EVOLUTION IN TGD UNIVERSE

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January 23, 2025

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 $H = M^4 \times CP_2$ [L123]. 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 [L36, L56](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 [L125].

- 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 [K102, L69].

- 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 [K24, K56] [L110].

- 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 [L117]. 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 [L129].

- 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 [L34, L35] 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 [L126]. 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 [L102], 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 [A10]. I have proposed [K49, K26, K100, K82, L125] 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 [K102, L69] 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 [L120]. 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 [L95, L96] 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 [L129].

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 [L113]. 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.

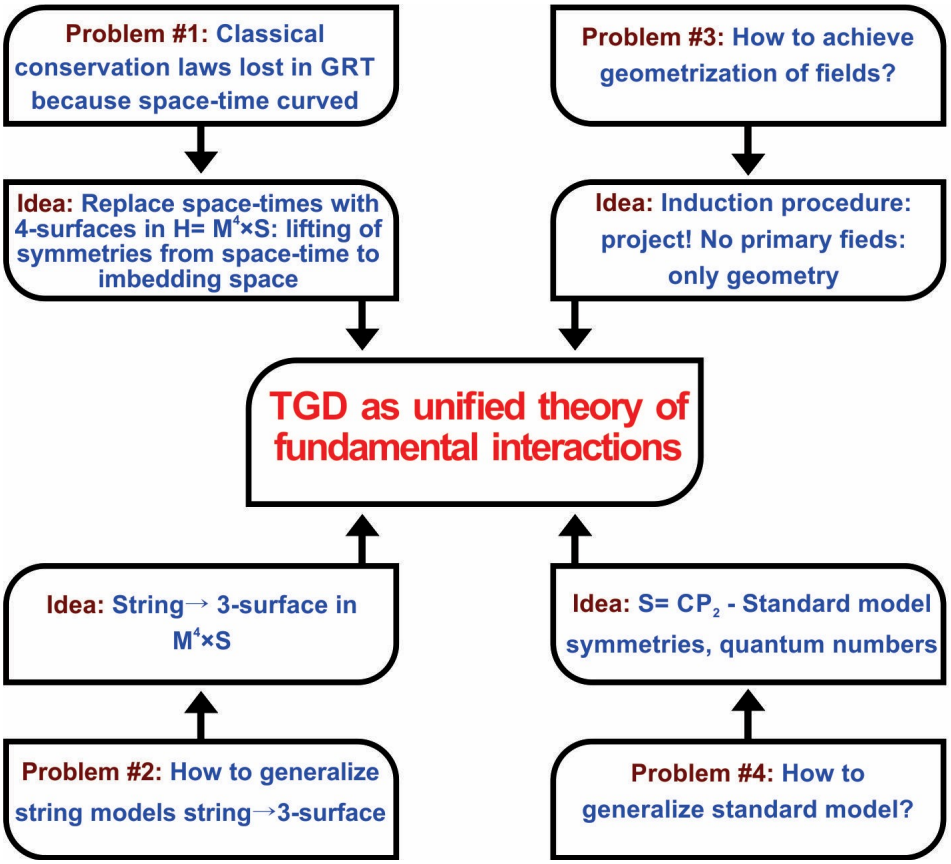


Figure 1: The problems leading to TGD as their solution.

- 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.

