric breakdown from the surface of di-electric surrounding coil wire or from the di-electric surrounding entire coil. This phase transition dissipates energy, and one expects that resistance increases in the vicinity of the resonance as function of ω. This means also maximum for reactance. Phase transition like property would suggests sharp peak like maximum instead of a smooth parabolic maximum.

ii. The phase transition to dark super-conductivity is expected to be assignable to the coil itself and involve generation of dark magnetic flux tubes and Cooper pairs of dark electrons as current carries at it. This phase transition is expected to reduce dissipation and induce a peak like minimum in resistance difficult to explain in terms of plasma generation - this assuming that impedance corresponds to the entire current rather than only its visible part. This is the case if the dark current transforms to ordinary one in the measurement of the current-voltage frequency response.

iii. These two phase transitions have electric *resp.* magnetic character and are could be seen as duals. The data about impedances of certain kind of coils suggests that

these phase transitions occur pairwise at nearby frequencies ω_1 and ω_2] spanning a frequency range $[\omega_1, \omega_2]$ inside which the sign of the phase angle Φ between current and voltage remains constant. Even Φ is expected to be approximately constant for small enough values of resistance. The could be also seen as support for the proposal that resistance has maximum/minimum, which could be assigned with the proposed two kinds of phase transitions.

iv. There is however a strong objection against this speculative line of thought. Complex circuitry can produce this kind of behaviors without any new physics. This is clear from the rules for the analytic expressions of the circuit parameters as one builds circuit from smaller circuits in parallel or in series. The phase transitions related to new physics should occur for strong electric fields above the threshold for dielectric breakdown. The peaky behavior however occur also for the impedances obtained using low input voltages (actually the only possible manner to determine impedance) so that poor resolution is the natural explanation for it.

(d) Since the dark matter resonance could induce (quantum) phase transition and criticality, one expects that various physical observables are in general non-analytic functions of the dimensionless parameter $(\omega - \omega_0)/\omega_0$ near ω_0. This applies also to the phase transition to plasma phase. ω would be be analogous to temperature and ω_0 to a critical temperature. Whereas high temperature super conductivity is in finite temperature range, the dark phase would exist in the recent situation in finite frequency range around the resonance frequency (of course, also the temperature range could be finite).

(e) Typically non-analytic sharp peaks involving functions u^m, where one has $u = |(\omega - \omega_0)/\omega_0|$ and m is so called critical exponent, appear. For $|Z|$ one expects have $m < 1$ meaning divergent and discontinuous derivative at ω_0. The sides of the curved "V" (possibly upside down) would be convex - in other worlds, the derivate would decrease in magnitude as one proceeds from the singularity outwards. Ordinary circuit theory predicts a smooth parabolic behavior $|Z| = \sqrt{R^2 + bu^2}$ for which "V" would be replaced with what looks like a bottom of a smooth potential well. For very small resistance R this situation looks in a non-optimal frequency resolution like $Z \simeq R + ku$ having discontinuous but *finite* derivative at ω_0. These are very general qualitative predictions and easily testable using sufficiently high frequency resolution so that the local diffeo-invariants can be identified reliably.

(f) It could quite well be that the resonances look like smooth parabolic peaks in good enough frequency resolution. This does not mean that the assignment of phase transition to the resonance is physically wrong. In TGD framework the notion of resolution is an essential part of the physical description and different length scale resolutions correspond to different sheets of many-sheeted space-time. At small space-time sheets the description in terms as ordinary resonances could quite well make sense. Of course, already the usual description of critical systems relies on the notion of resolution - in the recent case for frequency and the successes of the conformal field theory justify fully the notion of resolution.

TGD based view about high T_c superconductors provides additional insights about the situation.

(a) Since charge carriers are concentrated at the surfaces of conductors, conductors are effectively 2-D systems and since quantum TGD itself describes a universe which is effectively 2-dimensional, 2-D conformal field theories with temperature replaced with frequency as an external parameter could provide a lot of theoretical information about the system both at criticality and in its vicinity. Of course, dark phase could also occur in finite temperature range as the properties of living matter suggest. One should of course test whether linearity is true or whether also amplitude of the oscillating voltage could a parameter analogous to the dimensionless parameter $(\omega - \omega_i)/\omega_i$ so that dark phase would exist also in voltage windows.

By conformal invariance the observables are scaling covariant at criticality and various correlations functions behave in a simple manner at criticality being characterized by anomalous dimensions. In the vicinity of critical point various observables are simple power functions of $(\omega - \omega_i)/\omega_i$ characterized by critical exponents (`http://tinyurl.`

com/ybkl3c8c). The anomalous dimensions and critical exponents do not depend on the details of the system, and one characterize the system by its universality class near criticality.

(b) In TGD inspired model of high T_c superconductivity the analog of percolation (say (liquid trickling through a porous material) (http://tinyurl.com/34nujm) serves as a basic mechanism of high T_c superconductivity. Magnetic flux tubes with relatively small value of h_{eff} would be present and super-conducting but have short length. In the phase transition to super-conductivity the flux tubes would be scaled up in length and combine to longer ones corresponding to larger value of h_{eff} and supra currents would flow through the entire wire. In 2-D case the phase transition to percolation is believed to be describable by a 2-D conformal field theory.
There exist rather detailed theoretical results about the behavior of the system at criticality and outside it and it might be possible to extrapolate these results to the recent case. One should be however very cautious since in TGD framework the view about renormalization group evolution crucial for the standard view about criticality is not quite the standard one.

(c) Continuous coupling constant evolution having continuous scaling parameter as argument is in TGD framework replaced with a discrete evolution with discrete hierarchy of p-adic length scales replacing continuous scale. All physical states corresponds to fixed points of renormalization group for each p-adic length scale. 2-D conformal field theories indeed describe fixed points renormalization group which the effective 2-dimensionality of TGD Universe implied by strong form of holography and general coordinate invariance conforms with this. Various quantum criticalities differ only in the degree of criticality measured by the number of variables which are critical. In catastrophe theory the singularities of potential function provide a visualization of the situation: the simplest situation occurs with potential has extremum. A more critical situation occurs when also the matrix defined by the second derivatives of the potential function has vanishing determinant. This sequence can be continued indefinitely if the numbers of control parameters and behaviour variables are arbitrarily large.
What does this general picture imply in the recent situation? For instance, should one interpret the entire frequency range in which system is dark super-conductor as critical so that the standard thermodynamical picture assigning criticality only to the phase transition point would not apply as such in quantal situation. It seems that self-organized criticality is nearer to the TGD picture although the critical system is not attractor in the ordinary sense in TGD framework. State function reduction generates critical states and negentropic entanglement and Negentropy Maximization Principle guarantees their stability.

What would be remarkable is that the generation of dark matter phase would be directly measurable using standard measurements. For instance, one could study the frequency dependence of impedance for simple coils and transformers to see whether resonance involving minimum of frequency dependent resistance occur and whether they look like phase transitions - being peaked. If this is the case, one could study the properties of the system around resonance and try to identify further signatures for dark matter (say Josephson currents between turns of a coil). The conclusion is that it is better to be very cautious: the exotic phenomena are expected tro occur for very high voltages and electric fields for which linear circuit theory fails. Peaking however occurs for weak voltages so that they are probably due to poor resolution.

Could the arrow of time change in electric circuits?

The change of the arrow of geometric time means that dissipation as a loss of energy takes place in reversed time direction. Second law holds still but in a generalized form. In zero energy ontology (ZEO) the quantum jump sequence corresponds to a sequence of pairs of state function reductions to the opposite boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones. The arrow of geometric time would change in each state function reduction since the state is prepared state at either boundary

and de-localisation occurs at opposite boundary whose position (and thus the size of CD in quantum superposition) varies.

For large enough CDs the arrow of geometric time as perceived by an observer would remain constant. For short time scales characterizing CD the observer would interpret the change of the arrow of time as thermodynamical fluctuations. In living matter the change of the geometric arrow of time might take place continually. Italian theoretician Fantappie indeed suggested long time ago that this might be the case and introduced the notion of syntropy. Syntropy could be interpreted in TGD framework as time reversed counterpart of entropy [J30].

The reversal of the arrow of geometric time implies that the system becomes apparently an over unity system producing energy instead of dissipating it. Since dissipation power equals to $P = I^2/R$ in circuit theory, time reversal would imply a negative resistance. The concrete signature for the change of the arrow of time is that the magnitude of the phase angle between the current and voltage defined by the impedance would become larger than $\pi/2$.

There are indications for this kind of phenomenon in coil like systems. For instance, the measurements of inductance for a coil reported in the master thesis "Voltage distribution along reactor winding under very fast transients" by Salman Ejaz and Saeed Anwar (`http://tinyurl.com/ydx85jwa.pdf`) demonstrate this kind of effect (Figure 9) [H4]. The graphs of impedance demonstrates also the change of the sign of the phase angle as function of frequency suggesting interpretation as a time reversed resonance. The radical interpretation would be as a temporary change of the arrow of geometric time. Also over-unity effects have been reported - in particular by the free energy community.

The transition to time reversed situation occurs by state function reduction suggesting that it cannot be performed continuously. For a given CD one cannot change the arrow of time in a continuous manner by going through an intermediate frequency for which resistance vanishes. This conclusion does not hold true if the system decomposes a collection of CDs with different arrows of geometric time in the transition.

Skeptic can invent at least the following objections against this interpretation.

(a) The system measuring the impedance does not work properly and gives phase whose magnitude exceeds $\pi/2$ predicted by the positivity of resistance.

(b) The model of an electric component using LCR parameterization is only an effective description for a complex system which can involve also a generation of plasma phase meaning that the coil is not anymore a closed system since charge carriers leak out. It can happen that the magnitude of the phase difference between current and voltage can become larger than $\pi/2$.

Could remote metabolism work for a Tesla coil acting as a capacitor?

The best manner to demonstrate new phenomenon is to generate it artificially. The previous considerations suggest a possible model for how artificial remote metabolism could be realized in terms of something akin to Tesla coil or magnifying transmitter. Bifilar coil (`http://tinyurl.com/mvweora`) looks like a promising realization of the coil. There are two options corresponding to the possibilities that the currents in the two components of bifilar coil runs in same or opposite directions. In the latter case, the magnetic field generated by the bifilar coil is very weak and coil acts as capacitor.

(a) The secondary in Tesla transmitter acts as both inductance and capacitor. The alternating magnetic field associated with the inductance implies magnetic motor activity for topologically quantized magnetic field, and would make it ideal for developing reconnections with the flux tubes of a larger magnetic body providing via remote metabolism the energy and charge to the secondary acting as a capacitor. It is however essential that the strength of the magnetic field at the flux tube is same as that at the larger magnetic body.

(b) The model for cold electricity in terms of dark matter suggests that when the voltage along bifilar coil exceeds critical voltage V_{cr}, it becomes charged and together with Earth forms a capacitor in voltage V_J defining Josephson potential for the resulting Josephson

junction. A good guess for V_{cr} is $eVcr = m_e = .5$ MeV. V_J is rather high and above the critical voltage V_d for dielectric breakdown. The generation of charge is due to the "traffic jam" for electrons making also possible the phase transition to dark matter. If this picture is correct, Josephson currents do not appear below V_{cr} and coil or bifilar coil acting as a capacitor is necessary for the the remote metabolism. The constant part of voltage would make the resulting coil/capacitor hybrid analogous to cell membrane. Also DNA double strand could serve as a similar coil/capacitor-like system: now the traffic jam would correspond to the presence of two electron charges per nucleotide due to the attached phosphates expected to relate closely to metabolism and therefore also remote metabolism.

(c) For general coils or bifilars for which the currents are parallel the transition to the dark phase would have measurable circuit theoretic correlates. The traffic jam for electrons would generate dark supra phase propagating along dark magnetic flux tubes. Only very weak ordinary magnetic fields are generated. Therefore the inductance in visible sector is very small and system becomes capacitive. The resonance like transitions from a situation in which the phase of the frequency dependent impedance $Z = R + i(\omega L - 1/(\omega C)$ (R, L and C depend on ω) characterizing physics in the visible sector suddenly changes sign and changes from almost $\pi/2$ to $-\pi/2$ could be seen as a measurable signature for the generation of dark Cooper pairs (cold currents of Tesla). Dark phases could appear in finite frequency ranges.

(d) The interpretation in terms of the credit card mechanism would suggest that the resulting system is able to store energy at its magnetic body and also load it when needed - even from foreign magnetic body. The loading should be a spontaneous process and understandable in terms of the need to survive reducing to Negentropy Maximization Principle [K64]. Hence the system would in this respect act like a living system. Loading means the sending of negative energy signals to the magnetic body as phase conjugate Josephson photons. This involves also the change of the arrow of the embedding space geometric time in the time scale defined by single cycle of the process. Macroscopic quantum phenomenon would therefore be in question.

12.8.6 Tesla's Findings From A New Viewpoint

Tesla's experiments with induction coils generated strong AC electric fields inducing charge separations leading to di-electric breakdowns through the surrounding air, kind of mini-lightnings. I have proposed that both real and mini-lightnings involve large h_{eff} phase making possible high temperature super-conductivity along pairs of magnetic flux tubes forming possible U-shaped loops which reconnect with the target: this provides a model for high T_c superconductivity. There is evidence that electrons in lightnings travel to the surface of Earth with very low dissipation and also gamma rays are observed. These facts are not consistent with the standard physics models for lightnings since the dissipation in atmosphere does not allow these phenomena.

A concrete model for the Cooper pairs would be as pairs of electrons at neighboring tubes with magnetic fluxes which have same (opposite) directions. The presence of magnetic fields concentrated at flux tubes favors formation of $S = 1, L = 1$ Cooper pairs ($S = 0, L = 2$) Cooper pairs [K23, K92, K83].

To proceed one should try to find a more concrete model for the generation of large value of h_{eff} making possible super-conductivity.

How to understand the value of $heff$?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

(a) The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [K12].

The findings of Pollack and the difficulties to understand metabolic energy quantum of nominal value.5 eV in the simplest model for cell membrane as Josephson junction as Josephson energy for Cooper pair equalto to $ZeV = 10-10.6$ mV inspired the assumption that cyclotron energies at flux tubes traversing cell membrane can be different at the two sides of the cell membrane [K40, K83]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_A C$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC})$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_C$. Note that correct sign requires $\Delta f_C - f_{AC} > 0$.

(b) The conjecture $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

(c) $h_{eff} = h_{em} = Z_1 Z_2 e^2/v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory is in powers of $1/h_{eff}$) possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n-branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.

(d) Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K55] when one requires internal consistency.

Could dark electrons or protons at magnetic flux tubes serve as current carriers?

There are clearly many options for h_{eff} to choose if one wants to model Tesla's findings. Some options are characterized by AC frequency and some options by rotation velocity. The electrons in the secondary Tesla coil were believed to get stuck which one could take to mean that ohmic AC current does not flow anymore. If this really occurs electrons do not carry any current and high negative local charge density is generated.

One can consider several mechanisms for the super-conductivity.

(a) Some fraction of electrons flows as dark Cooper pairs along magnetic flux tubes. The members of the Cooper pair could reside at the flux tubes of the approximately dipolar magnetic field located in the interior of the coilandat the exterior of the coil near its surface and carrying magnetic fluxes in opposite direction. The interaction of spin with magnetic field usually tends to disrupt the Cooper pair but not it stabilizes it. One can consider several guesses for the value of h_{eff} since AC current is in question.

(b) If the notion of exclusion zone makes sense also for more general systems than water, one might guess that perhaps dark magnetic flux tubes carrying dark protonic currents along them are generated. The objection is that water is not present now and this option works only if there is source of protons. This option does not look very promising now.

Second challenge is to identify candidates for the supra currents and Josephson currents possibly appearing in the system.

(a) Mini-lightnings carrying supra currents could form when U-shaped flux tubes from the secondary coil reconnect with "ground" and dark supra current flows along them. The formula $h_{eff} = Z_1 Z_2 e^2/v_0$ or even $h_{gr} = M_E m(pair)/v_0$, v_0 rotational velocity of Earth, suggests itself now. Z_2 could be the charge $2e$ of the Cooper pair and Z_2 could be assigned with ground as charge reservoir.

(b) One can also consider Josephson currents flowing along flux tube pairs associated with the time-dependent dipole magnetic field accompanying the coil. They would replace the Ohmic AC currents when electrons are "stuck". Josephson frequency would co-incide with AC frequency.

In the case of Josephson current the problem seems to be that the voltage defining Josephson frequency varies periodically as also the magnetic field for AC current. The sticking of Ohmic charge is however expected to destroy AC current so that one would obtain static voltage if ohmic DC current runs through the coil. Thus DC current seems to be necessary.

Static magnetic fields are also necessary for high T_c super-conductivity. They are achieved if the AC component of the Ohmic current becomes small or vanishing. In Maxwell's ED also also a small DC current present unless the coil contains ferromagnet. In TGD Universe it is also possible that a magnetic field with flux tubes carrying monopole flux requiring no DC current is is generated. This kind of monopole magnetic fields could be responsible for the magnetic fields encountered in cosmology and astrophysics (the observed fields are 11 orders of magnitude stronger than the predicted) and could also appear in superconductors and even in ferromagnets.

In this situation the formula $h_{eff}/h = E_J/hf_{AC}$ would state that the coil acts as a generalized Josephson junction with AC current replaced with Josephson current with $f_J = E_J/h_{eff} = f_{AC}$. The formula $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC})$ would require that the magnetic field strengths at the ends of coil are different so that also the cyclotron frequencies are different. AC frequency would be equal to the generalized Josephson frequency: $f_{AC} = \Delta f_c - E_J/h_{eff}$. In this case one can consider even the possibility that there is no DC current so that one has $f_{AC} = \Delta f_c$. This fixes the increment ΔB for the magnetic field.

12.9 Teslaphoresis in TGD

I found an interesting popular article about a recently discovered phenomenon christened Teslaphoresis [D4] (see `http://tinyurl.com/htyaf4h`). This phenomenon might involve new physics. Tesla studied systems critical against di-electric breakdown and observed strange electrical discharges occurring in very long length scales. Colleagues decided that these phenomena have mere entertainment value and are "understood" in Maxwellian electrodynamics. The amateurs have however continued the experiments of Tesla, and Teslaphoresis could be the final proof that something genuinely new is involved.

In TGD framework these long ranged strange phenomena could correspond in TGD quantum criticality and to large values of Planck constant implying quantum coherence in long length scales. The phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant would correspond to dark matter in TGD framework. I have earlier considered Tesla's findings from TGD point of view and my personal opinion has been that Tesla might have been the first experimenter to detect dark matter in TGD sense. Teslaphoresis gives further support for this proposal.