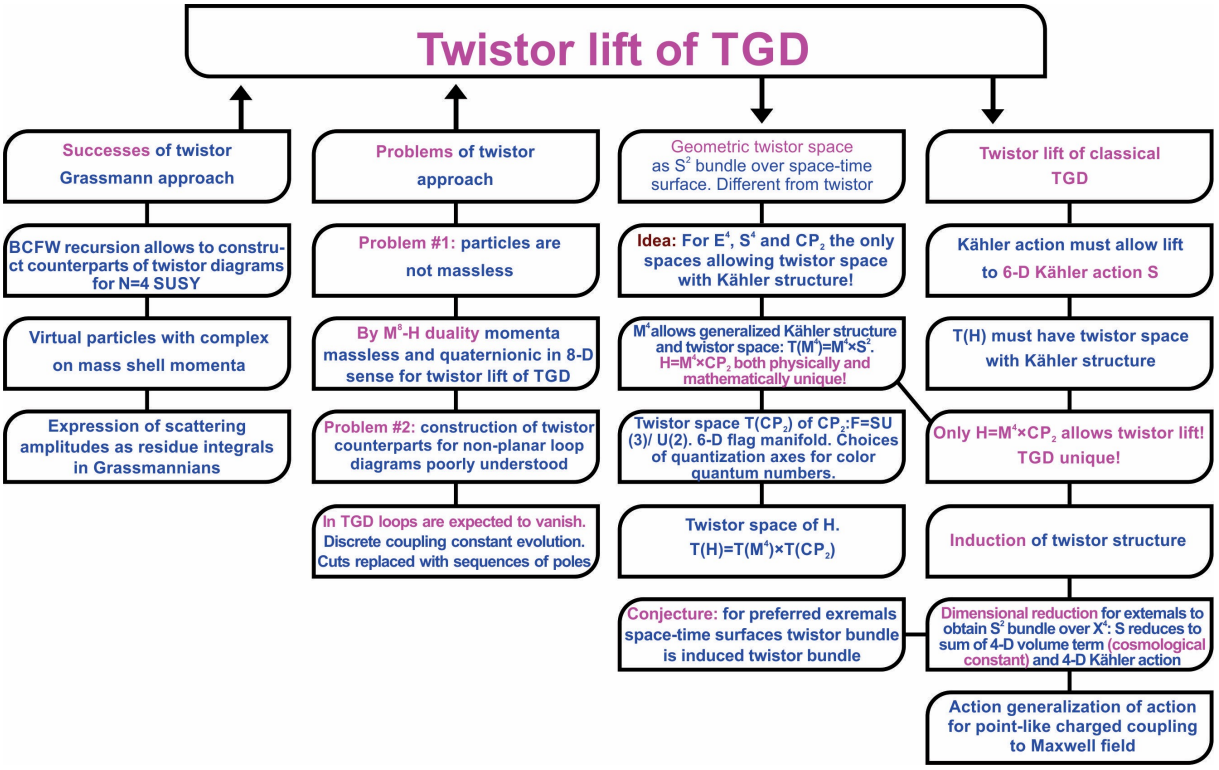


Figure 2: Twistor lift

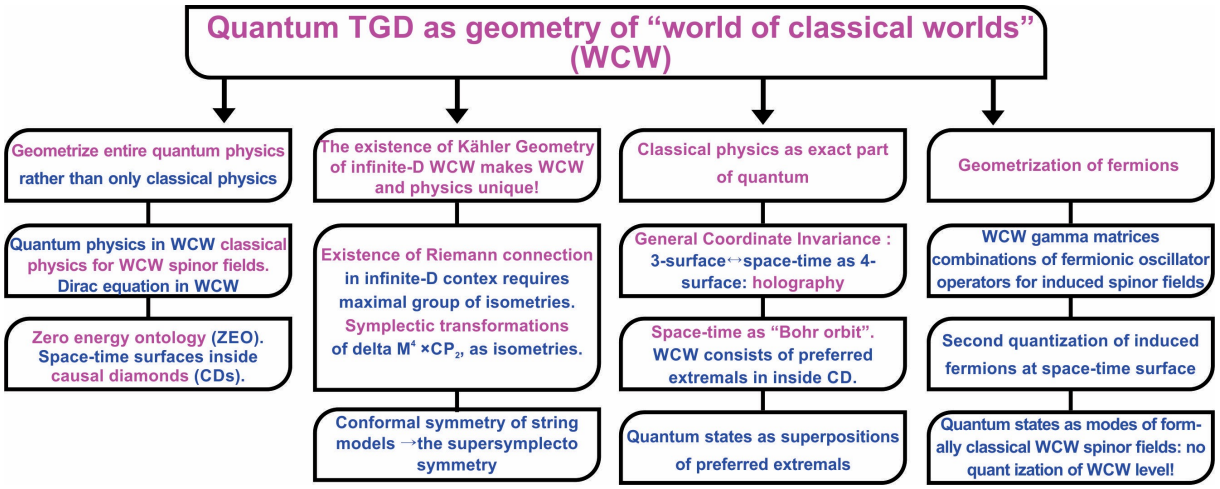


Figure 3: Geometrization of quantum physics in terms of WCW

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

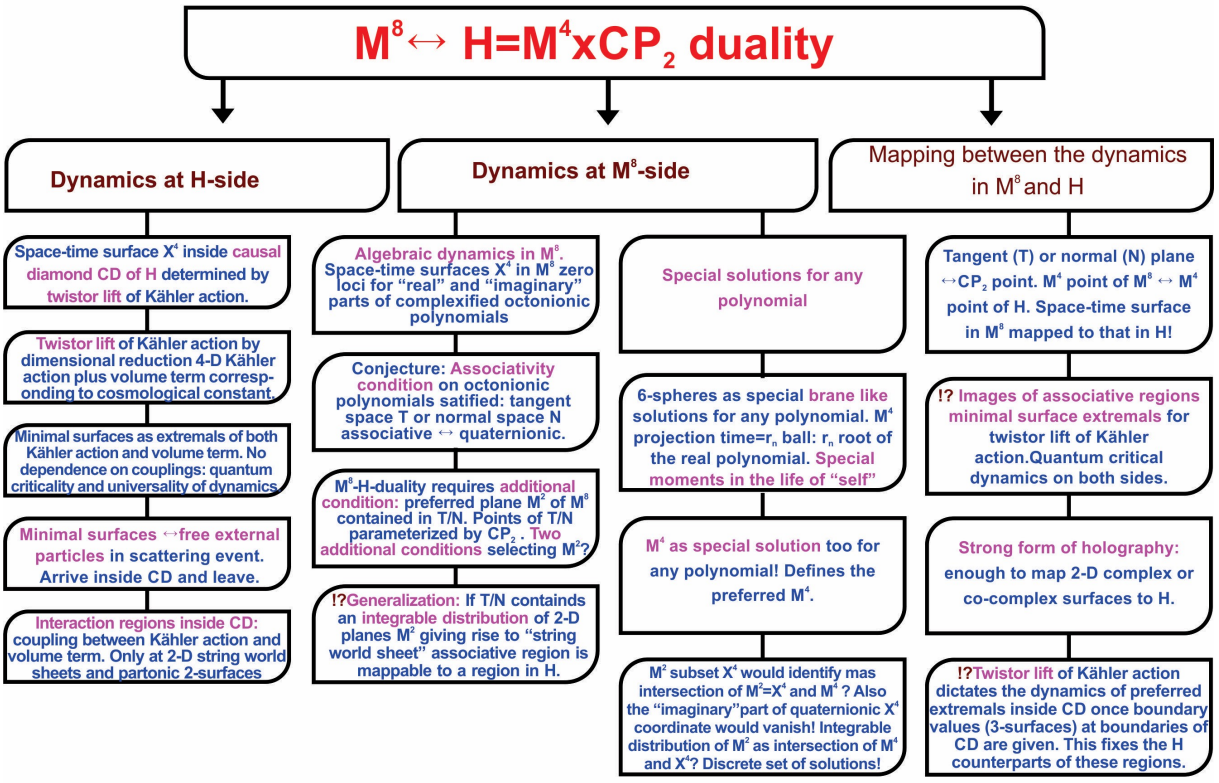


Figure 4: $M^8 - H$ duality

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

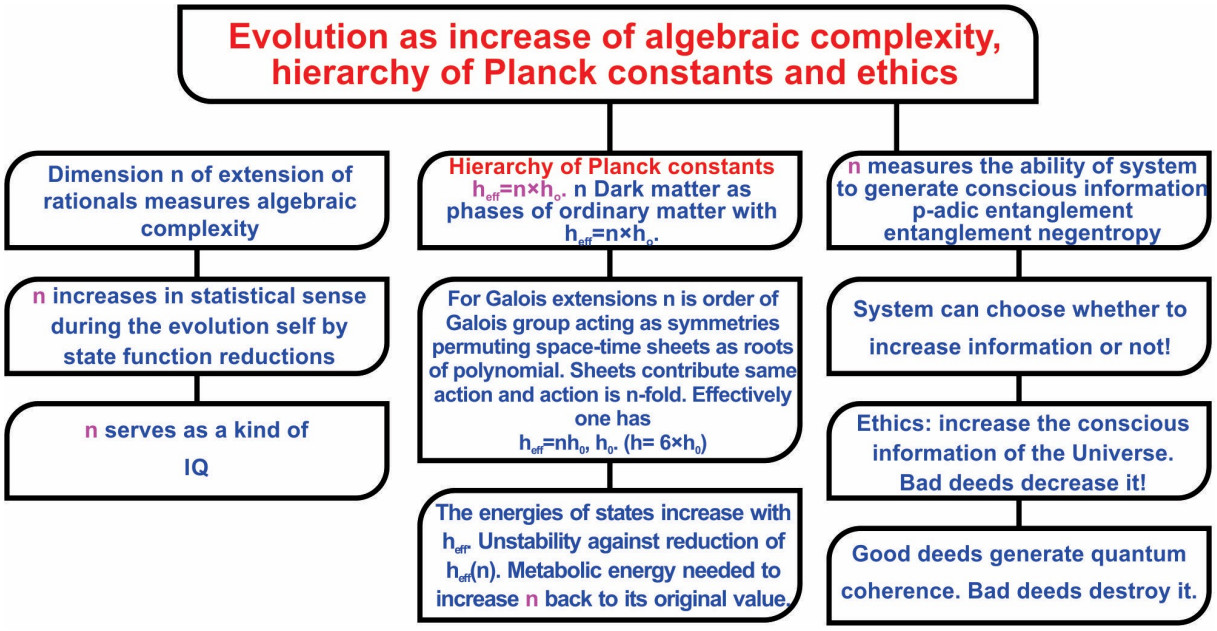


Figure 5: Number theoretic view of evolution

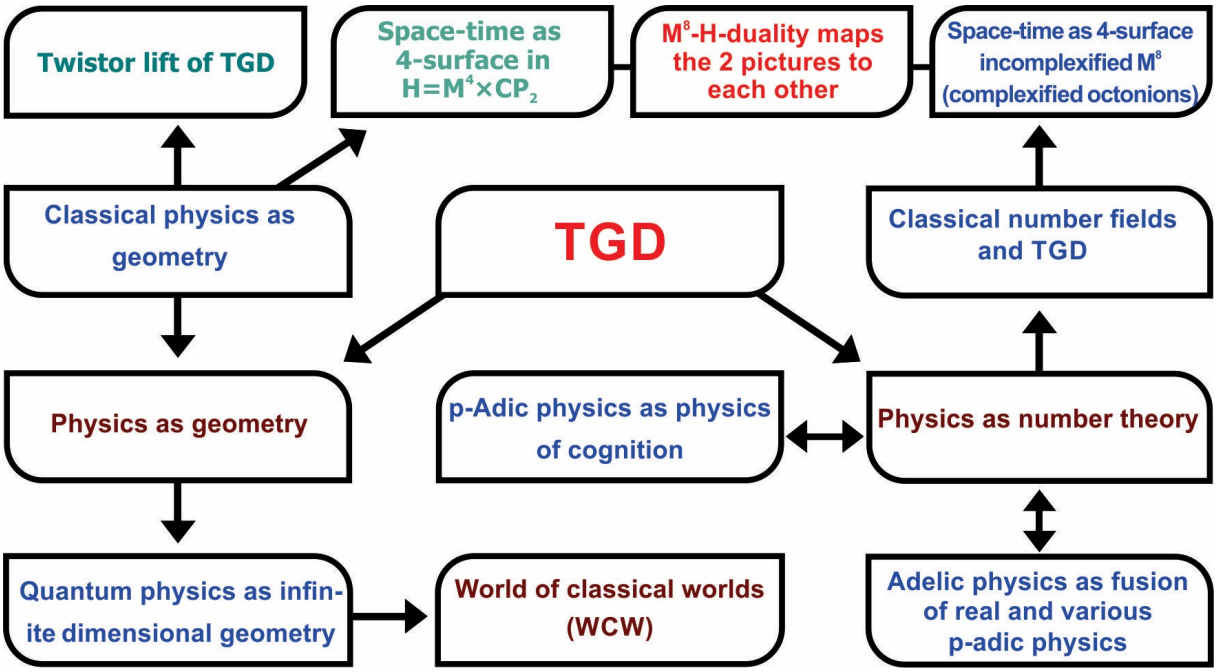


Figure 6: TGD is based on two complementary visions: physics as geometry and physics as number theory.