The title of the popular article is "Reconfigured Tesla coil aligns, electrifies materials from a distance" tells about the effects involved. The research group is led by Paul Churukuri and there is also an abstract about the work in ADS Nano journal [D4] (see `http://tinyurl.com/z3qybx2`). This article contains also an excellent illustration allowing to understand both the Tesla coil and the magnetic and electric fields involved. The abstract of the paper provides a summary about the results.

This paper introduces Teslaphoresis, the directed motion and self-assembly of matter by a Tesla coil, and studies this electrokinetic phenomenon using single-walled carbon nanotubes (CNTs). Conventional directed self-assembly of matter using electric fields has been restricted to small scale structures, but with Teslaphoresis, we exceed this limitation by using the Tesla coil's

antenna to create a gradient high-voltage force field that projects into free space. CNTs placed within the Teslaphoretic (TEP) field polarize and self-assemble into wires that span from the nanoscale to the macroscale, the longest thus far being 15 cm. We show that the TEP field not only directs the self-assembly of long nanotube wires at remote distances ($\geq$ 30 cm) but can also wirelessly power nanotube-based LED circuits. Furthermore, individualized CNTs self-organize to form long parallel arrays with high fidelity alignment to the TEP field. Thus, Teslaphoresis is effective for directed self-assembly from the bottom-up to the macroscale.

To sum up: what is found that single-walled carbon nanotubes (CNTs) polarise and self-assemble along the electric fields created by capacitor in much longer length scales than expected. Biological applications (involving linear molecules like microtubules) come in mind. CNTs tend to also move towards the capacitance of the secondary coil of the Tesla coil (TC).

I the sequel the TGD counterparts for the Maxwellian em fields involved with Tesla coils are considered in TGD framework and it is found that many-sheetedness of space-time is necessary to understand the standing waves also involved. The fact that massless extremals (MEs) can carry light-like currents is essential for modelling currents classically using many-sheeted space-time. The presence of magnetic monopole flux tubes distinguishing TGD from Maxwellian theory is suggestive and could explain why Teslaphoresis occurs in so long length scales and why it induces self-organization phenomena for CNTs. The situation can be seen as a special case of more general situation encountered in TGD based model of living matter.

12.9.1 What Tesla coils are?

Wikipedia contains a nice description of Tesla coils (`http://tinyurl.com/mh68y7b`). Also the abstract (see `http://tinyurl.com/z3qybx2`) provides an illustration about the Tesla coil used.

Harmonic oscillator serves as an indispensable mechanical analogy for time dependent voltage source $V(t)$ and components (L, C, R) coupled in series to forma closed circuir. The dynamics is governed by differential equation

$$L\frac{d^2I}{dt^2} + R\frac{dI}{dt} + \frac{I}{C} = dV_{ext}(t) \ . \tag{12.9.1}$$

Here L inductance (associated with coils in the illustration) with LdI/dt telling the voltage between ends of the inductance coil, C is the capacitance associated with the metal torus telling the charge of the capacitor ($Q = CV$) in potential V relative to the ground. Also relative capacitance with ground replaced with metal object in constant potential and V with the voltage between the two makes sense. IR is the contribution to the voltage of the circuit. V_{ext} is the external voltage. The mechanical analogy corresponds to $(I, L, C, R, dV_{ext}/dt) \leftrightarrow (x, m, 1/k, K, F_{ext})$ where (x, m, k, K, F_{ext}) are the position, mass force constant, friction, and external force applied on the harmonic oscillator.

The circuit consists of three parts (see `http://tinyurl.com/hetyaac`).

(a) The first part has in parallel inductance L_0 and AC source characterized by voltage amplitude V_0 and frequency f acting as external driving force. L_0 corresponds to the outer coil in the figure of abstract.

(b) The primary circuit has inductance $L_{1,1}$ and capacitance C_1 in series in the situation in which di-electric breakdown has not taken place so that the current switch defined by the air gap is off. There is also internal resistance R_1, not included to the illustration. In the simplest model for the situation the voltage U_1 relates to U_0 by $U_1/U_0 = N_2/N_1$, where N_2 and N_1 are in numbers of windings for the two coils. On the other hand, one has $U_1 = Q_1/C_1$ equal to $(N_2/N_1)U_1$.

When the value of the electric field associated with U_1 exceeds critical value (in the range 5-30 kV/m) dielectric breakdown takes place and the current starts to run in the entire primary circuit $(L_{1,2}, R_1, C_1)$ and induces via the coil $L_{1,2}$ a current in secondary circuit (L_2, R_2, C_2). $L_{1,1}$ corresponds in the illustration of the article to a tunable inductance and L_2 corresponds to the inner cylindrical coil. C_2 corresponds to the sum of the stray capacitance of L_2 and capacitance C_2 of the metal torus.

The circuits $(L_{1,1}, L_{1,2}, R_1C_1)$ and (L_2, R_2, C_2) are chosen so that their resonance frequencies are the same and equal to the input frequency to achieve resonance. The frequencies are in radio frequency range and according to Wikipedia article vary in the range 50 kHz to 1 MHz. The duration of the on-period much longer than the corresponding time scales. What happens during the on-period is that capacitor C_2 develops oscillating charge and oscillating electric field orthogonal to the capacitor at its surface. Also oscillating magnetic field is induced: here the possible current along the electric field lines affects the situation. Also at this dielectric breakdowns can occur of the local electric field near the C_2 exceeds critical value.

The discovery is that the radial oscillating electric fields induces what is christened as Teslaphoresis (for more general phenomenon of dielectrophoresis see `http://tinyurl.com/hgj645q`). What is seen as surprising is that the phenomenon takes place in length scales longer than 30 cm. The wavelengths of the AC photons vary in the range [124 m , 6 km]. The fact that Tesla managed to produce this kind of strange phenomena in a length scale of entire town suggests that the wavelength of the radio waves is the key scale, perhaps quantum scale.

CNTs polarize and self-organize along the field lines of the electric field involved. CTNs can also self organize to form a wiring between LEDs and extract energy from the fields of TC so that the LEDs shine. This would be a partial fulfilment of Tesla's dream about wireless energy transfer. If the length scale involved is that of radio waves, the dream might be realized in rather long scales. Also the tractor effect is observed: CNTs are attracted towards TC along electric field lines. This can be understood if they develop polarization parallel to the electric field of the capacitor C_2.

12.9.2 How TGD could be involved?

My earlier attempts to understand what happened in Tesla's circuits [K41, K12] inspired the question whether some new physics could be involved. The presence of effects in unexpectedly long length scales raises the question whether quantum criticality and the hierarchy of Planck constants could be involved. The conjecture has indeed been that quantum criticality leads to a generation of phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant and thus quantum coherence in length scales scaled up by factor n from what they are usually [K34, K35, K36, K37]. Dielectric breakdown is a critical phenomenon and an essential part of the functioning of TC. The test for the hypothesis is to look whether the effects disappear when the coupling between primary and secondary is not by dielectric breakdown.

Radio wavelengths are used. The experience from quantum biological models [**?**]ncourages to ask whether the photons become dark at quantum criticality and whether their energies $E = h_{eff} \times f$ are above thermal energy. TGD inspired quantum biology would suggests that the energies could be in visible and UV range just as bio-photons identified as decay products of dark photons. Large energy of dark radiowave photons would make possible effective energy transfer along long distances. The transformation of dark photons to ordinary photons would generate energetic photons and could serve as a signature of the effect analogous to bio-photons. The self-organization of CNTs along electric field line should involve macroscopic quantum coherence.

The modelling of time varying electromagnetic fields involves open questions in TGD framework. Consider first the available building bricks [K20, K14].

(a) The embedding of any em field locally is possible but the imbeddability to CP_2 implies topological field quantization, which is reasonably well understood for static fields. The preferred extremal property reflecting strong form of holography implying effective 2-dimensionality poses further powerful constraints at the level of single space-time sheet so that extremely restricted repertoire of field patterns is expected to be possible.
At the level of many-sheeted space-time the situation is different. The Maxwellian limit of TGD is obtained by replacing the sheets of many-sheeted space-time with single region of Minkowski space and by summing induced gauge potentials at various sheets (test particle experiences touching space-time sheets experiences the sum of gauge potentials and induced gravitational field identified as sum CP_2 parts of the induced metric).

(b) There are excellent reasons to assume that cosmic string solutions $X^2 \times Y^2$ with X^2 minimal surface in M^4 and Y^2 a homologically non-trivial complex surface of CP_2 allow deformations to magnetic flux tubes having 4-D CP_2 projection. One can make Lorentz boosts for the magnetic flux tubes and together with many-sheetedness this makes possible complex repertoire of moving quasi-stationary fields patterns at Maxwellian limit.

(c) Deformations of CP_2 type vacuum extremals provide description of Euclidian space-time regions identified as lines of generalized Feynman diagrams. The light-like 3-D boundaries between Minkowskian and Euclidian space-time regions having degenerate 4-metric can equivalently regarded as lines of generalized Feynman diagrams are identified as orbits of 2-D partons performing kind of zitterbewebung with local light-velocity. The average velocity is typically time-like.

(d) Massless extremals (MEs) are radiation type solutions but with local directions of polarization and light-like local propagation 4-velocity $(1, v(x)$ with $1 - v \cdot v = 0$. Since the direction can vary the average current is typically time-like.

The first special feature is that MEs allow light-like currents parallel to $(1, v(x)$. Second special feature is that linear superposition is restricted to four-momenta proportional to the local four-velocity $(1, v(x))$ so that one can say that all Fourier components correspond to parallel four vectors ($(1, v)$ and $(-1, -v)$ are regarded as parallel). Field pulses propagate in single direction without change in shape and in precisely targeted manner, which is optimal situation concerning information transfer.

The general linear superposition of Maxwell's theory is lost and one can say that for given space-time sheet the field decomposes to quanta in geometric sense. Linear superposition is however replaced with set theoretic union of parallel space-time sheets: the test particle experiences the sum of gauge potentials associated with different sheets so that nothing is lost in Maxwellian limit.

Consider now what the TGD description could look like for standing waves.

(a) Only linearly polarized waves with local wave vector k are possible. Circular polarizations are not representable classically. In many-sheeted space-time the problem can be solved by using two parallel space-time sheets with of orthogonal linear polarizations and suitable phase lag.

(b) In circuit systems there are oscillating electric fields associated with the capacitor and also oscillating magnetic fields and electric fields accompanying them. These fields do not propagate although one can assign to them frequency and wave vectors locally. In Maxwellian theory they can be represented as superposition of real waves propagating in opposite directions with light-velocity ($cos(\omega t - kx) + cos(\omega t + kx) = 2cos(\omega t)cos(kx)$, $\omega = k$ using unit $c = 1$).

In TGD framework standing wave solutions are not possible as radiative solutions since only the waves with parallel local 4-velocities can superpose. At least two parallel space-time sheets representing copies of MEs related by 4-D reflection are needed to describe the fields in the region outside capacitor. Since the electric field is radial at the surface of capacitor C_2, the MEs should propagate parallel to C_2 near its surface.

Maxwell's theory involves currents in an essential manner although their description involves structural equations and is therefore only phenomenological. These fields have 4-currents as sources. In the recent case the currents are associated with the surfaces of inductances and more or less stationary charge densities with the surfaces of the capacitors.

(a) In TGD framework the 4-currents correspond at quantum level to fundamental fermions at string world sheets and together with partonic 2-surfaces string world sheets carry the data needed by the strong form of holography (SH). This microscopic description is quite too far from the practical modelling of Tesla coils. SH guarantees 4-D description and the question concerns the translation of 2-D vocabulary to 4-D one. One question is what the fermionic currents assignable to the ends of fermionic strings correspond in 4-D vocabulary.

(b) The field equations for Kähler action do not contain external currents explicitly. MEs however allow light-like currents parallel to them and by using parallel MEs with light-like currents boosted in opposite directions it is possible to obtain time-like net currents at Maxwellian limit.

In particular, one can have stationary charge densities needed at the surfaces of C_2 as well as currents moving with non-relativistic velocities needed at the surfaces of the induction coils. The rule could be that parallel MEs gives rise to net current parallel to microscopic fermionic currents propagating along partonic surfaces: these currents can look stationary in induced metric at partonic 2-surfaces so that it need not expand).

(c) String world sheets have their ends carrying fermion number at the 3-D light-like orbits of partonic 2-surfaces. Since monopole fluxes connect wormhole throats, the strings are parallel to monopole flux tubes connect fermions moving along light-like curves of space-time surface. If indeed so, magnetic flux tubes and ME form locally orthogonal network. One cannot therefore neglect the magnetic flux tubes (carrying dark matter). In the recent case this would suggest the presence of dark magnetic flux tubes in directions orthogonal to the capacitor C_2. These flux tubes would carry monopole flux and no current would be needed to generate this magnetic field: the cross section would be two sheeted closed surface rather than disk with boundary.
The monopole magnetic flux tubes carrying dark matter emanating radially from capacitor C_2 would be essential for new physics effects. In particular, dark supra currents could flow along these flux tubes. Together with MEs they are proposed to play fundamental role in TGD inspired quantum biology.

To sum up, the TGD inspired model of Teslaphoresis could be seen as an application of basic ideas of TGD inspired quantum biology explaining macroscopic quantum coherence and dark matter. If so, Tesla would have observed dark matter and new quantum theory based on the hierarchy of Planck constants already century ago.

Chapter 13

Homeostasis as self-organized quantum criticality?

13.1 Introduction

This chapter has been written together with Reza Rastmanesh. The article started as an attempt to understand the properties of cold shock proteins (CSPs) and heat shock proteins (HSPs) in TGD framework. As a matter of fact , these proteins have great deal of similarity and have much more general functions, so it is easier to talk about stress proteins (SPs) having two different modes of operation.

As we proceed, it will be revealed that this issue is only one particular facet of a much bigger problem: how self-organized quantum criticality (SOQC) is possible? Criticality means by definition instability but SOQC is stable, which seems to be in conflict with the standard thermodynamics. In fact, living systems as a whole seem to be quantum critical [I106] and manage to stay near criticality, which means SOQC. Note that the self-organized criticality (SOC) is generalized to SOQC.

Topological Geometrodynamics (TGD) [**?**] [K4, K7] is a 43 year old proposal for a unification of fundamental interactions. Zero energy ontology (ZEO) [L119] is basic aspect of quantum TGD and allows to extend quantum measurement theory to a theory of consciousness and of living systems. ZEO also leads to a quantum theory of self-organization [L103] predicting both arrows of time. Could ZEO make SOQC possible as well?

13.1.1 Summary of the basic properties of CSPs and HSPs

Let's consider a summary of CSPs and HSPs or briefly SPs.

(a) There is a large variety of cold shock proteins (CSP) and heat shock proteins (HSPs). CSPs and HSPs are essentially the same proteins and labelled by HSPX, where X denotes the molecular weight of the protein in kDaltons. The value range of X includes the values $\{22, 60, 70, 90, 104, 110\}$ and HSPs are classified into 6 families: small HSPs, HSPX, $X \in \{40, 60, 70, 90, 110\}$. At least HSP70 [I14] and HSP90 [I12] have ATPase at their end whereas HSP60 has ATP binding site [I13]. CSPs and HSPs consist of about $10^3 - 10^4$ amino acids so that X varies by one order of magnitude.

Their lengths in the un-folded active configuration are below 1 micrometer. CSPs/HSPs [I10, I4, I95, I117] are expressed when the temperature of the organism is reduced /increased from the physiological temperature. CSPs possess cold-shock domains [I3] consisting of about 70-80 amino-acids thought to be crucial for their function. Part of the domain is similar to the so called RNP-1 RNA-binding motif. In fact, it has turned that CSP and HSP are essentially the same object and stress protein (SP) is a more appropriate term.

Wikipedia article about cold shock domain [I3] mentions Escherichia Coli as an example. When the temperature is reduced from 37 °C to 10 °C, there is 4-5 hours lag phase after

which growth is resumed at a reduced rate. During lag phase expression of around 13 proteins containing cold shock domains is increased 2-10 fold. CSPs are thought to help the cell to survive in temperatures lower than optimum growth temperature, by contrast with HSPs, which help the cell to survive in temperatures greater than the optimum, possibly by condensation of the chromosome and organization of the prokaryotic nucleoid. What is the mechanism behinds SP property is the main question.

(b) SPs have a multitude of functions involved with the regulation, maintenance and healing of the system [I118, I23, I33, I77, I117]. They appear in stress situations like starvation, exposure to cold or heat or to UV light, during wound healing or tissue remodeling, and during the development of the embryo. SPs can act as chaperones [I23] and as ATPAses [I69, I97].
SPs facilitate translation, and protein folding in these situations, which suggests that they are able to induce local heating/cooling of the molecules involved in these processes. CSPs could be considered like ovens and HSPs like coolants; systems with very large heat capacity acting as a heat bath and therefore able to perform temperature control. SPs serve as kind of molecular blacksmiths - or technical staff - stabilizing new proteins to facilitate correct folding and helping to refold damaged proteins. The blacksmith analogy suggests that this involves a local "melting" of proteins making it possible to modify them. What "melting" could mean in this context? One can distinguish between denaturation in which the folding ability is not lost and melting in which it is lost. Either local denaturation or even melting would be involved depending on how large the temperature increase is. In a aqueous environment the melting of water surrounding the protein as splitting of hydrogen bonds is also involved. One could also speak also about local unfolding of protein.

(c) There is evidence for large change ΔC_p of heat capacity C_p ($C_p = dE/dT$ for pressure changing feed of heat energy) for formation ion nucleotide-CSP fusion [I97]. This could be due to the high C_p of CSP. The value of heat capacity of SPs could be large only *in vivo*, not *in vitro*.

(d) HSPs can appear even in hyper-thermophiles living in very hot places. This suggests that CSPs and HSPs are basically identical - more or less - but operate in different modes. CSPs must be able to extract metabolic energy and they indeed act as ATPases. HSPs must be able to extract thermal energy. If they are able to change their arrow of time as ZEO suggests, they can do this by dissipating with a reversed arrow of time.

To elucidate the topic from other angles, the following key questions should be answered:

(a) Are CSPs and HSPs essentially identical?

(b) Can one assign to SPs a high heat capacity (HHC) possibly explaining their ability to regulate temperature by acting as a heat bath? One can also ask whether HHC is present only *in vivo* that is in a aqueous environment and whether it is present only in the unfolded configuration of HP?