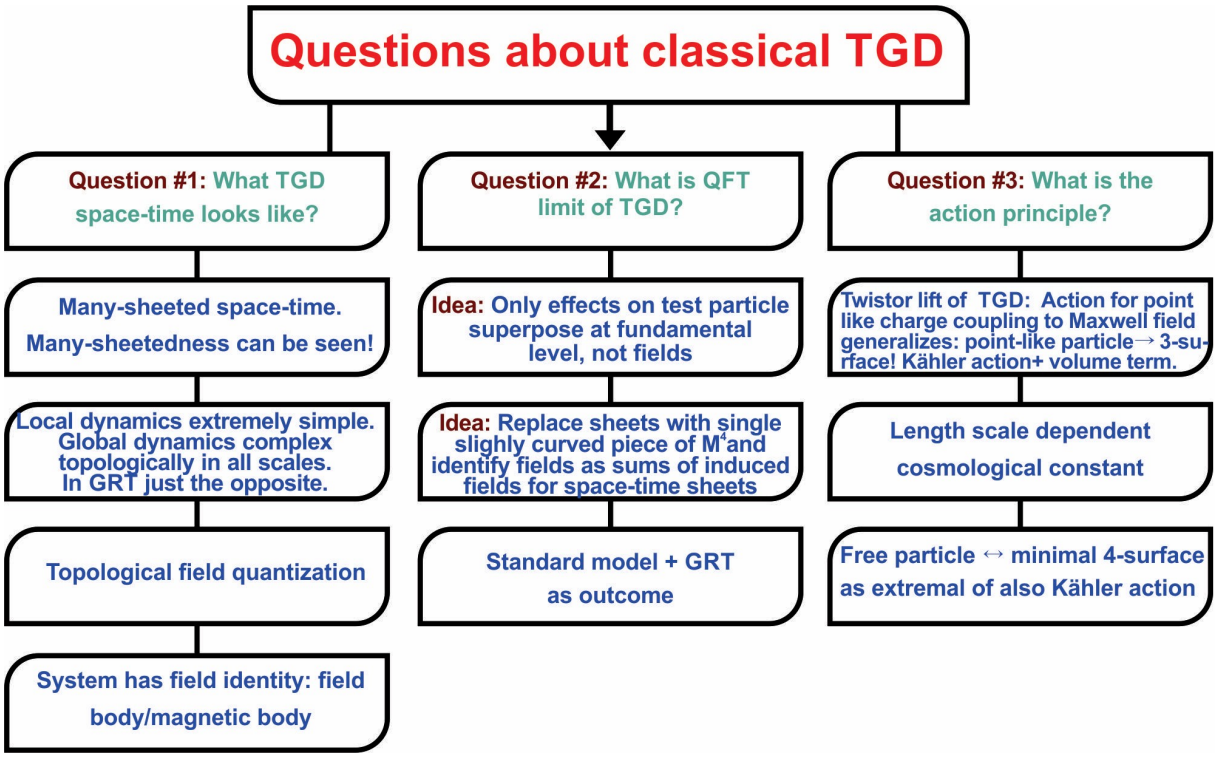


Figure 7: Questions about classical TGD.

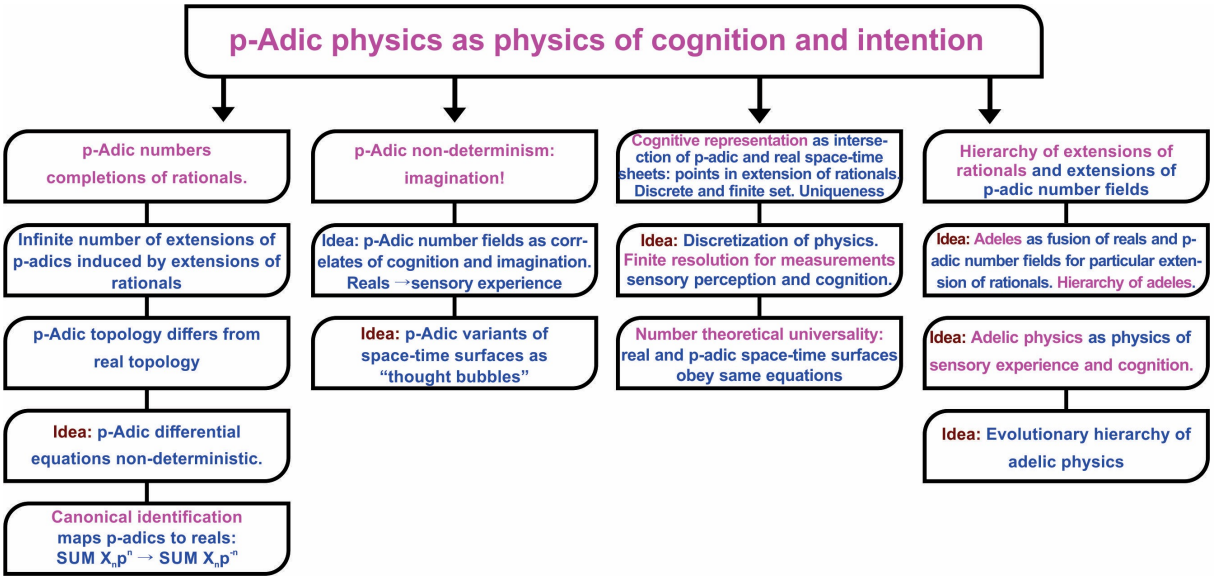


Figure 8: p-Adic physics as physics of cognition and imagination.

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.