13.1.2 The notion of quantum criticality

The basic postulate of quantum TGD is that the TGD Universe is quantum critical [K4, K7] [L35, L34]. There is only a single parameter, Kähler coupling strength α_K mathematically analogous to a temperature and theory is unique by requiring that it is analogous to critical temperature. Kähler coupling strength has discrete spectrum labelled by the parameters of the extensions of rationals. Discrete p-adic coupling constant evolution replacing continuous coupling constant evolution is one aspect of quantum criticality.

What does quantum criticality mean?

(a) Quite generally, critical states define higher-dimensional surfaces in the space of states labelled for instance by thermo-dynamical parameters like temperature, pressure, volume, and chemical potentials. Critical lines in the (P,T) plane is one example. Bringing in more variables one gets critical 2-surfaces, 3-surfaces, etc. For instance, in Thom's catastrophe theory [A7] cusp catastrophe corresponds to a V-shaped line, whose vertex is a critical point whereas butterflly catasrophe to 2-D critical surface. In thermodynamics

the presence of additional thermodynamical variables like magnetization besides P and T leads to higher-dimensional critical surfaces.

(b) There is a hierarchy of criticalities: there are criticalities inside criticalities. Critical point is the highest form of criticality for finite-D systems. Triple point, for instance, for water in which one cannot tell whether the phase is solid, liquid or gas. This applies completely generally irrespective of whether the system is a thermo-dynamical or quantal system. Also the catastrophe theory of Thom gives the same picture [A7]. The catastrophe graphs available in the Wikipedia article illustrate the situation for lower-dimensional catastrophes.

(c) In TGD framework finite measurement resolution implies that the number of degrees of freedom (DFs) is effectively finite. Quantum criticality with finite measurement resolution is realized as an infinite number of hierarchies of inclusions of extensions of rationals. They correspond to inclusion hierarchies of hyperfinite factors of type II_1 (HFFs). The included HFF defines the DFs remaining below measurement resolution and it is possible to assign to the detected DFs dynamical symmetry groups, which are finite-dimensional. The symmetry group in never reachable ideal measurement resolution is infinite-D super-symplectic group of isometries of "world of classical worlds" (WCW) consisting of preferred extremals of Kähler action as analogs of Bohr orbits. Super-symplectic group extends the symmetries of superstring models [K4] [**?**, **?**, **?**, **?**].

(d) Criticality in living systems is a special case of criticality - and as the work of Kauffman [I106] suggests - of quantum crticality as well. Living matter as we know, it most probably corresponds to extremely high level of criticality so that very many variables are nearly critical, not only temperature but also pressure. This relates directly to the high value of h_{eff} serving as IQ. The higher the value of h_{eff}, the higher the complexity of the system, and the larger the fluctuations and the scale of quantum coherence. There is a fractal hierarchy of increasingly quantum critical systems labelled by a hierarchy of increasing scales (also time scales).

In ZEO classical physics is an exact part of quantum physics and quantum physics prevails in all scales. ZEO makes discontinuous macroscopic BSFRs to look like smooth deterministic time evolutions for the external observer with opposite arrow of time so that the illusion that physics is classical in long length scales is created.

Number theoretical physics or adelic physics [L59, L60] is the cornerstone of TGD inspired theory of cognition and living matter and makes powerful predictions.

p-Adic length scale hypothesis deserves to be mentioned as an example of prediction since it has direct relevance for SPs.

(a) p-Adic length scale hypothesis predicts that preferred p-adic length scales correspond to primes $p \simeq 2^k$: $L(k) = 2^{(k-151)/2}L(151)$, $L(151) \simeq 10$ nm, thickness of neuronal membrane and a scale often appearing molecular biology.

(b) TGD predicts 4 especially interesting p-adic length scales in the range 10 nm- 25 μ. One could speak of a number theoretical miracle. They correspond to Gaussian Mersenne primes $M_{G,k} = (1+i)^{k-1}$ with prime $k \in \{151, 157, 163, 167\}$ and could define fundamental scales related with DNA coiling for instance.

(c) The p-adic length scale $L(k = 167) = 2^{(167-151)/2}L(151) = 2.5$ μ m so that SPs could correspond to $k \in \{165, 167, 169\}$. $L(167)$ corresponds to the largest Gaussian Mersenne in the above series of 4 Gaussian Mersennes and to the size of cell nucleus. The size scale of a cold shock domain in turn corresponds to $L(157)$, also associated with Gaussian Mersenne. Note that the wavelength defined by $L(167)$ corresponds rather precisely to the metabolic currency .5 eV.

(d) HSPX, $X \in \{60, 70, 90\}$ corresponds to a mass of X kDaltons (Dalton corresponds to proton mass). From the average mass 110 Dalton of amino acid and length of 1 nm one deduces that the straight HSP60, HSP70, and HSP90 have lengths about .55 μm, .64 μ, and .8 μm. The proportionality of the protein mass to length suggests that the energy scale assignable to HSPX is proportional to X. (HSP60, HSP70, HSP90) would have energy scales (2.27, 1.95,1.5 eV) for $h_{eff} = h$ naturally assignable to biomolecules. The lower boundary of visible photon energies is a 1.7 eV.

Remark: One has $h = h_{eff} = nh_0$ for $n = 6$. What if one assumes $n = 2$ giving $h_{eff} = h/3$ for which the observations of Randel Mills [D9] give support [L64]? This scales down the energy scales by factor 1/3 to (.77,.65,0.5) eV not far from the nominal value of metabolic energy currency of about .5 eV.
There are strong motivations to assign to HSPs the thermal energy $E = T = .031$ eV at physiological temperature: this is not the energy $E_{max} = .084$ eV at the maximum of the energy distribution, which is by a factor 2.82 higher than E. The energies above are however larger by more than one order of magnitude. This scale should be assigned with the MBs of SPs.

(e) The wavelengths assignable to HSPs correspond to the "notes" represented by dark photon frequencies. There is an amusing co-incidence suggesting a connection with the model of bio-harmony [L28, L29]: the ratios of energy scales of HSP60 and HSP70 to the HSP90 energy are 3/2 and 1.3, respectively. If HSP90 corresponds to note C, HSP60 corresponds to G and HSP70 to note E with ratio 1.33. This gives C major chord in a reasonable approximation! Probably this is an accident. Note also that the weights X of HSPXs are only nominal values.

13.1.3 Hagedorn temperature, HHC, and self-organized quantum criticality (SOC)

Self-organized criticality (SOC) is an empirically verified notion. For instance, sand piles are SOQC systems. The paradoxical property of SOQC is that although criticality suggests instability, these systems stay around criticality. In standard physics SOQC is not well-understood. TGD based model for SOQC involves two basic elements: ZEO and Hagedorn temperature.

(a) ZEO predicts that quantum coherence is possible in all scales due to the hierarchy of effective Planck constants predicted by adelic physics. "Big" (ordinary) state function reductions (BSFRs) change the arrow of time [L119]. Dissipation in reversed arrow of time looks like generation of order and structures instead of their decay - that is self-organization. Hence SOQC could be made possible by the instability of quantum critical systems in non-standard time direction. The system paradoxically attracted by the critical manifold in standard time direction would be repelled from it in an opposite time direction as criticality indeed requires.

(b) Surfaces are systems with infinite number of DFs. Strings satisfy this condition as also magnetic flux tubes idealizable as strings in reasonable approximation. The number of DFs is infinite and this implies that when one heats this kind of system, the temperature grows slowly since heat energy excites new DFs. The system's maximum temperature is known as Hagedorn temperature and it depends on string tension for strings.
In the TGD framework, magnetic flux tubes can be approximated as strings characterized by a string tension decreasing in long p-adic length scales. This implies a very high value of heat capacity since very small change of temperature implies very large flow of energy between the system and environment.
T_H could be a general property of MB in all scales (this does not yet imply SOQC property). An entire hierarchy of Hagedorn temperatures determined by the string tension of the flux tube, and naturally identifiable as critical temperatures is predicted. The temperature is equal to the thermal energy of massless excitations such as photons emitted by the flux tube modellable as a black body.
Remark: If the condition $h_{eff} = h_{gr}$ [L81], where h_{gr} is gravitational Planck constant introduced originally by Nottale [E1], holds true, the cyclotron energies of the dark photons do not depend on h_{eff}, which makes them an ideal tool of quantum control.
Hagedorn temperature would make them SOQC systems by temperature regulation if CSP type systems are present they can serve as ovens by liberating heat energy and force the local temperature of environment to their own temperature near T_H. Their own temperature is reduced very little in the process. These systems can also act as HSP/CSP type systems by extracting heat energy from/providing it to the environment

and in this way reduce/increase the local temperature. System would be able to regulate its temperature.

A natural hypothesis is that T_H corresponds to quantum critical temperature and in living matter to the physiological temperature. The ability to regulate the local temperature so that it stays near T_H has interpretation as self-organized (quantum) criticality (SOC). In the TGD framework these notions are more or less equivalent since classical physics is an exact part of quantum physics and BSFRs create the illusion that the Universe is classical in long (actually all!) scales.

Homeostasis is a basic aspect of living systems. System tends to preserve its flow equilibrium and opposes the attempts to modify it. Homeostasis involves complex many-levels field back circuits involving excitatory and inhibitory elements. If living systems are indeed quantum critical systems, homeostasis could more or less reduce to SOQC as a basic property of the TGD Universe.

13.2 The basic ideas about SPs

The TGD based model for SPs relies on the notion of MB carrying dark matter as $h_{eff} > h$ phases and the notions of heat transfer and heat capacity. The basic idea is that at least in aqueous environment the MBs of biomolecules in general have a large number of DFs and act as heat reservoirs with a stable temperature near a Hagedorn temperature. MBs of SPs have also high heat transfer rates between the thermal environment of the ordinary matter. ZEO - in particular time reversal - makes it possible to realize thermal regulation in terms of SOQC. On the other hand, information carrying biomolecules cannot have high heat transfer rate with environment.

13.2.1 Conditions on the heat transfer rates between the systems involved

To avoid lengthy explanations, it is appropriate to introduce some shorthand notations. Denote by $j_H(X-Y)$ heat transfer rate between systems X and Y. Denote by E. Denote BB(X) the biological body of system X. X can denote the ordinary biomolecule (DNA,RNA,protein) denoted by BM or stress protein SP.

There are several conditions on the model explaining the HHC

(a) $j_H(MB(SP)-E)$ should be high so that the MB of SP can rapidly adapt to temperature changes and extract thermal energy from the environment and act as an oven or a coolant. $j_H(MB(SP)-BM$ should be high so that CSPs could rapidly warm up BMs for processes like translation, transcription and folding.
$j_H(MB(SP)-BM$ can be also high if heat transfer occurs indirectly via $MB(BM)$. This requires that both $j_H(MB(BM)-BM$ and $j_H(MB(SP)-MB(BM)$ are high. However, the large value of $j_H(MB(BM)-BM$ implies that BMs can take care of temperature regulation without the help of SPs. Hence this option does not seem to be consistent with empirical facts. Hence $j_H(MB(BM)-BM$ must be low.
There is also a deeper rational for this. The MBs of ordinary bio-molecules must carry information and cannot be thermalized so that the energy transfer rate between them and their BB and between them and the environment must be low.

(b) In CSP mode the MBs of SPs should actively extract energy from fats. The BMs should extract thermal energy from MBs of SPs. In HSP mode MBs of SPs at temperature than that of the local thermal environment (including BMs) should cool it by absorbing thermal energy from it.

The following table summarizes the constraints on the symmetric matrix of heat transfer rates $j_H(A,B)$ for various combinations of subsystems X and Y. The shorthand notations are (SP,BM,E) for (stress protein, basic biomolecule, environment) and $MB(X)$ for the MB of molecule X. Environment E is taken as the thermal environment at the level of ordinary matter. The diagonal heat transfer rates are not considered. H/L for the matrix element

$j_H(X,Y)$ of the table means that its value can be large/small. The symbol "*" means that this particular transfer is not relevant.

X/Y	SP	$MB(SP)$	BM	$MB(BM)$	E
SP	$*$	**H**	$*$	$*$	$*$
$MB(SP)$	**H**	$*$	**H**	$*$	**H**
BM	$*$	**H**	$*$	**L**	$*$
$MB(BM)$	$*$	$*$	**L**	$*$	$*$
E	$*$	**H**	$*$	$*$	$*$

(13.2.1)

In the minimal scenario the only constraints are on $j_J(SP, MB(SP)$ (H), $j_J(BM, MB(SP)$ (H), and $j_J(BM, MB(BM)$ (L).

The natural question is what makes it possible for the MBs of SPs to gain energy.

(a) The first manner to get energy is heat transfer from the environment. Passive heat transfer would involve either ordinary photons transformed to dark photons and absorbed by MB(SP) or active heat extraction in time reversed mode involving emission of dark photons transformed to ordinary photons and absorbed by ordinary matter. The energies should be in the range of thermal energies at physiological temperatures.

(b) The negative energy photons from the MB of biomolecule can be also received by other MBs acting as analogs of population reversed laser. Thermalisation is expected to occur if there is large number of this kind of states. MB should allow almost continuum of cyclotron energy state in the energy resolution defined by the size scale of the molecules.

(c) At least some SPs such as HSP70 and HSP90 could act as ATPases providing the heat energy at their MBs to drive ADP $\rightarrow$ ATP process. They would act as general purpose quantum heat engines with MB acting as a heat bath running the ATPase machinery. Heat engine function requires a heating of the MB SP to a temperature above the local physiological temperature but below the Hagedorn temperature: in ZEO time reversal for the MB of SP allows this: it would look like extraction of thermal energy from the environment. Part of the energy heating MB of SP could come from the binding of ATP to ATPAse part of PS. This energy is in the range of 3-7 eV for nucleotides and could heat the MB of SP.

One could also consider remote metabolism for the molecules receiving the metabolic energy quantum with a negative energy photon inducing $ATP \rightarrow ADP$. Note that the metabolic energy quantum .5 eV is in infra-rede (IR) range and corresponds to 2.4 μm wavelength very near to the largest p-adic length scale $L(167)$ in the quadruplet of primes $k \in \{151, 157, 163, 167\}$ defining four Gaussian Mersennes and defining the size scale of nucleus.

Now, consider the extraction of heat energy from the environment:

(a) The energies assignable to the photon wavelengths defined by the lengths of HSPX proteins are proportional to 1/X and above 1.5 eV, which is considerably above the energy of thermal photon at the maximum of Planck distribution for energy is $E_{max} = .084$ eV).

(b) The energy transfer would be based on energy resonance and is possible only if the cyclotron frequency spectrum of dark particles contains energies possessed by molecules in their spectrum in infrared range. This poses a condition on the cyclotron energies $E = \hbar_{eff} eB/m$ assumed to be in bio-photon energy range: this requires that $h_{eff} = nh_0 = \hbar_{gr} = BMm/v_0$ is large: one has $E = GMB/v_0$ does not depend on the mass of charged particle. Cyclotron energies involve also the contribution from a longitudinal motion along the flux tube. The energy scale for dark photon is now $\hbar_{eff}/L$ and also universal since L scales as $\hbar_{gr}$. If L is small the energy scale is so large that longitudinal DFs are not excited and thermalization does not occur. Same is true if B is large enough. Magnetic field strength is expected to scale like $1/L^2(k)$, where $L(k)$ is the p-adic length scale characterizing the molecule. The endogenous magnetic field $B_{end} = 2B_E/5$ identified as the monopole flux part of the Earth's magnetic field is expected to define an important value in the spectrum of magnetic fields. The corresponding p-adic length scale corresponds to the length scales assignable to SPs. Also octaves of this value are

expected and the model of bio-harmony [L28, L29] suggests that the preferred values are given by 12-note scale.

For short linear molecules the energy scales would be too high to allow thermalization so that these molecules can serve as information molecules. For long DNA one has length scale hierarchy and thermalization can occur only in long enough length scales. Human DNA has total length of order 1 meter but if the size of DNA defines the p-adic length scale, then DNA does not thermalize since the size of nucleus is not larger than $L(167) = 2.5$ μm. Note that DNA defines a length scale hierarchy in codons, genes, and also coiling scales define hierarchy levels. When the length of the molecules is longer than the wavelength of thermal photon at room temperature, one expects thermalisation to occur. SPs have lengths below 1 μm.

(c) The thermalization should take place for the MBs of SPs. There are two energy scales associated with the cyclotron energies and the free motion along the flux tube respectively. Thermal energy scale could correspond to either of these length scales.

   i. Cyclotron energy scale is given by $E_c = GMB/v_0$ for $h_{eff} = h_{gr}$ and the scales are proportional to B. Longitudinal energy scale dose not depend on h_{eff} since the flux tube length scales like h_{eff}. Since B scales like $1/L^2(k)$, cyclotron length scale increases for small protein sizes. This suggests that thermalization is associated with the cyclotron DF and appears for large enough p-adic length scales characterizig protein size.

   ii. Longitudinal energy scale naturally corresponds to the lengh of protein for $h_{eff} = n$. The energy scale of longitudinal excitations is consirably above the thermal energy scale so that thermalization would not be possible. It might be however possible to transfer energy from these DFs to the MB of SP where it is transformed to thermal energy.

13.2.2 A new physics model for HHC

Now, consider a more concrete new physics model for HHC:

(a) HHC suggests the existence of new DFs to which energy is stored so that temperature is not raised as new DFs become available.

(b) In the theory of extended objects like strings, the very large number (infinite) of degress of freedom (DFs) implies a maximal temperature T_H known as Hagedorn temperature. Flux tubes are extended objects. This suggests that the MBs of SPs are near to the Hagedorn temperature defining the maximal temperature for their MBs. Also the assumption that the physiological temperature is near but usually below T_H: this condition allows SP to act as heat engine. This cannot be true for the information carrying biomolecules such as DNA, RNA and proteins since thermalization destroys information. Therefore they must have a temperature much below T_H.

(c) In a hot environment the existence of Hagedorn temperature T_H for the MB of HSP means that the thermal energy is transferred from the environment to the MB of HSP. This tends to reduce the local temperature of the environment towards T_H. HSP would act as an ideal coolant. Their presence would faciliate the basic functions of cells.

(d) CSP and its MB would be at temperature near T_H and could act as an oven. Their presence around DNA, RNA, and proteins would raise their temperature locally and facilitate transcription, translation and protein folding and unfolding otherwise prevented by a low temperature.