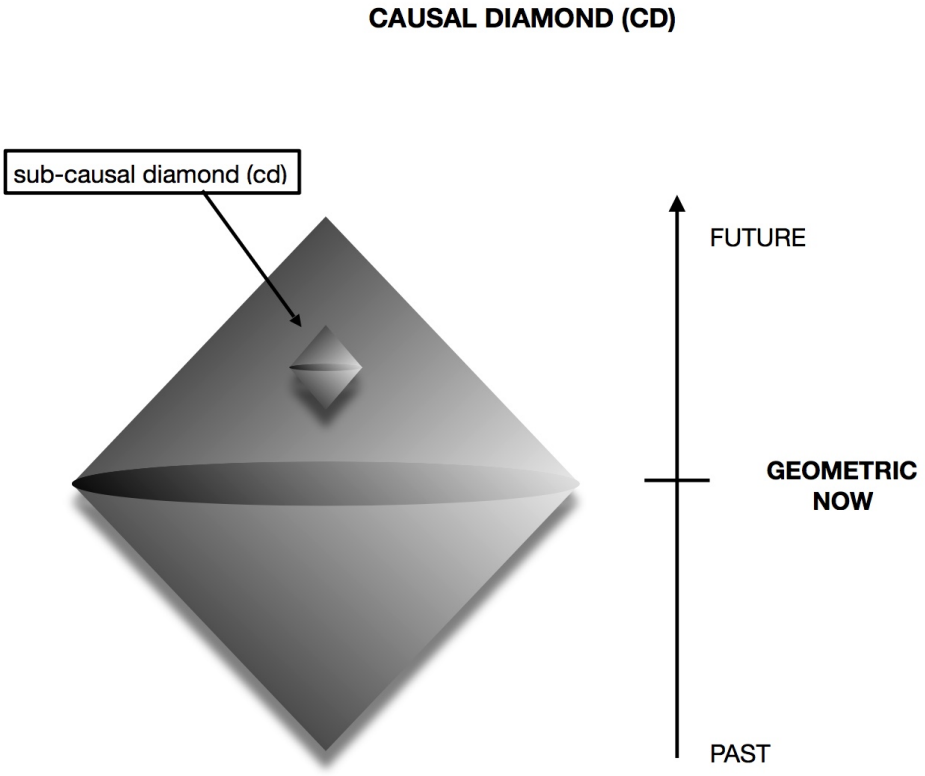


Figure 9: Causal diamond

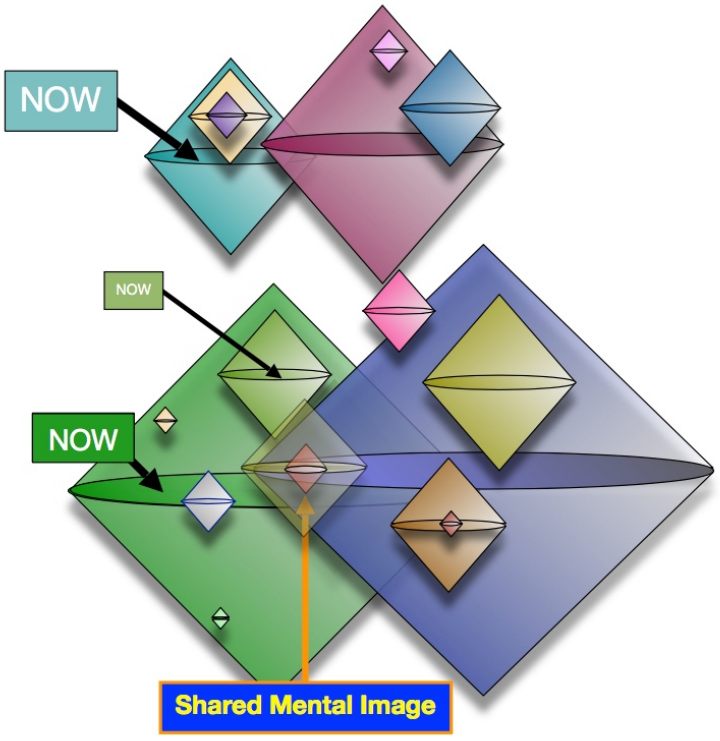


Figure 10: CDs define a fractal "conscious atlas"

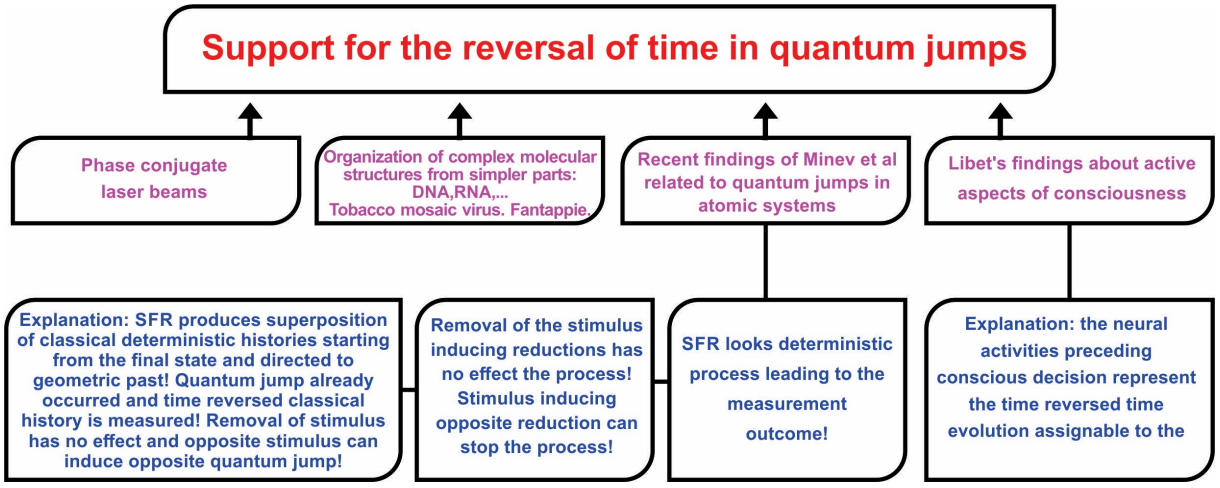


Figure 11: Time reversal occurs in BSFR

Figures

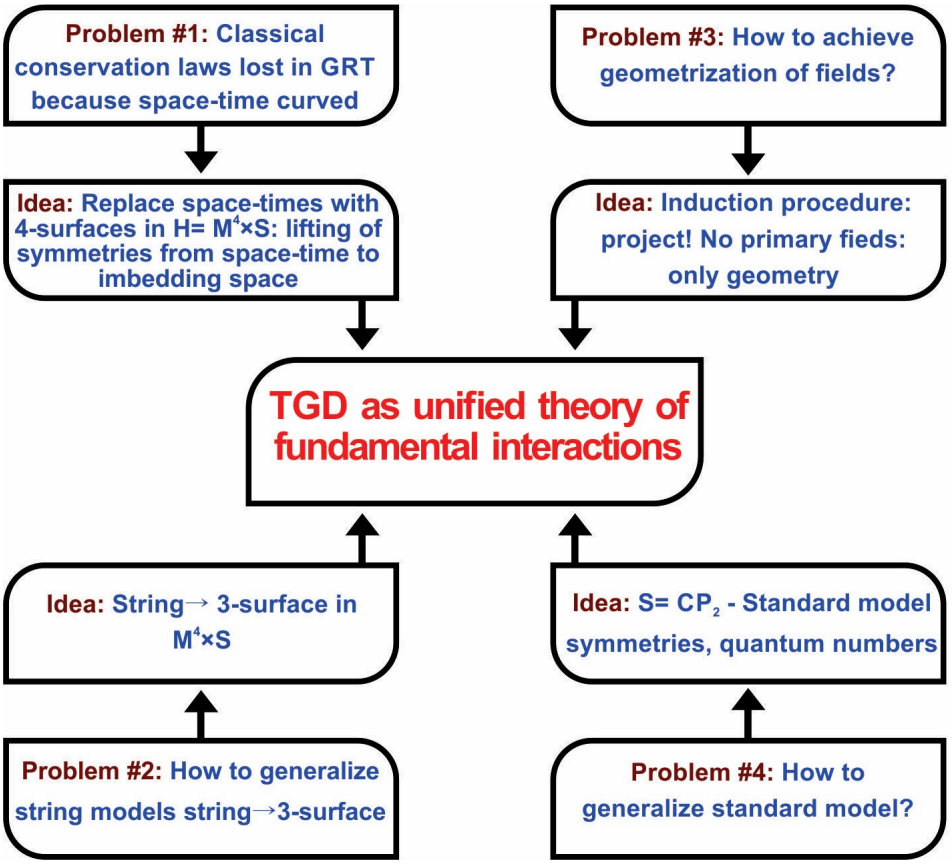


Figure 12: The problems leading to TGD as their solution.

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

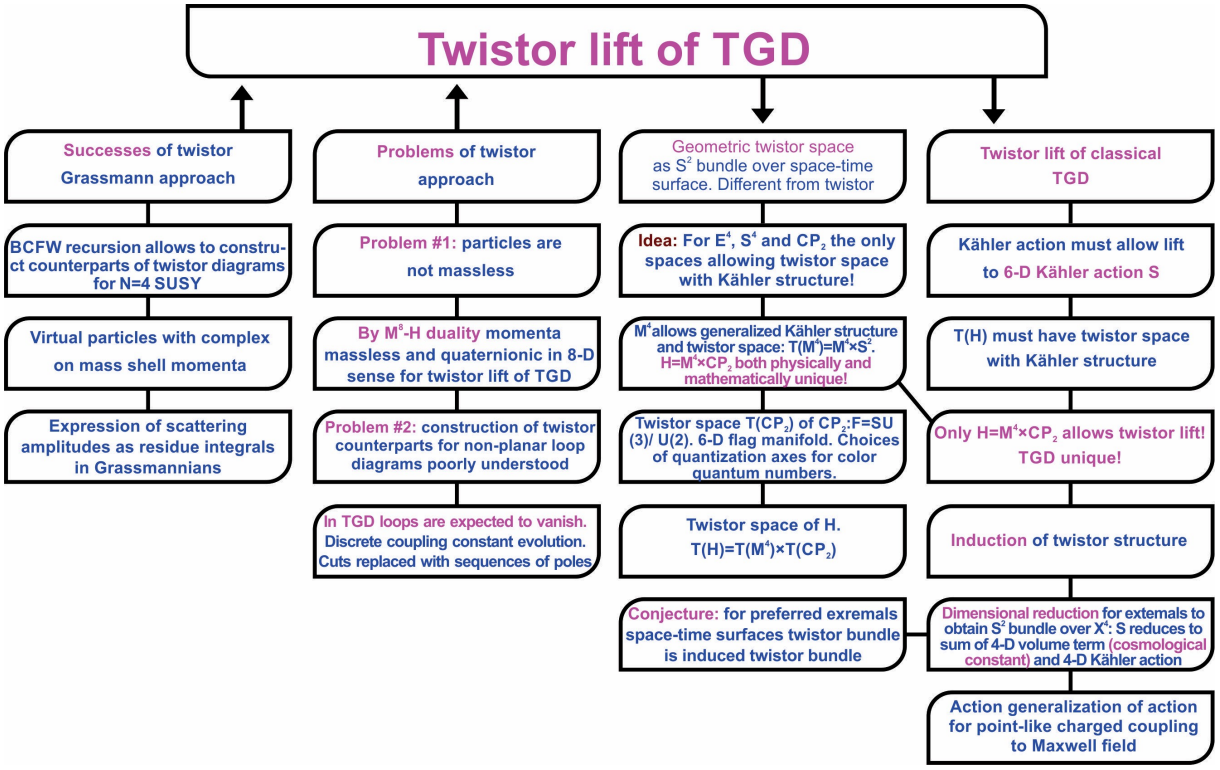


Figure 13: Twistor lift

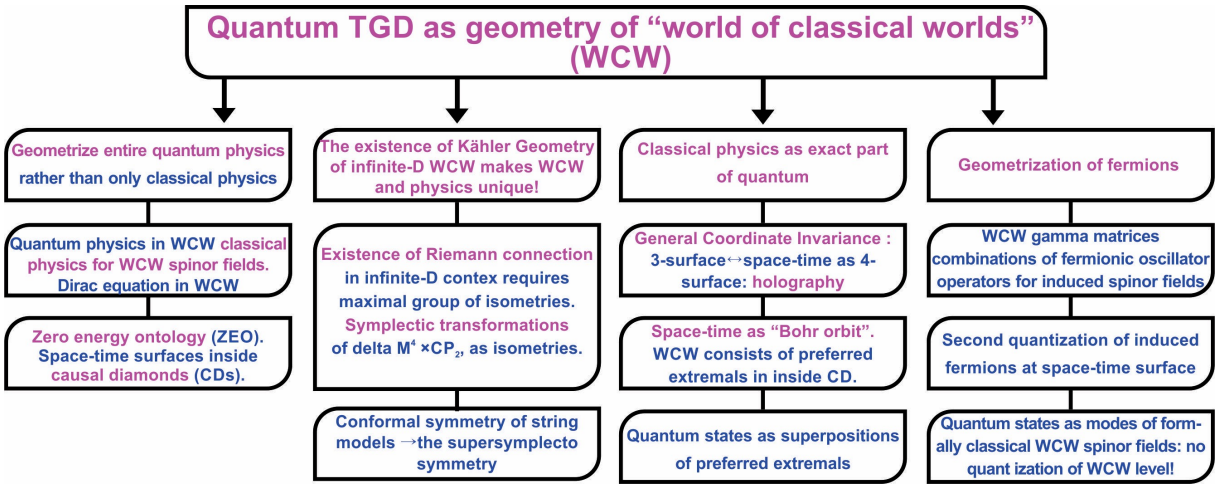