(e) SPs could act as heat engines providing heat energy to molecular motors [**?**]. This entails SP to have a temperature higher than the temperature of environment. In ZEO this is possoble by using a time reversed mode for SP to extract energy from the environment. Many SPs have ATPase at their end and this would make them universal heat engines providing the work as metabolic energy currency for any molecular user.

(f) Quite generally, by their ATPase property, many SPs could act as metabolic energy sources in stressful situations - this comprises many other situations in addition to low and high temperatures. Metabolic energy feed increases h_{eff} and would increase the scale

quantum coherence reduced in the damage of DNA, proteins and tissue, for instance. After this, the system could self-organize to the healed state. For instance, CSPs could induce local melting of misfolded proteins leading to a repair. CSPs act as chaperones and their basic tool would be local "melting" (remind our operational definition of "melting") by feeding heat energy - allowing to establish a correct conformation.

(g) The MBs of SPs could extract their thermal energy from the thermal energy of the environment in time reversed mode allowed by ZEP allowing the temperature of SP to even exceed that of environment in the final state of BSFR.

Consider a quantitative estimate.

(a) For a typical flux tube length is larger than the radius of the flux tube. The critical temperature identified as Hagedorn temperature corresponds to a typical thermal energy of the flux tube and is determined by flux tube length and its string tension. The critical temperature is inversely proportional to the length of the flux tube.

(b) Critical temperature T_H roughly corresponds to the energy of a photon with wavelength equal to the flux tube length L : $E = T_H \sim h_{eff}/L$. For $h_{eff} = h$ the flux tube length corresponds to the length scale of CSP but for large values of $h_{eff} = h_{gr}$ it corresponds to a scale of even Earth. The energies and temperature T_H are however the same irrespective of the value of h_{eff} and thus length of flux tube.

(c) The rough estimate is that for physiological temperatures T_{ph} around T_H, the length for $h_{eff} = h$ the wave length for a thermal photon at temperate 310 K the maximum of energy distribution is around 14.7 μm: note that the sizes of most animal and plant cells are oin the rage of 10-100 μm. For the wavelength distribution the wavelength for the maximum is roughly 7 μm. CSPs and HSPs consist of about 100-1000 amino acids or so. Length would be in the range .1-1 μm. The energies of photons with a wave length of straight SP are definitely above thermal energy range.

Some questions are in order.

(a) If the new DFs are associated with MB, what can one say about the value of h_{eff} serving as IQ could be? SPs are possessed already by bacteria which suggests that the value of h_{eff} cannot be very large. Acting as a chaperon is a control function, which suggests a higher than normal value of h_{eff}. Higher than normal value ignites intriguing question whether they have higher IQ (as a value of h_{eff} characterizing number theoretic complexity) than other proteins helping to survive in difficult situations. On the other hand, the thermalization means that SP flux tubes cannot carry information unlike the flux tubes of basic bio-molecules with their MBs at very low temperature.

(b) Cell membrane must stay flexible as temperature is lowered. This is known to be achieved by a generation of unsaturated bonds to lipids. This involves desaturase enzyme creating C-C double bond. Desaturase enzymes are not SPs. SPs can however faciliate the transcription and translation of desaturase enzymes.

13.2.3 Physiological temperature as Hagedorn temperature, local temperature regulation, and self organized quantum criticality

The notions of quantum criticality, self-organized quantum criticality (SOC) and Hagedorn temperature leads to a new physics based model for the explanation of SP functions.

(a) Hagedorn temperature T_H as a maximal temperature of MB of stress protein would be crucial for its functioning. Why the physiological temperature is around 310 K is one of the puzzles of biology. The work of Kauffman [I106] suggests that the interpretation as a quantum critical temperature is appropriate. TGD predicts a hierarchy of quantum critical temperatures. The natural guess would be that this quantum critical temperature is Hagedorn temperature realized at the level of MB asymptotically: in practice, the temperature of MB would be somewhat below T_H.
This would facilitate temperature regulation or perhaps even make it possible. At quantum criticality also long length scale quantum fluctuations are possible and this makes modifications of the system possible - say damaged proteins. If the temperature T of the

environment at BB is above T_H, the thermal energy flows to MB of SP and its temperature T is reduced. MB can also make BSFR reversing the arrow of time and extract thermal energy from the environment.

(b) Self-organized criticality (SOC) generalizes to self-organized quantum criticality (SOQC) in the TGD framework. SOC is well-known but it is not understood. For instance, sand piles are SOC systems. They tend to approach a critical state, which looks paradoxical since just the opposite should hold for critical systems by their defining property which makes them unstable! Critical system is optimal for measuring and representing since it has a large number of different states with roughly the same energy. Therefore biosystems should be critical systems.

The basic objection against SOC and SOQC is that SCs are unstable by definition. In ZEO this objection can be circumvented. Quantum coherence is possible in all scales and in BSFRs the arrow of time is changed. This transforms the critical manifold from a repeller to an attractor and time reversals make SOQC possible. The occurrence of SOQC would be direct empirical proof for the ZEO and its most dramatic predictions.

What is the distinction between CSP and HSP modes of SPs? SOQC according to ZEO suggests that time reversal could explain this difference. How do the time reversals for CSP and HSP modes differ? The following picture is suggestive.

(a) The time reversal occurs for the MB of SP in HSP mode so that they extract thermal energy from environment.

(b) The time reversal occurs for the MBs molecules interacting with SPs in CSP mode so that they can extract heat energy from the MB of CSP.

It has been already told that homeostasis in presence of quantum criticality is essentially quantum critical SOC.

13.2.4 $\Delta C_p > 0$ for HSP90-nucleotide binding as support for the model

Chistopher *et al* have studied enthalpy driven reactions involving nucleotide or ansamycin bimnding to HSP90: the title of the article [I97] is "*Structural–Thermodynamic Relationships ofInteractions in the N-Terminal ATP-Binding Domain*". These reactions occurring in constant pressure are enthalpy driven meaning that heat is liberated in these reactions - the second option would be entropy driven reaction in which the large entropy gain makes reaction possible. The formation of a bound state means a reduction of DFs suggesting a decrease of the heat capacity C_p of the combined system.

Researchers however find $\Delta C_p > 0$ when another reactant is nucleotide but not for the ansamycin case. Intuitively, the number of DFs should increase to explain this. The authors of the article discussed a number of explanations for their unexpected finding.

The presence of MB means new hidden DFs and the neglect of its presence could lead to thermo-dynamical anomalies. Could $\Delta C_p > 0$ in an enthalpy driven reaction leading to a formation of bound state be such an anomaly?

(a) Suppose HSP90 has MB can have large C_p and that it is at the temperature of the environment. The temperature varies in the range 2-25 °C being considerably below the physiological temperature 37 C proposed to correspond to a maximal temperature - Hagedorn temperature - for the magnetic flux tubes of SPs. C_p for the MB of SP is expected to increase as the temperature rises since new DFs are thermally excited.

C_p could be rather high already for the initial state if it corresponds to the sum of heat capacities for nucleotide/ansamycin and HSP90. The size of the MB of nucleotide for $h_eff = h$ should be small if it correlates with the size of nucleotide/ansamycin. Nucleotide is an information molecule and therefore its MB should be at a low temperature and have low C_p (thermal energies cannot excite the states at low temperature).

(b) Since binding reaction is in question, C_p for the combined system should be reduced unless something happens at the level of MBs. Could the heat capacity of MB of HSP90 increase for nucleotide binding? Could even the value of ΔH for the nucleotide case be larger than thought due to the fact that part of ΔH is transferred to MB of HSP90?

i. A lot of heat is liberated in the exothermic binding reaction in both cases. The measure part of the liberated heat goes to the standard DFs discussed in the article. Part of ΔH is transferred to the MB of HSP90 and can heat it to a higher local temperature. New DFs open and heat capacity of MB of CPS90 increases so much that the net heat capacity can increase despite the reduction of ordinary contribution to C_p.
This would happen for the nucleotide but not for ansamycin. Why would the fraction of liberated heat going to the MB of HSP be so small for ansamycin that ΔC_p remains negative?

ii. Could the heat ΔH liberated in the nucleotide case be considerably larger than assumed and larger than for ansamycin plus CSP. This is quite possible since only the fraction going to the environment is measured, not that transferred to MB. Theoretical estimates do not of course take the possible presence MB into account. If ΔH for the nucleotide case is larger than believed, then MB of HSP90 can be heated more and $\Delta C_p > 0$ is possible.

iii. The inspection of tables of [I97] shows that the values of ΔH for the nucleotide case are in the range 3-8 eV *per* reaction and correspond to UV energies. For reactions $\Delta C_p < 0$ the values of ΔH are of order .3 eV and correspond to IR photons but with energies larger than thermal energies. The difference is more than order of magnitude and suggests a similar difference for ΔH transferred to MB, which supports the proposed explanation.

13.2.5 Some functions of SPs in TGD perspective

SPs as heat baths for molecular heat engines and providers of heat energy to ATPs

Heat is produced as a side effect of metabolism and HSPs could extract this heat using remote metabolism and transform it to heat energy resourses liberated when needed.

SPs could be used for heating as in the basic biological processes like transcription and transcription. SPs could also act as heat engines transforming heat energy to work in the case of molecular motors [**?**].

There are reports about the role of HSPs in doing molecular work [I23, I88, I77]: the new element would be heat energy coming from the MB of SP. At least SPs such as HSP60, HSP70, HSP90, HSP104 binding to ATP could serve as general purpose heat engines transforming heat energy at their MB to metabolic energy currency used in various biological processes.

(a) All processes produce heat and the very idea of HSPs would the that HSPs gather this heat energy and act as heaters as in the case of transcription, translation, and replication or as heat engines liberating the heat energy as ordered energy. Action as ATPase would make HSP a general purpose molecular heat engine. Currently, we know that HSPX for $X \in \{60, 60, 90, 104\}$ at least act as ATPases.
Very important question: Is ATPase property a general property of HSPs?*
By the second law of thermodynamics these heat engines have some maximal efficiency proportional to the difference of the temperatures for heat bath - now MB - and the system receiving the energy. Hence HSP MBs must be at a temperature higher than the systems receiving the energy. The formation of HSP90-ATP bound state would liberate binding energy about 3-7 eV *per* reaction (metabolic energy quantum is .5) eV and this heats MB of HSP and would lead to the reported increase of heat capacity.

(b) There is, however, a reason to worry. By Carnot's law maximal effectiveness is proportional to $\Delta T/T$, where ΔT is the temperature difference between the system receiving the work and heat bath, now the MB of SP, and T the temperature of the heat bath. Is the temperature difference high enough to give a reasonable effectiveness?
ZEO provides a quantum manner to get rid of worries. Time reversal could make possible for the MB of HSP to develop a temperature higher than that of environment by what looks for an observer extraction of thermal energy from the environment but is actually BSFR leading to final state which dissipates in reverse time direction to a state

in which the temperatures are equal. T_H should be however somewhat higher than the physiological temperature.

Heat shock protein 70 and ATP in homeostasis

ATP depletes in stress situations due to the lack of ordinary metabolic energy feed as in ischemia. The role of HSP70 and its co-function with ATP in this kind of situation is discussed in [I88] . Also HSP70 involves ATPase and the lack of the ordinary metabolic energy could be replaced by thermal metabolic energy feed from the MBs of say HSP70.

SPs and infection

One can distinguish between immune response, which is specific to the invader organism (say bacterium or virus) or molecule and non-specific immune response involving inflammation and fever. Infection includes both the effects of the invader and those caused by the non-specific immune response.

(a) The invader specific immune response would be basically an action of the MB: this is the basic vision of TGD. Already the MB of water recognizes the invader molecules by the cyclotron energy spectrum of their MBs: this is just water memory [J7, I87, I50] discussed from TGD point view in [L16]. "Homeopathy" is he ugly synonym for "water memory" and involves mechanical agitation feeds energy to the MBs of water clusters forming a population mimicking invader molecules.
MBs of water clusters are varying its flux tube thicknesses and in this manner changing corresponding cyclotron frequencies to get in tune with possible invaders: this is similar to what we do when we search for a radio station. When a hit occurs, MB of the water cluster fixes the flux tube thickness. After getting to resonance, the MBs of water molecules clusters can reconnect with U-shaped flux tubes to corresponding bacterial flux tubes: a pair of flux tubes connecting the water cluster MB to the invader molecule is formed. Invader is caught. The chemical side of the immune system emerged later and would involve sequences of dark proton triplets associated with proteins as addresses - 3N-fold resonance.

(b) When bacteria infect cells, they induce inflammation and fever by raising the body temperature as a non-specific immune response. Inflammation can be seen as the body's protective response against infection. The fever helps immune cells to migrate to infection by a process known as chemotaxis. What fever and inflammation could mean in the proposed picture about SPs?

A possible explanation is as follows.

(a) Quite generally, the loss of quantum coherence as a reduction of h_{eff} induced by the attack by bacteria should transform ordered energy to heat and produce entropy and also raise the temperature inducing fever. One possible mechanism producing heat in the loss of quantum coherence could be the decay of dark cyclotron condensates and dark photon states to biophotons with $h_{eff} = h$ and with energies around Hagedorn energy of order the energy associated with the physiological temperature. Also the decay of dark proton sequences in the reduction $h_{eff} \to h$ to ordinary protons would liberate energy as photons: Pollack's experiments show that IR irradiation produces exclusion zones (EZs) most effectively so that the energy would be in IR range.

(b) Inflammation involves HSPs, in particular HSP70 [I47]. If the heat produced by the infection causing the fever can be seen as an entropic waste energy, SPs such as HSP90 would do its best to transform it to ordered energy realized as metabolic energy quanta with the nominal value around .5 eV. As discussed, this would mean a formation of bound states liberating energy - for instance, HMP90-ATP bound state would liberate energy with part going to the MB of HSP70/90 and part to a local environment.
HMP70/90 acting as ATPases in the bound state and generate metabolic energy quanta by the ADP $\to ATP$ process. The liberated binding energy could cause the observed raise of C_p of the MB of HMP90 and allow it to absorb more effectively heat energy from the

environment by temporary time reversal and transform it to metabolic energy quanta. HSPs would be thus generated to absorb the surplus heat to be used as a metabolic energy resource and fever would be reduced as a consequence.

13.2.6 Could 1/f noise be interpreted as a signature of time reversal?

Reza Rastmanesh sent a paper by Dmitri Zhukov with the title "How the theory of self-organized criticality explains punctuated equilibrium in social systems" [J9] (`https://cutt.ly/YJUYx0n`)

Self-organized criticality (SOC) is a very interesting phenomenon. Systems with SOC are able to stay near criticality. This is difficult, maybe even impossible, to understand in standard ontology since critical states are repellors of the dynamics and the system is expected to approach a stable state rather than remaining near criticality.

One can understand SOC as a manifestation of zero energy ontology (ZEO),which forms the cornerstone of TGD-based quantum measurement theory and TGD inspired theory of conscious experience. "Big" and "small" state function reductions (SFRs), BSFR and SSFR are the basic notions. BSRR is the TGD counterpart of ordinary state function reduction but reverses the arrow of time. SSFR is the counterpart of "weak" measurement and much like classical measurement: in particular, the arrow of change is preserved.

(a) In TGD the magnetic body of a SOC system would be quantum critical and involve BSFRs in arbitrarily long scales at the level of MB. Since BSFR changes the arrow of time, the repellor becomes an attractor and the system would return to the vicinity of what was a repeller earlier. Homeostasis, which means an ability to stay near criticality, would be made possible by BSFRs: no complex biological control programs would be needed [L193].

(b) The period of time reversed time evolution for BSFR would correspond from the viewpoint of an outsider with an opposite arrow of time to an apparently stable state. The time reversed evolution to the geometric past would send classical signals to the direction of the geometric past of the observer and they would not be received by an outsider in the geometric future. Hence time reversed states are difficult to observe if the time reversed system is totally in the geometric past of the receiver.
In the case of MB this need not be the case and the receiver could be in the geometric past with respect to the signal source at MB and receive the "negative energy" signal of MB just as would happen in memory recall. This could correspond to anticipation. This was discussed in one of our articles.

(c) It would seem that BSFR corresponds to the "avalanche" from the point of view of an observer. Earthquakes represent one example of this kind of BSFR [L86].

(d) 1/f noise is one basic characteristic of SOC and ZEO provides an explanation for it so that 1/f noise could be seen as evidence for ZEO. If the states of time reversed MB are near quantum criticality for BSFR, there are quantum fluctuations and by the scale invariance of the quantum dynamics of TGD they have 1/f spectrum.
[Supersymplectic symmetry involves super-conformal symmetry and scaling invariance justifying 1/f, I just wrote an article about this related to p-adic mass calculations [L164].]

There are two ways in which 1/f noise could be interpreted as signals sent by the time reversed SOC MB. There are two options.

(a) Suppose that the time reversed SOC MB is in the geometric past of the observer.
Could the 1/f noise be induced by signals sent by the MB with a reversed arrow of time from the geometric past? These signals would be impossible in the standard classical world since they would propagate in the "wrong" time direction (which would now be the "right" time direction for their receiver!).
"Negative energy signals" are assumed in the model of memory based on time reflection, which involves a BSFR for the system receiving or sending the signal. Could a subsystem of time reversed MB make BSFRs reversing their arrow of time so that they would send signals to the geometric future?

(b) Suppose that the observer is in the geometric past of the time reversed SOC MB. In this case the observer would receive the signal sent by MB propagating into geometric past and the receival would involve BSFR for some subsystem of the receiver.
If this picture makes sense, 1/f signals could be seen as communications of time reversed systems with signals propagating in the observer's direction of time.
So: if the time reversed systems exist and if they are also able to send signals also in the time direction of the receiver with some probability, the 1/f noise could be understood as a support for ZEO and TGD based model of memory recall as time reflection.

There is an amusing correspondence with everyday life. A period of sleep would be a counterpart for the silent period predicted by ZEO (sleep as a "small death") and near the wake-up the 1/f fluctuations would become stronger. EEG indeed shows 1/f noise. During aging the noise level increases: old people have problems with sleep as I know so well!

13.3 Speculative mechanisms explaining some biological observations

In the sequel some speculative applications will be considered.

13.3.1 Obesity, failing diets, and SPs

The effects of diets on HSP expression and activation have recently been studied, see for instance [I34, I104, I114, I107]. During the initial phase of diet the weight is lost. After that the weight often starts to regain. Does a new energy source emerge or is the level of metabolic energy consumption reduced so that the weight regain starts although the nutrient feed stays at the same albeit reduced level?