Figure 14: Geometrization of quantum physics in terms of WCW

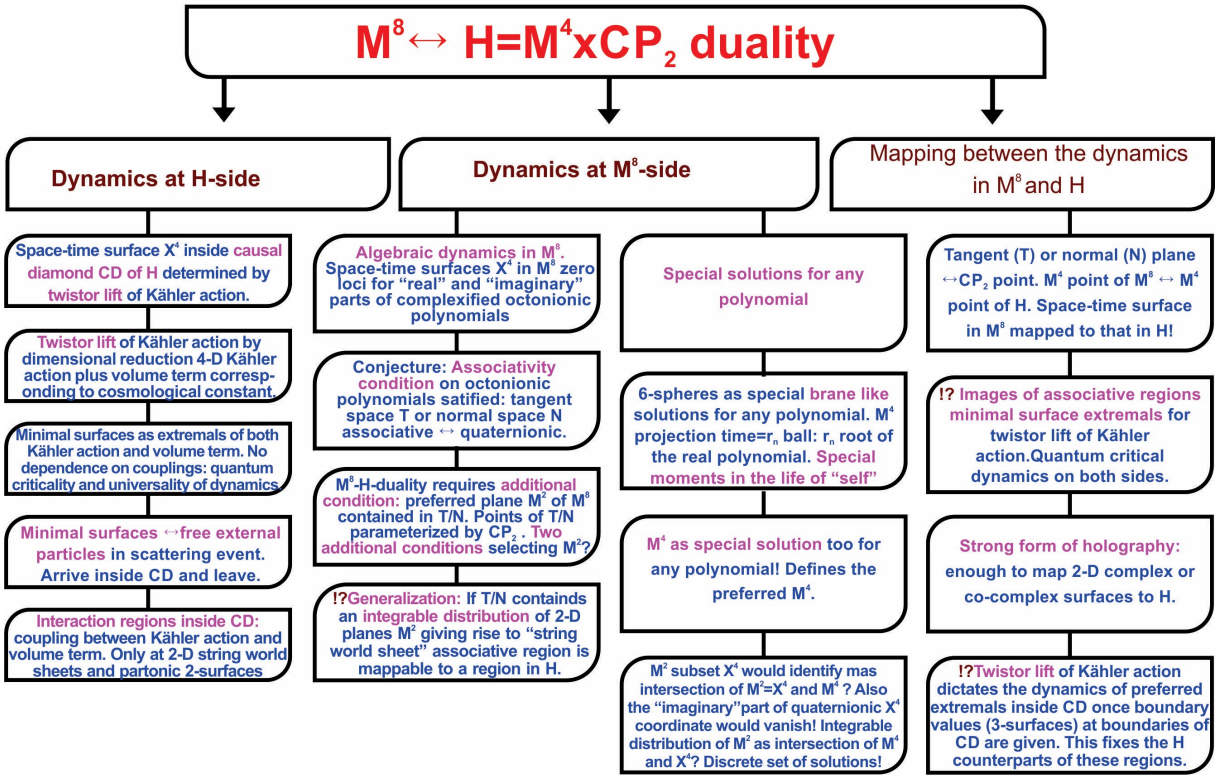


Figure 15: $M^8 - H$ duality

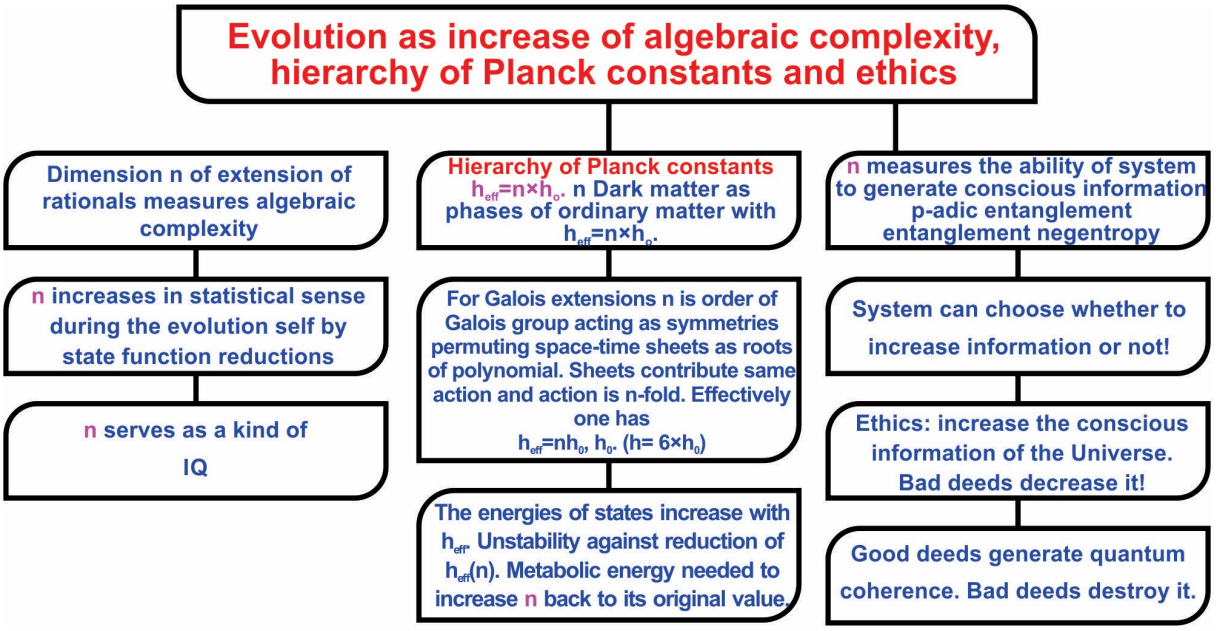
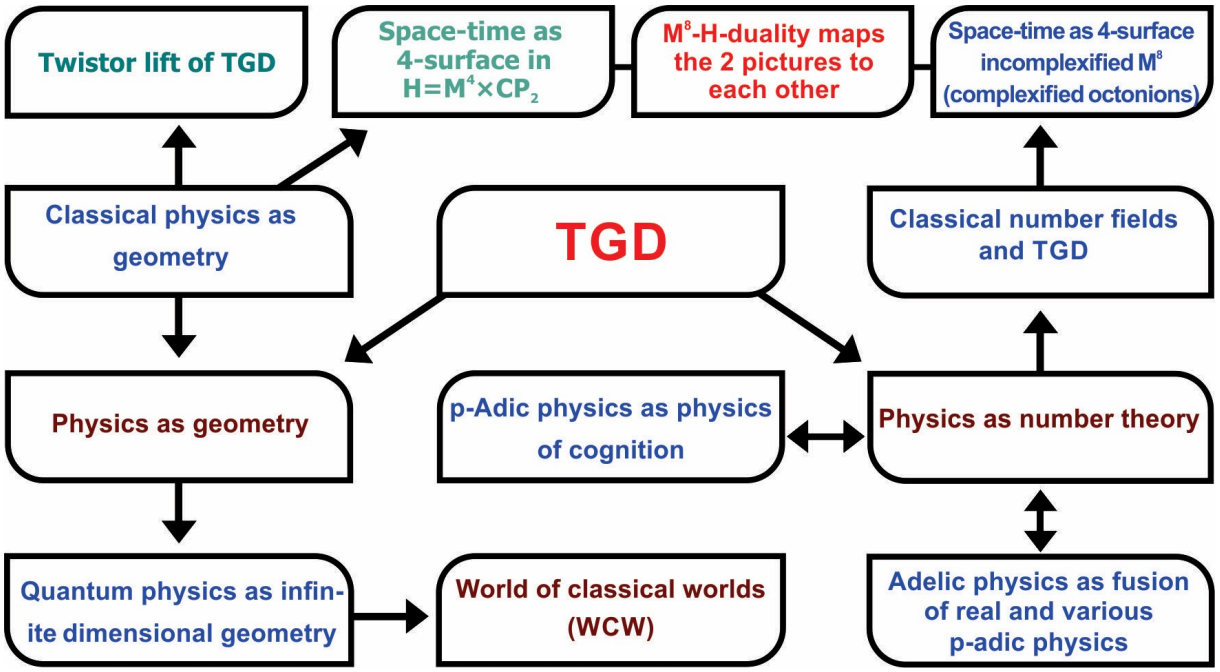