(a) The fractality of TGD Universe suggests an analogy to our society. Living organism is a molecular society, and the fractality of the TGD Universe encourages looking at the situation from the point of view of our own society. Our energy resources have been depleting and we have learned to save energy, and also to recycle thermal energy to increase thermal efficiency. Could the organism learn to use remote metabolism to extract thermal energy from the environment besides SPs. Note that the thermal energy of a thermal photon at room temperature is rather near to the Coulomb energy of a unit charge assignable to the cell membrane voltage perhaps defining another metabolic energy currency.

(b) The TGD explanation relies on the proposed ability of at least some SPs to act as ATPases transforming heat energy of their MB to ordered energy realized as metabolic energy quanta. The binding of SPs to ATP [I97] would also liberate binding energy transformed to heat, which is partially transferred to MB as heat energy serving as an additional metabolic energy source. Also the reduction of heat losses would mean more effective use of metabolic energy.
People having obesity predisposition might generate HSP60 or HSP70 and HSP90 even in situations without stress. Also psychological stress such as depression might generate HSPs [I36]. HSP60 is known to be associated with obesity [I114]. HSP60 is associated with mitochondria and has ATP binding site but does not have ATPase. Could ATP binding site give HSP60 a role analogous to that of ATPase using heat energy of MB of HSP70 to generate ATP from ADP? A more plausible option is that the binding of ATP provides energy for HSP60 and only HSP70 and HSP90 act as ATPases.
HSP70 [I103] expression is considerably higher in obesity without metabolic syndrome but lower in obesity with metabolic syndrome [I107]. This would suggest that the diet induces expression of HSP70 and therefore brings an additional metabolic energy source available. In metabolic syndrome the level of HSP70 utilizing thermal energy and reducing entropy of the system would be abnormally low. Besides the expression of HSP70, also its activation is needed [I58]. If the activation takes a considerable time, one could understand why it takes time for the additional metabolic energy source to emerge.

(c) The ability to act as heat engines and ATPases relies on ZEO: the MBs of SPs could extract thermal energy from the environment in a mode with reversed arrow of time: instead of a disappearance of the necessary temperature gradient it would be generated. One can also say that system learns during diet to use remote metabolism.
The phenomenon of remote metabolism or quantum credit card has been previously proposed by Pitkänen [L22]: system would actively extract energy rather than receive it passively. The receiver of effective negative energy signal would be analogous to a population reversed laser assignable to MB. Quantum credit card would facilitate rapid access to energy via bypassing "bureaucratic formalities". This mechanism applies also to information transfer and makes communications possible with effective signal velocity exceeding the maximal signal velocity.
Quite recently, it has been learned that quite simple physical systems can "breathe" by extracting the energy of Brownian motion [D16]: the finding is discussed from the point of view of ZEO in [L107].

(d) The utilization of metabolic energy becomes more effective during diet and there is less waste of energy. Less nutrients would be required and if the dietary consumption stays at the same albeit reduced levels, fat begins to be regenerated. Dietary stress would induce the generation of SPs. SPs acting as APTases would extract thermal energy from the environment and also from the liberated binding energy in the formation of SP-ATP complex and liberate it as ordered energy by ADP$\rightarrow$ ATP process. The slow rate for the generation of enzymes needed to generate and activate SPs might be the reason for the slow response

(e) One could see the situation also in the following manner. ZEO and time reversal are involved with the extraction of thermal energy from the environment by the MBs of SPs. One can also say that the system learns during the diet to use remote metabolism. The time reversal would be the analog of sleep period. Also we get metabolic energy resources during sleep and the same mechanism could be involved. This could be also seen as hibernation/sleeping at the molecular level and the hibernation/sleep even at the level of organisms could rely on the same mechanism.

13.3.2 Sleigh dogs which run for days without eating, and starving bacterial colonies

Suppose that the general view about SPs is correct. Assume also there is a fractal hierarchy of MBs. Not only those of biomolecules and of smaller systems, but also of cells, organelles, organs, bodies, larger units like populations...

Assume also that $h_{eff} = h_g r$ holds true so that the cyclotron energy spectrum does not depend on the mass of the dark charged particle. This implies that MBs at all levels of the hierarchy can communicate with the lowest level and also exchange energy and serve as metabolic energy sources. SPs would thus allow the transfer of energy to all these levels.

This admittedly speculative picture could explain the reported ability of sled dogs to run several days without eating [I30]: they could store the energy to their MBs and use it during substrate lack. A possible storage to their collective MB would increase further the energy storage ability. This would mean a connection to collective levels of consciousness predicted by TGD and receival of metabolic energy feed as dark photons from these levels [L22]. h_{eff} hierarchy indeed makes possible energy transfer and communications between widely different scales characterizing a hierarchy of conscious entities.

This picture could partially explain also why bacteria in media lacking substrate form tightly bound colonies looking like multicellulars. They could store energy to their MB and use it during its substrate lack. Perhaps also the dissipation is reduced because h_{eff} increases.

The cells could also learn to extract thermal energy of the cellular environment besides the thermal energy of SPs, which is more or less another manner to say the same. Starvation could have been the evolutionary pressure leading to the formation of multicellulars. Indeed, the embryos of multicellulars are found to form tightly bound bacterial colonies [I59]: the TGD based model is discussed in [L118]. There is also anecdotal evidence about analogous abilities of Tibetan monks and people regarded as saints.

To summarize, the proposed general model involves several new physics elements. the new view about space-time and fields, the new view about quantum theory based on ZEO predicting time reversal in BSFRs and a new view about self organization and a realization of SOQC, the h_{eff} hierarchy labelling dark matter as phases of ordinary matter predicted by number theoretic vision about TGD, and the hierarchy of collective levels if consciousness having as a correlate the hierarchy of MBs carrying dark matter in TGD sense. This vision can be defended only by its internal consistency and ability to solve a long list of deep problems of recent day physics.

Chapter 14

Aging from TGD point of view

14.1 Introduction

This article was inspired by a birthday gift. The gift was a highly inspiring book "Lifespan" by David Sinclair and Matthew LaPlante [I31]. The book tells about the recent understanding concerning aging. The general vision about aging represented in the book can be summarized as follows.

(a) The key idea is that genes do not determine everything. DNA has also continuum degrees of freedom characterized by its shape. These degrees of freedom are related to epigenesis which is higher level control activity controlling what genes are expressed. The basic mechanisms are prevention and allowance of gene expression. Acetylization [I2], methylation [I16] and many other modifications affect the gene expression by attaching to proteins known as histones forming kind of pearls in the necklace defined by DNA: genes follow nucleosomes in the DNa strand. Also the reversals of these processes - for instance, deacetylation [I7, I53]and demethylation [I16] are essential for the control of gene expressions.

(b) Aging involves the emergence of various diseases. Usually the attention is directed to dealing with these diseases. Now the view is however more general. Aging is seen as a gradual approach to chaos manifesting as various diseases. In order to prevent the diseases one should slow down the approach to chaos.

(c) Epigenetic chaos hypothesis suggests that some control systems associated with information molecules and related to the control of DNA transcription and translation by epigenesis must approach chaos. This is seen as the gradual randomization of DNA conformations causing problems in the transcription of DNA: DNA becomes loopy. The DNA coding for the ribosome acting as the translation machinery of DNA is of special importance and becomes also loopy. What comes first in physicist's mind, is an approach to thermal equilibrium. Is there some system controlling epigenesis which approaches thermal equilibrium with the environment? In standard chemistry it is difficult to identify this kind of system.

(d) Biology has invented ingenious mechanisms to slow down aging. For instance, there are molecules having two functions. There are proteins making the translation of the genes related to cell replication possible.
When the DNA coding for the ribosome gets loopy their function changes. The translation of genes ceases as the proteins leave the histone molecules and enter the damaged DNA and freeze it so that it can be prepared. This however slows down cell replication and also causes other problems leading to various diseases related to aging. One can say that a cell is like a hospitalized patient.
The slowing down of aging would be in this framework basically fighting against the thermo-dynamical arrow of time. Is it really possible to understand the processes involved in the framework of standard bio-chemistry with a single arrow of time?

Even the understanding of the biocatalysis is difficult: how the reacting molecules are able to find each other in the molecular soup and how the huge increase for the rate of these processes is possible. The TGD based solution of these problems will be discussed later.

What could TGD inspired theory of consciousness and quantum biology rely on zero energy ontology (ZEO) inspired biology allow to say about the mechanism behind aging?

(a) Negentropy Maximization Principle (NMP) as the variational principle of consciousness replaces the second law and implies it for ordinary matter. State function reduction (SFR) means a reduction of the entanglement for a pair $S_a - S_b$ of sub-system S_a and its complement S_b in S. Measurement cascade proceeding from long to short scales decomposes at each step a system to a pair of unentangled subsystems is in question. NMP as a variational principle of consciousness states that negentropy gain in these reductions is maximized and selects the pair $S_a - S_b$ at given step.
In adelic physics [L60, L59] the negentropy $N = -S_1 - S_2$ is sum of real and various p-adic negentropies but p-adic negentropy can be positive so that for non-trivial extensions of rationals one can have $N > 0$. This kind of entanglement is stable against NMP so that the process stops. One can assign positively colored emotions to this kind of entanglement and it distinguishes between living and inanimate matter and also between dark and ordinary matter.

(b) TGD inspired theory of consciousness is basically an extension of quantum measurement theory allowing to get rid of the basic paradox of quantum measurement theory. There are two kinds of state function reductions (SFRs) "big" SFR and "small" SFR (briefly BSFR and SSFR) [L96].
SSFRs are counterparts of "weak" measurements which are much like classical measurements and do not involve any dramatic changes. The sequence of SSFRs gives rise to a conscious entity -self - as a sequence of moments of consciousness. Subjective time as a sequence of SSFRs correlates with the geometric time. BSFRs are counterparts of ordinary quantum measurements and have a dramatic effect: in a very general sense one can say that self dies and reincarnates with an opposite arrow of geometric time.

(c) There is a hierarchy of magnetic bodies carrying dark matter as phases of ordinary matter with effective value $h_{eff} = nh_0$ of Planck constant. n corresponds to the dimension of an extension of rationals. The extensions define evolutionary hierarchies with increasing complexity. n serves as a measure of algebraic complexity and as a universal IQ, and also characterizes the scale of quantum coherence. For instance, genes are characterized by the value of h_{eff} associated with their MB.
Since MBs have higher universal IQ than ordinary biomatter, they control the biochemistry. In particular, they would control DNA and DNAs MB would actually realize genetic codons in terms of dark proton triplets. Also dark photon triplets would provide this kind of realization crucial for control of and communication with ordinary biomatter.

(d) ZEO implies a theory of self-organization [L91] and of self-organized quantum criticality (SOQC) relying on time reversal [L193]. The dissipation of a system looks like in reversed time direction extraction of energy from the environment. Also SOQC becomes possible since criticality, since a state, which is a repeller, becomes an attractor in reversed time direction. The system seems to tend to criticality for an observer with an opposite arrow of time.

(e) In this framework the aging could be seen as the approach of the system formed by MBs of the information molecules and of ordinary biomatter to a thermal equilibrium. The temperature of MB gradually grows and eventually reaches a maximal temperature (due to the stringy character of flux loops) known as Hagedorn temperature and identifiable as the physiological temperature. System dies.

14.2 Very brief summary about some aspects of aging?

The book of Sinclair and LaPlante [I31] is about aging and how to slow down it. The basic hypothesis is that aging need not mean getting sicker and sicker all the time. Biology has

developed molecular tools for slowing down aging and there are longevity genes analogs to SPs taking care of this. It might be possible to help them by a healthy lifestyle.

The books represents a vision involving the following pieces.

(a) Aging is information loss and molecular level, in particular DNA level. Ribosomal DNA seems to be in a special role assignable to nucleolus. Physicist could try to understand this from the second law: entropy un-avoidably increases . Entropy increases for isolated system but it is perhaps not so simple.

(b) It has been learned that damage to DNA alone cannot explain aging. There must be additional degrees of freedom assignable to epigenesis as a control of genome. Besides genetic code there should exist additional continuous information carrying degrees of freedom.

Epigenesis involves these degrees of freedom and DNAs conformation (involving coilings of coilings of ..) represents these degrees of freedom. Histones appear tangles along the DNA double strand selecting which genes are expressed. Acetyl tag in the histome allows gene expression to take place. When acetyl is absent, nothing happens. The effect of acetyl tag can be also silenced.

(c) There are enzymes Sirn, $n = 1, 2, ..7$, called sirtuins [I18, I74] (`https://cutt.ly/Hjkh0ia`). In particular, Sir2 silences so-called mating type genes so that the cell replicates normally. If Sir2 is not present in mating type genes, they are expressed and replication does not take place normally. I understood that for yeast, the cell loses its sexual identity and does not replicate.

During this non-replication period the cell would concentrate on maintenance. Under stress situations this would occur quite generally and make survival possible. If you cannot eat and replicate, sleep, and generate metabolic energy from thermal energy for instance. Also SPs would be at work. On the basis of [L193], one could guess that a kind of hibernation state with a reversed arrow of time could be in question. To live longer it is good to die sufficiently often!

(d) This is not the only function of Sir2. When DNA double strand is broken, Sir2 must leave its job and hurry to the broken DNA and catalyze expression of SIRn coding for histone deacetylase HDAC, which removes acetyl tags from histones and deactivates DNA. After this the broken DNA is prepared. This is like putting a victim of a traffic accident to a hospital bed or even artificial coma.

As cells get older, this kind of DNA breaks occur more often and Sir2 must leave its basic job more often and the cell loses its ability to replicate more often. It can also happen that Sir2 does not find its original position in the mating gene and starts to silence a wrong gene. This leads to epigenetic noise inducing aging.

(e) In particular, ribosomal DNA in the nucleolus, the largest structure of the nucleus, can end up with chaos. Loops are formed and recombination between portions of the same strand can occur (remember the reconnection mechanism and time reversal). Ribosome plays a fundamental role in translation so that there is no wonder that difficulties emerge. Important class of damage consists of breaking DNA double strands. This leads to a chaotic conformation involving loops. Sir2 must rush to the nucleolus and this means that mating genes activate and the replication stops. When these accidents occur too often, the cell becomes senescent.

14.3 Negentropy Maximization Principle (NMP) and Second Law

The natural expectation is that second law relates to aging. This motivates a section devoted to the recent view about Negentropy Maximization Principle (NMP) [K64] defining the variational principle of consciousness in the TGD framework and implying in adelic physics [L59, L60] second law in the case of non-negentropic entanglement (in standard physics entanglement is always non-negentropic).

Mathematically NMP is analogous to the second law in that it is not deterministic like the variational principles of classical physics. For a given entangled system NMP allows state

function reduction (SFR) for that sub-system-complement pair for which the negentropy gain is maximal. The state function reduction can occur to any eigenstate of the density matrix of the selected subsystem in accordance with standard quantum measurement theory. This would lead to a product of pure states and the negative entanglement negentropy of the initial state would become vanishing in the final state so that negentropy would increase. The inclusion of p-adic contribution to negentropy identifiable in terms of cognitive information assignable to entanglement changes the situation and the entanglement can be stable against NMP and state function reduction cascade stops to entangled state representing cognitive fixed point. Since negentropy gain is not anymore popssible in SSFRs, death is bound to take place.

14.3.1 General observations about second law

First some general observations about second law.

(a) Second law is an empirical fact. Second law forces the increase of entropy in statistical sense. Thermo-dynamical equilibrium is the most probable equilibrium. Second law in the standard form assumes a fixed arrow of time. Zero energy ontologuy (ZEO) forces to give up this assumption and allow both arrows of time.

(b) Quantum physics is certainly behind second law. If you have an entangled system state, SFRs occur for subsystems with reduction probabilities determined by its entanglement with the environment. This eventually leads to a loss of entanglement and quantum coherence and one must apply statistical using density matrix for individual sub-system and eventually justifies thermo-dynamical description. It is important to notice that in SFR the entanglement entropy of an individual system is reduced in SFR but that in the case of ensemble of identical systems this generates entanglement entropy identical to the entanglement entropy of single particle giving thermo-dynamical entropy as a special case.

One can consider two interpretations: a) the generation of entanglement generates single particle entropy although actually the entropy of the entire system does not increase in unitary evolution or b) the transformation of this entropy to ensemble entropy corresponds to second law. Option b) looks more realistic.

This is however only a description for what happens. One can ask what is behind second law. Is there some deeper principle as one might suspect because quantum measurement is so poorly defined theory. For instance, von Neumann proposed that only humans cause SFRs. It is often assumed that decoherence occurs without making any proposal how this happens. What is known and well-tested is that reduction probabilities for a measurement reducing the entanglement are coded by the measured density matrix, and one can say that the system goes to an eigenstate of the density matrix as the entanglement is reduced. For an ensemble of identical particles this process transforms entanglement entropy to ensemble entropy with the same value.

Negentropy Maximization Principle (NMP) is the TGD based proposal for the variational principle behind SFRs.

14.3.2 The new physics elements involved with NMP

NMP involves several new physics elements.

(a) What is new is the hierarchy of systems having the hierarchy of space-time sheets as a geometric correlate. At the level of consciousness theory it would have self hierarchy as a correlate. Quantum measurements are assumed to correspond to SFR cascades proceeding from higher to lower levels of the hierarchy.

(b) ZEO brings in the notions of "small" SFR (SSFR) as counterpart of "weak" measurement and "big" SFR (BSFR) as counterpart of ordinary quantum measurement [L96] and forces giving up the assumption about a fixed arrow of time. This modifies standard thermodynamics and leads to a new view about self-organization self-organized quantum criticality [L91, L193].

(c) In the standard physics framework there is no definition of negentropy as a measure of conscious information. Negentropy can be only defined as the negative of ordinary entropy and is therefore non-positive. The best that one could have would be vanishing negentropy. This failure is understandable since standard physics does not even try to describe cognition. One manner to solve the problem is to claim that only entropy gradients, whose sign can be also negative matter and thus consider only information flows. In TGD different view is adopted.

(d) To bring in conscious information one must introduce cognition. In the TGD framework it is assumed to be described by adelic physics [L60, L59]. This brings in p-adic space-time surfaces as correlates of cognition. Real space-time surfaces are replaced with their adelic counterparts forming a kind of Cartesian product of real and various p-adic space-time surfaces obeying the same algebraic equations.
By $M^8 - H$ duality [L104, L105] one can regard space-time surfaces as surfaces in M^8 or in $H = M^4 \times CP_2$. M^8 is a subspace of the space of complexified octonions O_c and space-time surface is determined as a 4-D "root" of a real polynomial algebraically continued to an octonionic polynomial. If the coefficients of the polynomial are rational numbers, the polynomial makes sense for both real and p-adic number fields implying number theoretical universality. The dynamical principle is simple: the normal space of the space-time surface is associative/quaternionic.
$M^8 - H$-duality maps these 4-surfaces to 4-surfaces in H. In both cases one has minimal surfaces. Also the notion of cognitive representation emerges and is essential for the number theoretical universality. It is also crucial for the construction of the scattering amplitudes [L117, L104, L105].

14.3.3 Detailed formulation of NMP

Consider now the formulation of NMP [K64] in this conceptual framework.

(a) In adelic physics cognition is described in terms of p-adic degrees of freedom. Entropy is a sum of two terms: $S = S_1 + S_2$.
S_1 is the ordinary entropy describing the amount of ignorance of the observer about the state of either entangled system - say Schrödinger cat and the bottle of poison.
S_2, as the p-adic variant of entropy (also real valued) assignable to cognitive information has an analogous formula and similar defining properties but can be *negative*(!) and is interpreted as a measure for the information carried by entanglement.
Thr possibility of having negative sign is basically due to the fact that the logarithms $log(p_k)$ of probabilities p_k in the Shannon formula $S = -\sum_k p_k log(p_k)$ for entropy are replaced by the logarithms of their p-adic norms $|p_k|_p$ given by p^{-n} for $p_k = p^n(a_0 + a_1 p + ...)$ (note that the exponent changes sign!): $log(p_k) \to log(|p_k|_p)$. Entropy remains additive since the p-adic norm of product is product of p-adic norms.
A more general formula for the real Shannon entropy S_1 is as $S_1 = -Tr(\rho log(\rho))$ (ρ is the density matrix). Even in the case that the matrix elements of ρ are in the extension of rationals used, this formula need not generalize for S_2 since also $log(\rho)$ should have this property. The manner to avoid the problem is to diagonalize ρ. This is possible if the eigenvalues of ρ - having an interpretation as entanglement probabilities p_k (equivalently reduction probabilities) - belong to the extension of rationals considered. At the fundamental level this extension is defined by the space-time surface determined by a polynomial with rational coefficients ($M^8 - H$ duality [L104, L105]): the roots of the polynomial determine the extension and space-time surface (number theoretic holography). If the entanglement probabilities are not in the extension, one might argue that the entanglement is stable - note however that NMP alone could make it stable.
Quantum coherence involves stable entanglement carrying cognitive information measured by S_2. The destruction of coherence if allow by NMP destroys information defined as the sum $N = -S = -S_1 - S_2$. In absence of cognition one would have $N = -S_1$ and NMP would transform to second law.

(b) The cascade of "small" state function reductions (SSFRs) eventually leads to a state in which the remaining entanglement is stable. There is no subsystem-complement pair for which SSFR could take place in such a way that negentropy $N = -S = -S_1 - S_2$ would increase. The resulting states are analogous to bound states.

(c) Remarkably, in its adelic formulation NMP states that the total entropy, which tends to be negative for extensions of rationals, gets smaller and negative: information is generated! The pessimistic second law transforms to an optimistic NMP! The gloomy character of second law would be due to the neglect of cognition from physics.
Cognitive entropy gets more and more negative but real entropy which is closely related to it but tending to have a smaller magnitude than p-adic entropy for extensions of rationals also increases [K64] [L96]. Hence their sum tends to increase with the dimension $n = h_{eff}/h_0$ of the extension.

What makes entanglement stable against SSFR? One can consider two mechanisms.

(a) Adelic physics allows negentropic entanglement, which tends to be stable against SSFRs since it can only become even more negentropic.

(b) One can also consider another stabilization mechanism. The rule would state that if the density matrix of the subsystem-complement pair does not allow eigenvalues in the extension of rationals considered, the reduction is not possible. For a stable entanglement density matrix would not allow eigenvalues in the extension of rationals considered. One can of course criticize this rule as somewhat *ad hoc* and the first option might be enough. One can also ask whether this mechanism is equivalent with the first mechanism.

(c) What could be the interpretation of the negentropic entanglement? I have assigned positive emotions like love to this entanglement, also experience of understanding, etc...

NMP implies increase of ordinary entanglement entropy

NMP implies increase of the ordinary entanglement entropy. The hasty conclusion would be that this implies also increase of thermal entropy and thus second law. Here one must be however cautious.

(a) Second law as an increase of ordinary entropy would still hold true but the increase of cognitive information would be larger than the increase of the real entropy for non-trivial extensions of rationals (this is always the case).
The asymptotic states with maximum negentropy and with stable entanglement would have maximal real and minimal p-adic entanglement entropy and their sum would be negative - and $N = -S$ would therefore serve as a measure for the amount of conscious information.

(b) One might argue that intelligent systems tend to pollute their environment: they are entanglement entropy generators and by witnessing what has been happening to our environment, it would be easy to agree.
One must be however extremely cautious with formulas. The stability of negentropic entanglement means that the real entanglement entropy cannot transform to ensemble entropy and cannot therefore actualize! Is this what distinguishes loving attention as something unique and positive: the entanglement is stable and cannot transform to ordinary entropy?

Could NMP allow the failure of second law in some situations?

The dream about eternal youth seems to be in conflict with the second law. For physicist second law is usually the absolute authority. Working with the details of NMP however force to challenge this view.

A generalization of second law taking into account time reversals is required in ZEO and already this implies apparent breakings of second law. Furthermore, NMP implies second law as the increase of entanglement entropy. NMP does not allow SFRs transforming negentropic entanglement entropy to thermodynamic ensemble entropy unless the SFRs occurs at higher

level of hierachy so that the local reduction of negentropy is compensated by its increase in a longer scale. The implications of this fact remain to be understood.

Could NMP break the second law? Can this be consistent with empirical facts? Could the breaking of second law occur at the level of dark matter only? Second law would apply only to the entropy transformable to thermal entropy. The sum $N = -S_1 - S_2$ is what matters: for a trivial extension one has $N = 0$ so that this transformation is possible. $N = 0$ can be however true also for non-trivial extensions. Could the total entanglement negentropy assignable to the ordinary matter satisfy $N = 0$ and be therefore transformable to thermal entropy whereas "dark" entanglement negentropy satisfying $N > 0$ would not allow this. Could one identify dark/living matter as negentropic matter and ordinary/inanimate matter as non-negentropic thermalizable matter? Note that also the phases with $h_{eff}/h_0 = n$ could in principle have $N = 0$. The stability of dark entanglement could directly relate to the failure to observe dark matter.

Comparison with the proposal of Jeremy England

Jeremy England [I98] has noticed that living systems increase entropy and has proposed it as a basic principle of biology. England's proposal is discussed from TGD point of view in [**?**]. I did not however realize in this article the fact, that negentropic entanglement entropy need not allow a transformation to thermal entropy.

One can represent several objections against England's idea.

(a) Second law cannot force or even allow the generation of life. Second law relates to the occurrence of SFRs but we do not have a real theory of quantum measurement.

(b) Second law assumes preferred arrow of time and there is a lot of support for its violation in living matter as realized first by Fantappie [J30]: in particular, self-organization processes could involve dissipation with reversed arrow of time.

(c) To understand life one must take it seriously. Living system is somehow different from inanimate matter. The emergence of life means the generation of conscious information but in the framework of standard physics there is no definition of conscious information.

These objections raise several questions. Why the emergence of life would be accompanied by a generation of entropy? What could serve as a measure for conscious information? How to describe cognition? To these questions adelic physics provides a possible answer. If entropy that England talks about is identified as the entropy produced in SFRs of systems having $N = 0$, TGD view is consistent with the proposal of England.

Cognitive fixed point instead of thermal equilibrium?

The analogy with the second law strongly suggests that the system approaches a cognitive fixed point (negentropy maximum) during the sequence of SSFRs followed by the analog of unitary time evolution. SSFRs cannot generate negentropy anymore. Since the system does not learn anymore, BSFR is bound to occur. A possible number theoretic formulation for the fixed point could be following.

(a) The time evolution following SSFR generates entanglement. This entanglement is maximally reduced in measurements of observables, which correspond to operators, whose action does not affect the states at the passive boundary.

(b) Cognitive measurements define an important class of such measurements [L115]. The cognitive quantum states correspond to wave functions in the Galois group G of the extension - that is elements of the group algebra $F(G)$ of G. G can be decomposed to a product $G = \prod G_i$ of subgroups defined by the hierarchy of normal subgroups of G defined by the representation of the extension as an extension of an extension of ... of rationals.

Elements of $F(G)$ decompose to superpositions of products of functions in G_i and the factors are entangled. Note that the order of G_i matters and is induced by the inclusion hierarchy for the extensions considered: the largest extension is at the top of the hierarchy. One has "ordered" entanglement. This is analogous to the directedness of attention which is difficult to understand in the standard physics framework.
Eastern philosophies speak also of states of consciousness in which there is no distinction between observer and observed and not division. Could this kind of attention involve negentropic entanglement between systems, which correspond to the same extension of rationals so that the. attention cannot be directed? Or could it correspond to negentropic cognitive entanglement allowing cognitive SSFRs?
The first cognitive measurement leads to a product decomposition in $F(G/(G_2...G_n)) \times F(G_2..G_n)$ if the entanglement coefficients between $G_1 = G/(G_2...G_n)$ and $F(G_2..G_n)$ are in the extension of rationals considered. Same can happen at the next step and leads to a similar decomposition of $F(G_2, ...G_n)$. The maximal cognitive measurement cascade leads to a product of wave functions in $F(G_i)$ but it can happen that there is no measurement cascade at all.

(c) The picture leads to ask whether one could speak of cognitive analogs of particle reactions representing interactions of thoughts. Finite group G has always a decomposition in terms of simple factors G_i induced by the hierarchy of normal subgroups. The simplest situation corresponds to a Cartesian product of simple subgroups: $G = \prod_i^{\times} G_i$. In this composition the order of factors does not matter and the situation is analogous to a many particle system without interactions.
The group algebra of G is a Cartesian product of group algebras of G_i and the natural group representations are unentangled tensor products as analogs of free many-particle states. One might say that there are no cognitive interactions. This situation is representable as a product $P = \prod_i P_i$ of polynomials P_i assignable to the factors. This polynomial is not irreducible. Note that the polynomial associated with a given Galois group is highly non-unique and that cognitive representations are discrete and preferred ones correspond to algebraic integers [L104, L105].
An irreducible polynomial representing a composite of polynomials with Galois group G having composition in terms of Galois groups of extension of extension of ... with extension at level i having Galois group G_i. Functional composition $P_{n_1} \circ P_{n_2} \circ ...$ can produce a decomposition of Galois groups G_i identified as Galois group of E_i as extension of E_{i-1}. It is not clear to me whether any composition is possible. For a given ordering of the G_i there can be several decompositions. Could non-trivial decompositions, which do not reduce to a Cartesian product, represent cognitive interactions?
The intuition about what happens in particle reactions suggests that the reduction of cognitive entanglement could correspond at space-time level a process in which incoming cognitive many-particle state is represented by a product of polynomials P_{n_i} and outgoing many particle state by the product of polynomials Q_{m_i} such that conservation of degree holds true: $\sum n_i = \sum m_i$. In the interaction region defined by CD, the polynomial would be some irreducible polynomial constructed as a functional composite of polynomials R_i. Do the continuity conditions at the boundaries of CD allow nontrivial interactions not requiring $P_i = Q_i$? Cognitive dynamics based on the representations of the Galois group assignable to cognitive representations would define a number theoretical analog of topological quantum field theory.

(d) Suppose that the time evolution following SSFR for individual mutually unentangled subsystems is in good approximation unitary (their interactions with other such subsystems can be neglected) so that they do not entangle, the density matrix of an individual system suffers a unitary automorphism so that entanglement entropies remain unaffected and the negentropy gain vanishes. One could speak of "asymptotic freedom" as a condition for the cognitive fixed point.
The cognitive fixed point would define the "silent wisdom" of the re-incarnate having the formerly active boundary of CD as a passive boundary of CD. What would be learned during life would help during the next life cycle.

14.4 TGD based model for aging

In this section the TGD based view about aging is discussed. The king idea is that the magnetic bodies (MBs) of information molecules and linear molecules formed from them (DNA,RNA, amino-acids,tRNA) are at very low temperature in the beginning. The temperature of MB starts to raise and approach the physiological temperature. The entropy of MB increases. Since the MB of the molecule controls the molecule, the control by MB starts to fail and this leads to the diseases accompanying aging.

14.4.1 Aging as approach of MB and BB to thermal equilibrium

Ordinary entropy increases for an isolated system, it approaches thermal equilibrium - thermalizes. Aging must correspond to thermalization in some sense. There are two views about this.

(a) The weak form of the proposal making sense in the standard physics context would identify aging as thermalization. For ordinary biomatter, which already is in thermal equilibrium in good approximation, this idea does not lead to anything interesting.

(b) Ordinary matter and the dark matter at MBs carrying dark matter as phases of ordinary matter with $h_{eff} = nh_0$ have widely different temperatures at the moment of birth. Aging means that these systems approach thermal equilibrium in the sense that temperatures become identical . MB has infinite number of degrees of freedom and therefore maximal temperature known as Hagedorn temperature identifiable naturally as physiological temperature [L193]. This option will be considered in the sequel.

Consider the situation in TGD.

(a) What are the continuous degrees of freedom whose entropy growth would lead to aging. In the TGD framework they would be naturally the geometric degrees of freedom associated with the flux tubes of dark DNA controlling ordinary DNA. Their number is infinite implying that temperature is below Hagedorn temperature around physiological temperature. One can assign a temperature to the flux tubes and also to these degrees of freedom and this is below Hagedorn temperature. When temperature at flux tubes increases, the geometric shape starts to thermally fluctuate and the overall size increases. Cells indeed increase in aging as do also we!

(b) For information molecules the temperature of MB must be very low: dark DNA flux tubes have a very precise shape and therefore also ordinary DNA. For SPs the situation is different and this makes possible their basic functions.

(c) Aging could simply mean that the dark genome approaches thermal equilibrium with ordinary biomatter at physiological (Hagedorn) temperature and entropy of dark genes and magnetic flux tubes increases. Flux tubes get more and more irregular shaped and induce a development of loops for ordinary DNA and breaks DNA double strand. Nucleosomes are loop like structures associated with histones and also these are known to be lost. Epigenetic chaos is induced. When thermal equilibrium is achieved death as heat death occurs and changes the arrow of time at the level of the entire body which is left in the geometric past of the standard observer to continue life with an opposite arrow of time.

Remark: ELF em fields at EEG frequency range have quantal effects affecting the behavior and physiology of vertebrate [J8]. EEG photons however have energies many orders of magnitude below thermal energies so that effects should be completely masked. My first proposal for explanation was that the temperature at the space-time sheets of ions is extremely low and below the energy of EEG photons. Later I gave up this option in favor of h_{eff} hypothesis.The two explanations are actually consistent. Thermal energy is proportional to the temperature. For an n-sheeted structure one has by the additivity of thermal energy for different identical sheets $T_H = nT_H(sheet)$ implying $T_H(sheet) = T_H/n$. For the huge values of h_{eff} and thus of n, $T(sheet) \leq T_H(sheet)$ is indeed extremely small!

(d) There is a connection to the article [L191] about DNA and arrow of time. One can argue as follows. As the electric field along DNA double strand decreases by the shortening of the sticky ends, the string tension as density of electric energy per length decreases, the stiffness of DNA decreases, and the fluctuations start to develop. Second possibility is that the shortening of telomeres and sticky ends is a controlled process causing a programmed aging.

(e) There are molecules devoted to preparation of the damaged DNA. The epigenetic tags on histones of mating genes could control the arrow of time for the gene involved. If the tag is present, the gene is expressed. If not or if inhibited by say Ser2, the arrow of time is reversed.

Objections related to metabolism

Metabolic energy feed is needed to keep the distribution of h_{eff}:s and even increase the values of h_{eff} - defining universal IQ and characterizing quantum coherence scale. This relates to the second important aspect of life: quantum coherence in long length scales is needed to generate the coherent behavior of ordinary biomatter and is not possible in standard bio.chemistry framework. Ageing would be a gradual reduction of this quantum coherence by thermalization of MBs of the basic information molecules, in particular the dark variants of the basic biomolecules. If you want to live long, take care of your personal quantum coherence!

One can develop some objections against the vision about ageing as thermalization of the MBs of information molecules.

(a) Aging is viewed as changes of the body after birth. What about the processes before birth? When sperm and gametes inoculate and divide and divide and form some distinguished organs, this process needs a high amount of energy; that is why mothers get to eat more during pregnancy.
Fetus generates new structures - parts of MBs containing dark matter as $h_{eff} = n \times h_0$ phases of ordinary matter with increasing value of h_{eff}. This requires high metabolic energy feed provided by mother. Information molecules are however still very far from thermal equilibrium and the gradual increase of the temperature of MBs has practically no effects. The situation remains the same also at the young age. At later age MBs approach thermal equilibrium and problems with the bio-control by MB emerge.

(b) Reactive Oxygen Species (ROS) cause also damage for DNA: the more ROS, the shorter the life of the cell. That is why food with low calories content or fastings or low carbohydrates (which need less oxygen to burn) diets are good for longevity.
ROS have been also seen as a cause of aging and one could argue that they should cause a lot of damage during the fetus period involving intense metabolism. The repair mechanisms of MB work almost optimally for fetus and at young age and allow handling of the problems due to ROS. The authors of [I31] argue that it is now known that ROS are not the basic reason for aging. As a matter of fact, ROS are essential for the demethylation [I9].

Is apoptosis as programmed cell death consistent witht he proposal?

Also programmed cell death - apoptosis - could be treated as an objection against aging as approach to thermal equilibrium. Apoptosis as a programmed cell death cannot be purely thermal event. It could be induced by MB at the higher level of hierarchy as BSFRs. Perhaps by MB of cell group as in the development of fingers from the cell mass. Apoptosis could have several motivations.

(a) The basic prediction is that giving systems are intentional systems having free will at all levels. MB at the higher level could act like dictator and destroy quantum coherence locally leading to the death of the cells but generating quantum coherence and generation of structures in longer scales which would also take the metabolic energy resources used by the dead cells.

Negentropy Maximization Principle (NMP) would be the deeper principle behind the second law. Apoptosis would be consistent with the NMP which implies second law as a by-product and as its name tells, implies negentropy increase. Therefore thermalization would not the only cause of cell death.

Apoptosis would indeed generate more complex structures when fingers develop from tissue. Destruction of lower level structure would be the price paid for the generation of a higher level structure and negentropy gain in longer scales.

(b) Evolution means steps in which h_{eff} increases in BSFRs and longer scales of quantum coherence at the level of MB emerge. Extinction of cells and sauri would be part of evolution.

A controlled BSFR causing the analog of death/hibernation of a subsystem could be also represented as an objection. The BSFR would have the survival of a larger system as a motivation [L193]. In fact, all motor actions can be seen as BSFRs at some lower level so that life is continual dying! Death/hibernation of a subsystem means savings of metabolic energy and can be seen as one manner to fight against second law since the dead subsystem lives with the opposite arrow of time: living system is basically 4-D entity in ZEO - not just the time slice which corresponds to conscious experience!

Is the biochemical approach trying to describe dissipation as a controlled process?

A general comment related to the distinction of the standard approach and the TGD approach relying on ZEO is in order. Standard approach does its best to identify control mechanisms leading from state A to state B. Huge amount of information exists about reaction pathways and one can only admire these data mountains.

This approach is very natural as long as time reversal is not involved. If this is the case, there are processes, basically healing and repair processes, that occur in a reversed time direction as dissipative processes and each BSFR leading to a time reversed state involves its own reaction pathways. The tragedy would be that the standard approach tries desperately to understand loss of order as a controlled process inventing endlessly reaction pathways!

Of course, this work would not be useless. The problem is however that a deeper understanding is missing and prevents seeing how incredibly simple the picture is at the fundamental level.

(a) The increase of entropy in reverse time direction apparently breaks second law in the standard time direction. Stress proteins (SPs) discussed in [L193] are involved with this battle. The magnetic bodies of SPs can extract heat energy from the environment in heat shock and heat DNA and proteins in cold shock, and also act as heat engines for molecular motors.

(b) As also the authors of [I31] emphasize: diseases are a consequence of a loss of information. Disorder increases as quantum coherence is lost, and manifests as numerous diseases. Quite concretely, the h_{eff} distribution flattens in the sequence of SSFRs. System gets less intelligent and is unable to cope with the hard reality! Second law would eventually win although this process can be slowed down by BSFRs of subsystems.

(c) Things can go wrong in very many ways: as Tolstoy said, families can be unhappy in myriads of different ways but there are very few ways to be a happy family! Therefore the disease centered thinking of medicine is perhaps not the best approach. One should do something which helps to prevent all diseases simultaneously. One can avoid diseases by choosing a healthy lifestyle. Also a medicine relying on the idea that BSFRs for subsystems could help. BSFR could be seen also as falling sleep and resting and gathering metabolic energy - even from thermal energy.

(d) Time reversed dissipative evolution looks like healing in the reversed arrow of time. If this is the case, the tragedy of biology would be the attempt to understand time reversed dissipation in terms of complex control actions based on complex reaction pathways or even as some kind of computer programs.

(e) MB would be in a key role since most diseases would be problems in the control performed by MB and basically due to the reduction of h_{eff} and therefore of information contents. About detailed criteria for when one has a disease this approach cannot say much.

Loss of the control of housekeeping genes causes vicious circle leading to death

The basic problem from the point of view of longevity would be that during aging MB gradually loses control of not only methylation, acetylation and their reversals but also other modification processes.

A possible explanation for hypermethylation is that the control actions inducing demethylation fail. The observed hypomethylation in the complement of CpG islands could be due the failure of methylation so that the state becomes stable. More generally, this suggests that the loss of control of all modifications is the mechanism leading to the situation in which the modifications cannot be changed. For instance, the differential methylation of hippocampus is known to be relevant for memory recall, which could relate to the emergence of memory problems at the old age.

CpG:s which are hypermethylated appear in the promoter regions of almost all housekeeper genes so that housekeeping [I11] (`https://cutt.ly/2jQgOSD`), in particular transcription and translation machineries, metabolism, functioning of stress proteins, etc.... becomes difficult.

The enzymes responsible for the methylation and demethylation are especially important for housekeeping genes [I11] whose promoter regions contain CpG islands. Metabolism related enzymes like Cytochrome P450 are involved also with demethylation as enzymes. Methylation of the promoter region of housekeeping genes means also methylation of genes coding for demethylase. This vicious circle - not so positive positive feedback - leads to death.

What causes the loss of the control of these modifications? The mechanisms leading to the loss of control would relate to modifications of the chromatin and DNA organization. These include reduced global heterochromatin, nucleosome remodeling and loss, changes in histone marks, global DNA hypomethylation with CpG island hypermethylation, and the relocalization of chromatin modifying factors [I91, I22, I56]. In the TGD framework these changes would be caused by the thermalization of the MBs of DNA and chromosomes.

Also cancer induces these changes about which the appearance of additional chromosomes in the mitochondrial DNA in cancer is an example. It has been found that a very weak oscillating magnetic field with strength in nanotesla range and with oscillation frequency around 60 Hz (Schumann frequency) leads to the disappearance of additional chromosomes [I125]. The loss of quantum coherence is the general explanation but it is not clear whether this can be due to thermalization at the level of DNA in this case. A possible explanation is that the control by MB at a higher level of hierarchy is lost and the presence of magnetic field re-establishes a connection with this MB in turn re-establishing quantum coherence [L69].

MB controls the conformations of DNA and chromosomes. MB is identifiable as a flux tube network and its control relies on its motor actions involving reconnections and shortenings of the flux tubes by a temporary reduction of h_{eff}. These motor actions of MB would become fuzzy by the thermal motion. The precise motor performance of MB is crucial for the realization of modifications occurring at the promoter regions near histones and at histone tails. Therefore the thermalization of the flux tube degrees of freedom of MB could be the basic reason for the problems.

When does death occur?

Aging could simply mean that the dark genome approaches thermal equilibrium with ordinary biomatter at physiological (Hagedorn) temperature [L193] and entropy of dark genes and magnetic flux tubes increases. Flux tubes get more and more irregular shaped and induce a development of loops for ordinary DNA and breaks DNA double strand. Epigenetic chaos is induced. When thermal equilibrium is achieved death as an analog of heat death occurs and changes the arrow of time at the level of the entire body which is left in the geometric past of the standard observer to continue life with an opposite arrow of time.

BSFR means death and death is bound to occur. But when? TGD proposes a general criterion: at a given step either SSFR or BSFR occurs and the SFR that means maximum negentropy gain takes place. This SFR is not unique. It can be either SSFR or BSFR and in both cases there are a lot of options for the final state.

When would BSFR win in the comparison?

(a) Total entropy can be defined as the sum of p-adic and real Shannon entropies. p-Adic Shannon entropies involving p-adic norms $N_p(p_k)$ of probabilities p_k in the logarithmic factors $log(N_p(p_k))$ can be negative. In this case they characterize the information (associated with cognition) assignable to the entanglement.

(b) Real entropy characterizes the lack of information about the state of either entangled system and is associated with sensory input (is the cat dead or alive?). The sum of the real and p-adic entropies can be negative for non-trivial extensions of rationals so that one would have genuine cognitive information. One could also speak of mere cognitive information as the p-adic contribution to the entropy and this can be negative.

(c) Intuitively it seems obvious that thermalization meaning that the temperature difference between MBs and systems such as genes is reduced, means loss of information defined in this manner. Information molecules cease to be information molecules at least in the geometric degrees of freedom.

(d) BSFR becomes the winner if SSFRs can give only very small negentropy gain or if the negentropy gain becomes negative. The fact that we do not learn much anymore at the old age, could reflect the reduction of the negentropy gain in SSFRs.

Also the distribution of $h_{eff} = n \times h_0$ values could reduce IQ. As found in [L115], a complete cognitive measurement inducing maximal reduction of entanglement for an extension with dimension n would reduces the state to a product state with state space with dimensions n. which are factors of n and thus smaller than n: instead of single MB with high IQ several with lower IQs. It might happen that the next SSFRs are not anymore able to regenerate larger values of n and the system becomes less intelligent.

An objection against this picture is that there are also situations when resurrection seems to occur: this has happened for people having had near-death experiences. One can also slow down the process of aging by a appropriate diet.

(a) The slowing down of the aging process is possible by the reversal of the arrow of time at lower levels so that time reversed dissipative processes at these levels look like self-organization and generate order from the point of view of the organism. This would be a general. mechanism used by living matter to slow down the approach of MB to thermal equilibrium with MB.

(b) This does not however explain resurrection. The opposite BSFR can however occur at the level of the entire organism but with a suitable stimulation like resuscitation opposite BSFR can take place. Taking into account the fact that also the organism is only one level in the hierarchy of conscious entities, this reduces to the first option.
The analog of resuscitation occurs at the atomic level in the experiments of Minev *et al* [L83]. Although the deterministic process apparently leading to the final state of BSFR had already occurred, it could be stopped by a suitable stimulus. In TGD framework the interpretation is that the BSFR had already occurred and the time reversed time evolution apparently leading to the final was observed. A suitable stimulation however induced the opposite BSFR so that the process apparently stopped [L83].

DNA and the arrow of time

There is a connection with the article about DNA and arrow of time by Rastmanesh and Pitkänen [L190]. The proposal is as follows. As the electric field along DNA double strand (with dark DNA strands included) decreases by the shortening of the sticky ends, the string tension as density of electric energy per unit length decreases, the stiffness of DNA is reduced, and thermal fluctuations start to develop.

Biologist might wonder how various biological and homeostatic maneuvers like weakening of acetylation/phosphorylation/methylation eventually translate to a decrease of the electric field strength along DNA! In the TGD framework one can see the situation in a different manner: chemistry is not the boss now but is controlled by MB.

(a) Modifications (or rather, the loss of the control of modifications) are not the primary cause of the weakening of the electric field. What happens at the control level, at MB,

is the primary cause. The weakening of the electric field along DNA would correlate with the shortening of the sticky ends carrying electric charges creating the longitudinal electric field.

This would also correlate with the reduction of the level of consciousness at the level of DNA if one is ready to generalize Becker's findings [J6] about the correlation of the strength of the longitudinal electric field along the body axis with the level of consciousness. Similar correlation with consciousness can be assigned to the electric field directed from visual cortex to frontal lobes.

(b) The reduction of the electric field strength reduces energy density of DNA and therefore string tension. DNA begins to fluctuate geometrically, which generates epigenetic noise. Initially dark DNA is like a tense guitar string but transforms gradually to spaghetti. Basically the reduction of string tension reflects the dissipation accompanying the approach of MB to thermal equilibrium with the ordinary bio-matter.

One could perhaps say that the reduction of string tension of MB flux tubes forces the reduction of electric field strength and the internal consistency (Maxwell equations) requires reduction of the sticky end lengths proportional to the charges generating the electric field along DNA. Note that also charge separations tend to disappear in the approach to thermal equilibrium.

(c) An interesting question is whether hyper-methylation accompanying aging [I45, I123, I109] could be seen as an attempt to minimize the effects of DNA damage - analogous to an amputation of a leg to prevent necrosis. Hyper-methylation accompanies also cancer [I27, I89].

Second view is that hypermethylation is due to the loss of control of MB caused by the approach to thermal equilibrium. Hyper-methylation could be seen as the failure of de-methylation caused by the low level of demethylase activated by MB and caused by methylation of the genes coding for demethylase! This positive feedback loop would lead to the failure of the control of MB.

Is the shortening of the telomeres a controlled process or due to thermalization? The first option could be argued to be realistic since otherwise the population would end up to fight about metabolic resources. Second law could of course solve the problem without any need for a controlled action. If the length of telomeres correlates with the charges of the sticky ends proportional to its length which in turn would be proportional to the length of the telomere as proposed in [L190], the conclusion would be that the shortening is not a controlled process.

14.5 Epigenesis and aging in TGD framework

In the TGD framework epigenesis would be control of the biological body by MB consisting of ordinary biomatter. The basic control tool would be dark photon 3N-plets coupling resonantly to the dark proton sequences of proteins serving as enzymes and RNAs serving as ribozymes. The coupling would be precise and based on the addresses defined by dark proton 3N-sequences defining emitting dark 3N-photons.

These would in turn catalyze the basic biochemical processes and here TGD suggests a mechanism explaining why the reactants find each other and where the energy needed to overcome the energy barrier to make reaction fast enough come. The reduction of h_{eff} for flux tubes would be the needed mechanism.

Also other catalysts than enzymes and ribozymes can be considered. For these catalysts and organic and non-organic molecules in general, the coupling with MB could be single photon resonant coupling transforming 3N-photon to bio-photon.

14.5.1 How MB could control biochemistry

How does the general biochemistry picture involving biomolecules and reaction pathways relate to the multi-resonance vision about how MB controls ordinary biomatter? Can one reduce this picture to a description in terms of multir-resonance frequencies - that is to the level of MB and MB-BB communications alone.

(a) Suppose that MB of DNA, RNA, or protein controls DNA, RNA or protein by signals from dark genes using multi-resonance mechanism allowing to select the target and use modulation of dark photon signal to code control signals. Also the MB of DNA, RNA, or protein can be controlled by a higher level of the hierarchy.
If all control takes place in this manner, epigenetic control would be control of proteins acting as enzymes, of RNA, in particular ribozymes, and of DNA. MB would also activate genes coding for various enzymes, in particular housekeeping enzymes.
The controlled proteins would be naturally enzymes catalyzing various biochemical reactions.

(b) Could the MB of DNA just change its geometric conformation inducing change of DNA conformation and changing also the epigenetic patterns determined by methylation, etc...? This would represent something new: in TGD one has a network of molecules connected by flux tubes, in biochemistry approach one has only molecules.
The first basic mechanism for the change of the conformation would be the reduction of h_{eff} leading to the shortening of the flux tubes and liberation of energy and its reversal. The reduction of h_{eff} is crucial in the TGD based model of bio-catalysis. The opposite process would feed metabolic energy to MB. The formation of reconnection would be another key process and allow to change the topology of the flux tube network. This would be the basic mechanism of the immune system and also of biocatalysis in which the U-shaped flux tubes associated with the reacting molecules would reconnect.
For instance, the actions of cells during say catastrophic events mean typically that proteins like Sir2 come in rescue by travelling along flux tubes or pairs of them serving as highways: these highways do not exist in standard biology. The existing pattern of flux tubes determines the road network. MB would control the topology of this network by reconnecting and by controlling the lengths of the flux tubes by h_{eff} changing transitions: motor actions of MB would be in question.

(c) TGD leads to a view about emotions as sensory perceptions of MB. The model for genetic code emerging from a model of bio-harmony [L24, L82, L112, L128] based on icosahedral and tetrahedral geometries and the observation that music expresses and induces emotions leads to the proposal that the bio-harmony characterized by 64 allowed 3-chords in one-one correspondence with DNA codons has 3N-resonances assignable to the 3-chords of the harmony as a correlate. These resonant interactions induce transitions of selected bio-molecules and possibly also specific transitions of a given biomolecule characterizing the harmony. Could epigenesis be regarded as expressions of emotions by music of light?

BSFR would create a superposition of deterministic time evolutions leading to the geometric past. It would define an average time evolution described in terms of reaction pathways. Could the final state of MB in BSFR dictate also the epigenetic patterns - say bio-harmony determined by frequencies of cyclotron transitions of protons? They are indeed determined by the strengths of the magnetic fields at flux tubes. This would conform with the proposal that the outcome of volitional action as BSFR dictates what happens in the brain of geometric past explaining the findings of Libet [J5] [L83].

SSFRs give rise to an approximately classical time evolution and generation of entropy, and therefore aging. h_{eff} distribution becomes flatter and MBs of information molecules and ordinary matter approaches thermal equilibrium. The distribution for the conformations of the magnetic flux tubes thermalizes and cell size increases. Basically string tensions decrease since the electric fields involved weaken and the electric and also magnetic contribution to the tension weakens.

What could be the general mechanism of bio-catalysis? The MB of the enzyme could activate the enzyme when the value of h_{eff} of a flux tube connecting it to other reactants is reduced and induces the shortening of the flux tube and liberation of energy.

Depending in what direction energy flows, one can imagine two scenarios for what happens.

(a) The energy could flow from higher levels of hierarchy to lower levels. The flux tube at the highest level would be shortened and liberate energy transferred to a lower level. At the lowest level enzyme would be excited and return to the ground state and liberate the energy needed to overcome the potential wall making reaction slow. Now the shortening of the flux tube of enzyme's MB does not seem to be necessary energetically.

The process would proceed from higher to lower levels in the hierarchy of MBs by this kind of excitations and de-excitations transferring the energy to the lower level, somewhat like in photosynthesis. The flow of money from top towards bottom in a big project serves as a second metaphor for the course of events.

(b) If the process is a generalized motor action involving BSFRs and time reversals, the higher levels in the hierarchy of MBs extract energy from shorter scales (very much like higher levels extract work of lower levels in the social hierarchies!). One could also say that negative energy is sent to the lower levels of the hierarchy.
The lower level would provide the energy by reducing its h_{eff} so that its energy is reduced and energy is liberated and taken by the higher level. This would induce the shortening of magnetic flux tubes at all levels. The cascade would proceed down to the level of MBs of proteins and also the U-shaped flux tubes connecting the protein to the other reactants would shorten and bring the reactants together. The reduction of the flux tube length should provide energy to overcome the potential wall, not only the energy going to the higher level of hierarchy.

It is not quite clear which option is realized. Motor actions involve transfer of metabolic energy from short to length scales giving rise to macroscopic coherent motion: time reversal would be natural from this point of view.

Methylation and acetylation

The figures of `https://cutt.ly/Qjgrko3` illustrate the effect of methylation and acetylation of DNA or of histone tail.

(a) The nucleosomes [I15] surround a given gene but nucleosomes can roll along DNA downstream towards the gene to be transcribed and opens the DNA double strand. The modification of the histone tail can prevent or facilitate the opening of the double strand.

(b) The portion of DNA between the nucleosome and gene corresponds to the promoter part of DNA initiating the gene expression. Proteins initiating the transcription bind to it or alternatively it can be transcribed to RNA.

The methylation [I15] and acetylation [I1] of the histone tail serves as the first example. The binding of the methyl, acetyl, or some other group to the histone tail has an indirect effect on the gene. Histone is positively charged. Since DNA is negatively charged, DNA and histone bind together.

The addition of a modifier can increase or reduce the charge of the histone and tighten or loosen the binding between histone and DNA. Methyl is positively charged and tightens the binding and makes the opening of DNA necessary for transcription more difficult. Acetyl is negatively charged and loosens the binding so that the transcription becomes easier.

Consider next the methylation of a promoter region (`https://cutt.ly/3jj8ohZ`).

(a) A promoter is a sequence of DNA to which proteins bind that initiate transcription of a single RNA from the DNA downstream of it. This RNA may encode a protein, or can have a function in and of itself, such as tRNA, mRNA, or rRNA. Promoter region has therefore two - it seems alternative - functions.

(b) The methylation of cytosin occurs at CpG islands associated with the promoter region of gene. Promoter region is the region to which proteins initiating the transcription of gene bind. Methylation occurs also for the promoter regions of CpG-islands [I44].

(c) How methylation silences the gene transcription? Methylation decreases the charge of DNA locally and loosens the binding to histone. This would favor the transcription of the promoter region instead of the transcription of the gene requriing the binding of RNA polymerase to the promoter region.

(d) If methyl is always positively charged, the direct binding to DNA reduces DNA charge locally and reduces the interaction between histone and help opening of DNA in the promoter region: this would not facilitate the transcription of gene but transcription of non-translated RNA or protein. The binding would also prevent the binding of RNA polymerase to the promoter region. The start codon of the non-protein coding gene could be in the promoter region.

More facts about DNA methylation [I16] (https://cutt.ly/pjj3G45) are needed to develop a TGD based view about the situation.

(a) DNA methylation reprogramming occurs during gameto-genesis and early embryogenesis. The methylation patterns are erased and regenerated. This requires that the memory about the methylation pattern is stored. In the TGD framework MB could serve as the temporary information storage.

(b) DNA methylation occurs also in highly transcribed gene bodies and must be distinguished from the methylation of promoter regions. The methylation of gene bodies seems to relate to splicing and could prevent the transcription of intronic portions of the gene.

(c) In general, the level of DNA methylation is very low. The level of methylation is however high in promoter regions. In particular, in CpG islands [I5] (https://cutt.ly/sjj3STW) accompanying the promoter regions of genes, especially those coding for housekeeping proteins.

(d) Usually the methylation of C in CpG leads to a mutation replacing C with T. This could have led to CpG loss in DNA except in CpG islands, where some stabilization mechanism should prevent the mutations: presumably an energy barrier somehow caused by CpG is involved.
Hypermethylation accompanies cancer and also aging [I109, I123] and could be seen in the TGD framework as reflecting the approach to epigenetic chaos basically due to the reduction of the scale of quantum coherence in turn caused by the reduction of the values of h_{eff}.

(e) CpG loss is believed to be induced by transposable elements (TEs) attaching to DNA and hopping around it. TEs are methylated and lose CpG as C transforms to T.

(f) So called housekeeping proteins [I11] are enzymes crucial for various functions including general gene expression, and the control of various housekeeping functions takes place via the control of the expression of housekeeping genes. Therefore CpG islands, which are stable against mutations and allow both methylation and demethylation are needed. Dynamical and differential methylation is also known to relate to memory recall in the case of hippocampus.
For CpG islands $C \to T$ the mutations induced by methylation are prevented by some mechanism. The loss of CpG makes sense outside CpG islands since this stabilizes the genes against C $\to$ T mutations.

MB uses enzymes and ribozymes as a tool in the control of the basic biochemical processes. DNA methyltransferases [I17] catalyze methylation and MB would control the process by activation of this enzyme. In the case of demethylation the enzymes used are demethylases [I8].

The mechanism of demethylation can be taken as an example since the failure of demethylation might lead to hypermethylation of CpG islands known to accompany aging [I109, I45] and in TGD framework it could be due to the approach of the dark genome and proteome to thermal equilibrium.

(a) Oxidative demethylation [I9] (https://cutt.ly/Gjj2Ilz) replaces CH_3 group with hydrogen. This requires the presence of a reactive oxygen species (ROS). ROS include superoxide O_2^-, hydrogen peroxide H_2O_2 and hydroxyl radical OH.(https://cutt.ly/yjj2Ubv).
Superoxide is produced in aerobic metabolism via $O_2 + e^- \to O_2^-$. This in turn leads to reactions $2H^+ + 2O_2^- \to H_2O_2 + O_2$ followed by $H_2O_2 + e^- \to HO^- + OH$ and $2H^+ + 2e^- + H_2O_2 \to H_2O$.

(b) Demethylation is catalyzed by demethylases in presence of O_2. N-methyl groups are oxidized with oxygen coming from ROS O_2 and CH_2O splits out so that the net reaction is $R_2N - CH_2 \to R_2N - H + CH_2O$.
Enzymes known as alpha-ketoglutarate-dependent hydroxylases act as DNA demethylases. Also Cytochrome P450 [I6] (https://cutt.ly/ujj2OuK) catalyzes demethylation in histones and some forms of DNA (cytocine associated with CpG). "450" refers to "450 nm"", which is the wavelength at which cytochrome P450 has maximum absorption. The

wavelength corresponds to blue light near UV range and the photon energy is 2.76 eV. CYPs is a very large class of enzymes catalyzing metabolic processes.

What TGD view could be?

(a) Suppose that MB controls bio-matter by expressing its moods coded by bio-harmonies in terms of dark photons 3N-plets (say) with the frequency patterns correlating with mood and affecting matter in mood dependent manner via a transformation to bio-photons.

(b) 60 per cent of promoter regions of human genes contain CpG islands of length about 100-1000 codons and almost all housekeeping genes have CpG islands in their promoter regions. Why?

(c) MB would induce both methylation and demethylation and other modification using various enzymes which they could activate by dark 3N-photons using as address the dark proton sequence associated with the enzyme. After activation the reaction would proceed by the proposed general mechanism of biocatalysis.

(d) One can imagine several alternative courses of events after the activation. Even the question whether the energy transfer is from short to long length scales associated with MB or vice versa is not fully settled: this depends on the arrow of time assignable to this process.

In the case of CYP450, one cannot avoid the temptation to ask whether a biophoton with 450 nm wavelength could be formed in a decay of 3N-dark photon to ordinary photon.

Methylation, aging, and memory

According to [**?**]`https://cutt.ly/njAKgFy`), the general trends, supported by an increasing body of both in vitro and in vivo work, are the establishment of global hypomethylation (non-CpG islands) and regions of hypermethylation (primarily CpG islands) with age. CpG islands are located in the promoter regions of genes, in particular those of housekeeping genes.

Hypomethylation outside CpG islands could be due to the spontaneous mutation $C \to T$ but also the failure of the control of the methylation by MB could be involved. Hypermetylation of promoter regions implies that the promoter region transcribing RNA is transcribed instead of gene. This could be due to the failure of demethylation caused by the loss of the control.

In both cases the loss of control could have the same reason. The MBs of the genes coding for housekeeping genes and possibly also the MBs of the housekeeping enzymes approach thermal equilibrium with the ordinary bio-matter.

How methylation could relate to aging in TGD framework?

(a) Methylation could become irreversible during aging and lead to hypermethylation if MB loses the control of demethylation. If enzymes are the control tools of MB, the reduced transcription of DNAs coding for demethylases would lead to a failure of the control. The approach of MBs of DNA and enzymes to thermal equilibrium with ordinary biomatter could be the basic reason for the failure.

(b) Housekeeping proteins are an especially important class of proteins since they catalyze basic biological functions necessary for the transcription of genes - also the genes coding form them. Their promoter regions are also almost always CpG islands. Therefore one can say that the methylation of their promoter regions would be a natural cause of various problems with housekeeping activities caused by aging.

(c) CYP450 catalyzes generation of ROS in turn catalyzing demethylation and a large number of metabolic processes crucial for the functioning of the organism. In particular, demethylation could become less effective with aging due to the reduced level of CYP450. CYP450 is a housekeeping protein and the promoter regions of genes coding for CYP450 would be methylated. Methylation slows down transcription of CYP450 and this in turn slows down demethylation. This positive feedback loop eventually leads to a kind of death spiral.

(d) Differential methylation of the hippocampus is known to be crucial for the memory recall (here memories are understood as learned behaviors rather than episodal memories) [J37]. Differential methylation is not possible without demethylation. If methylation becomes irreversible the formation of recallable memories becomes more difficult. Short term memory recall as also memory recall in longer time scales indeed become less effective during aging.

14.5.2 How epigenetic information is inherited?

There is evidence for the inheritance of epigenetic information.

(a) Epigenetic inheritance takes place in mitosis and sometimes also in meiosis. The methylation related epigenetic disorder increases with aging.

(b) How could the epigenetic information be inherited in this picture? It could be represented by the geometry of MB - flux tube network - and at the genetic level by both control genes. Emotional aspects, something new, would have bio-harmony as a correlate, and bio-harmony is determined by cyclotron frequencies determined by the magnetic field strengths of the flux tubes. Not only cell but also MB replicates and the replication of MB induces replication at cell and DNA level.

Both genetic and epigenetic information could be inherited in the replication if MB replicates geometrically like a particle in the decay A$\rightarrow$ A+A. Usually particles are regarded as pointlike and Feynman diagram expresses this. The line A decays to two lines A+A. This makes sense also for 3-surfaces, in particular magnetic bodies, replacing the point like particles. That replication occurs at the fundamental physics is a new element in TGD based vision.

At the level of causal diamonds (CDs) A$\rightarrow$A+A would look like follows. The CD of A in the initial state and the CDS of A+A in the final state would intersect and contain the vertex region. Could the moods of A be inherited by A:s in A+A under some conditions - in other words, are cyclotron frequency spectra of flux tubes of A inherited?: this is true i the flux tubes would replicate as such.

Some methylation patterns are inherited in meiosis but not all. If these patterns are determined by the bio-harmony, magnetic flux tubes are copied faithfully in some cases even in meiosis but not always.

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 [L59, L60]. In the recent view of quantum TGD [L163], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L104, L105] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L96] [K117] 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) [L96, L132] [K117] 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 [A12] 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

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \quad . \tag{A-2.1}$$

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 [A8] 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

$$\begin{array}{rclcrcl} e^0 & = & \frac{dr}{F} \ , & & e^1 & = & \frac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 & = & \frac{r\sigma_2}{\sqrt{F}} \ , & & e^3 & = & \frac{r\sigma_3}{F} \ . \end{array} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{array}{rclcrcl} e^0 & = & \frac{dr}{F} \ , & & e^1 & = & \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\ e^2 & = & \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & & e^3 & = & \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \ . \end{array} \tag{A-2.11}$$

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

$$\begin{array}{rclcrcl} V_{01} & = & -\frac{e^1}{r} \ , & & V_{23} & = & \frac{e^1}{r} \ , \\ V_{02} & = & -\frac{e^2}{r} \ , & & V_{31} & = & \frac{e^2}{r} \ , \\ V_{03} & = & (r - \frac{1}{r})e^3 \ , & & V_{12} & = & (2r + \frac{1}{r})e^3 \ . \end{array} \tag{A-2.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{array}{rclcrcl} R_{01} & = & e^0 \wedge e^1 - e^2 \wedge e^3 \ , & & R_{23} & = & e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ R_{02} & = & e^0 \wedge e^2 - e^3 \wedge e^1 \ , & & R_{31} & = & -e^0 \wedge e^2 + e^3 \wedge e^1 \ , \\ R_{03} & = & 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , & & R_{12} & = & 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ . \end{array} \tag{A-2.15}$$

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 [A5]. 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 [A20] 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 [B14] 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

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\ V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\ V_{03} &= (r - \tfrac{1}{r})e^3 \ , & V_{12} &= (2r + \tfrac{1}{r})e^3 \ , \end{aligned} \tag{A-2.25}$$

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

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ . \end{aligned} \tag{A-2.28}$$

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

$$\begin{aligned} R_{01} &= -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ R_{02} &= -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 \ , \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , \\ R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ . \end{aligned} \tag{A-2.30}$$

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

$$\begin{aligned} L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \ , \\ L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \ , \end{aligned} \tag{A-2.45}$$

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 [B1]. 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.

(a) 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).

(b) 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.

(c) $\langle Z^0 \rangle$ 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.

(a) The electromagnetic field [L180] 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

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 \quad , \end{aligned} \tag{A-2.50}$$

(b) 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?

(a) 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.

(b) 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.

(c) 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:

(a) Symmetries must be realized as purely geometric transformations.

(b) Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [B2] .

The action of the reflection P on spinors of is given by

$$\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.53}$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) \ , \\ \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \gamma^1\gamma^3 \otimes 1\Psi \ . \end{aligned} \tag{A-2.54}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \Psi^\dagger \gamma^2\gamma^0 \otimes 1 \ . \end{aligned} \tag{A-2.55}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Induction procedure and many-sheeted space-time

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has U(1) holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber if embedding space at their image points. In the recent case the embedding of space-time surface to embedding space defines the induction procedure. The induced gauge potentials and gauge fields are projections of the spinor connection of the embedding space to the space-time surface (see `http://tgdtheory.fi/appfigures/induct.jpg`).

Induction procedure makes sense also for the spinor fields of embedding space and one obtains geometrization of both electroweak gauge potentials and of spinors. The new element is induction of gamma matrices which gives their projections at space-time surface.

As a matter fact, the induced gamma matrices cannot appear in the counterpart of massless Dirac equation. To achieve super-symmetry, Dirac action must be replaced with Kähler-Dirac action for which gamma matrices are contractions of the canonical momentum currents of Kähler action with embedding space gamma matrices. Induced gamma matrices in Dirac action would correspond to 4-volume as action.

Fig. 9. Induction of spinor connection and metric as projection to the space-time surface. `http://tgdtheory.fi/appfigures/induct.jpg`.

A-3.2 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0. This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0, and Kähler fields

vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

Fig. 10. Illustration of many-sheeted space-time of TGD. `http://tgdtheory.fi/appfigures/manysheeted.jpg`

Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of M^4 (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields.This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through then so that the throats look like Kähler magnetic monopoles.

Fig. 11. Wormhole contact. `http://tgdtheory.fi/appfigures/wormholecontact.jpg`

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in H although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of M^4 and providing it with an effective metric obtained as sum of M^4 metric and deviations of the induced metrics of various space-time sheets from M^4 metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

Fig. 12. The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. `http://tgdtheory.fi/appfigures/fieldsuperpose.jpg`

Space-time surfaces of TGD are considerably simpler objects that the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means

that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the generi case. There are also magnetic flux quanta and electric flux quanta. The deformations of cosmic strings with 2-D string orbit as M^4 projection gives rise to magnetic flux tubes carrying monopole flux made possible by CP_2 topology allowing homological Kähler magnetic monopoles.

Fig. 13. Topological quantization for magnetic fields replaces magnetic fields with bundles of them defining flux tubes as topological field quanta. `http://tgdtheory.fi/appfigures/field.jpg`

The imbeddability condition for say magnetic field means that the region containing constant magnetic field splits into flux quanta, say tubes and sheets carrying constant magnetic field. Unless one assumes a separate boundary term in Kähler action, boundaries in the usual sense are forbidden except as ends of space-time surfaces at the boundaries of causal diamonds. One obtains typically pairs of sheets glued together along their boundaries giving rise to flux tubes with closed cross section possibly carrying monopole flux.

These kind of flux tubes might make possible magnetic fields in cosmic scales already during primordial period of cosmology since no currents are needed to generate these magnetic fields: cosmic string would be indeed this kind of objects and would dominated during the primordial period. Even superconductors and maybe even ferromagnets could involve this kind of monopole flux tubes.

A-3.4 Embedding space spinors and induced spinors

One can geometrize also fermionic degrees of freedom by inducing the spinor structure of $M^4 \times CP_2$.

CP_2 does not allow spinor structure in the ordinary sense but one can couple the opposite H-chiralities of H-spinors to an $n = 1$ ($n = 3$) integer multiple of Kähler gauge potential to obtain a respectable modified spinor structure. The em charges of resulting spinors are fractional (integer valued) and the interpretation as quarks (leptons) makes sense since the couplings to the induced spinor connection having interpretation in terms electro-weak gauge potential are identical to those assumed in standard model.

The notion of quark color differs from that of standard model.

(a) 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.

(b) 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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.

(a) 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.

(b) 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.

(c) 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

$$\begin{aligned} ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta}) d\Theta^2 + (s_{\Phi\Phi} + 2k s_{\Phi\Psi}) d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta} d\Theta^2 + s^{eff}_{\Phi\Phi} d\Phi^2] \ , \\ s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\ s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ , \end{aligned} \tag{A-3.7}$$

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 [K52, K32, K89] [L136, L163].

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.

(a) 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.

(b) 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.

(a) The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of "long" string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their super-conformal invariance behave like "short" strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.

(b) 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.

(c) 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 [K52, K89].

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 [L61] [L136, L142, L143] 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 [A12] 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.

(a) 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.

(b) 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.

(c) 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.

(a) 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.

(b) 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.

(a) 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.

(b) 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 [L163]. There are also other important algebras but these will not be discussed now.

(a) 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 [L163] 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.

(b) 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 [L163] 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 $n(P)$.

(a) 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.

(b) 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 [L163] 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 $n(SS)$.

(c) 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.

(d) 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 [L147] 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.

(e) 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 [K65, K66]). 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 $n(SS)$.

(a) 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 [L147], 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 $n(SS)$.

(b) According to [L147], 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 [L147].

(c) p-Adic length scale hypothesis [L164] 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.

(a) 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 [L163] 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.

(b) The symplectic transformations of WCW acting as isometries are assumed to be induced by the symplectic transformations of $\delta M^4_+ \times CP_2$ [K52, K32]. 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 [L157].

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 [K69, K59, K30]. The fusion of the various p-adic physics leads to what I call adelic physics [L59, L60]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K34, K35, K36, **?**, K35, K36, K36].

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 [L104, L105] 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 [L147, L157]. Also the ordinary 3→ 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 subspace. 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 [L61] 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 [A3]. 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:

(a) 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.

(b) Distances of points x and y inside single class are smaller than distances between different classes.

(c) 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 [B11]. 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.

(a) 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

(b) 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

(c) 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 9.5.6) has changed considerably towards the end 2021 [L136] 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 [L136] 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 [L136] 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 [L104, L105]. 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 $X^4 \subset M^8$ [L88]. 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 [L136]. 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 [L121] 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 [L136]. 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 [L96] [K117].

(a) 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 [L96].

(b) To avoid getting totally confused it is good to emphasize some aspects of ZEO.

   i. 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.

   ii. 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.

(c) 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.

i. The findings of Minev et al [L83] in atomic scale can be explained by the same mechanism [L83]. 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!

ii. Libets' experiments about active aspects of consciousness [J5] 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.

iii. 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 [L86]. 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 [L91, L193].

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 [L91, L193]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

(a) 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.

(b) 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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Index