Figure 16: Number theoretic view of evolution



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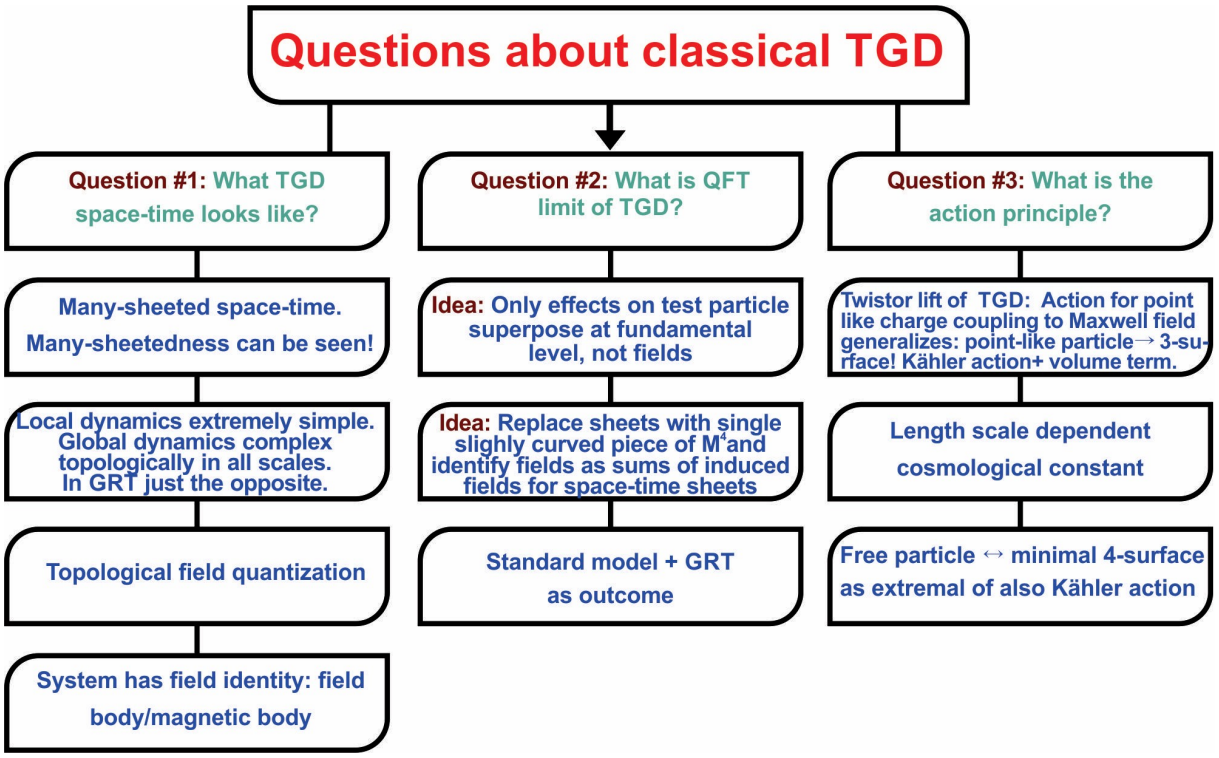

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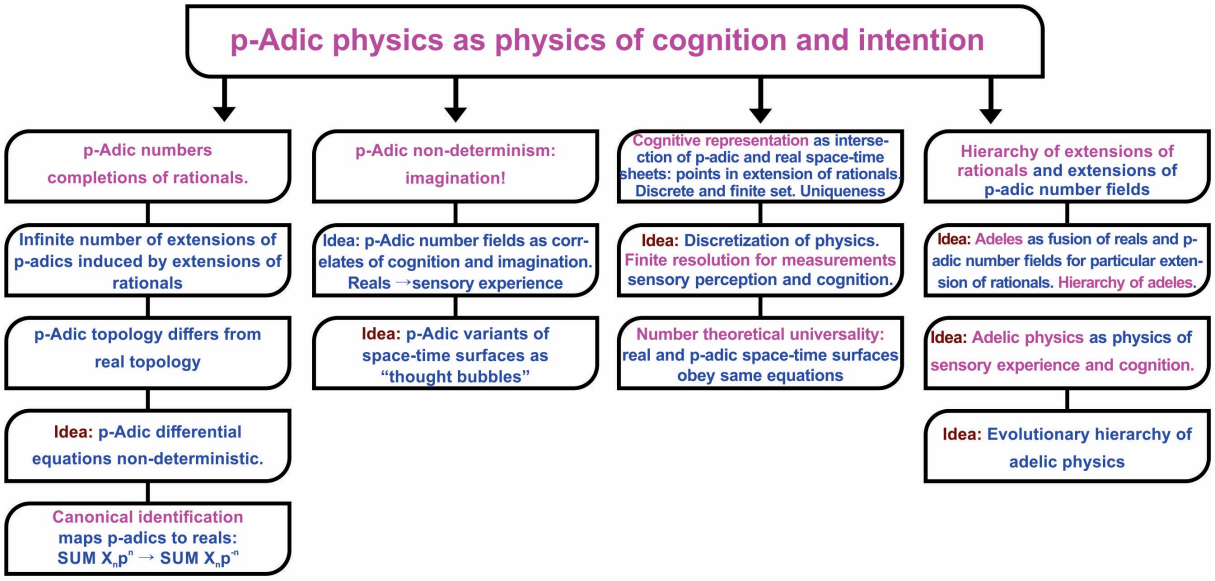


Figure 19: p-Adic physics as physics of cognition and imagination.

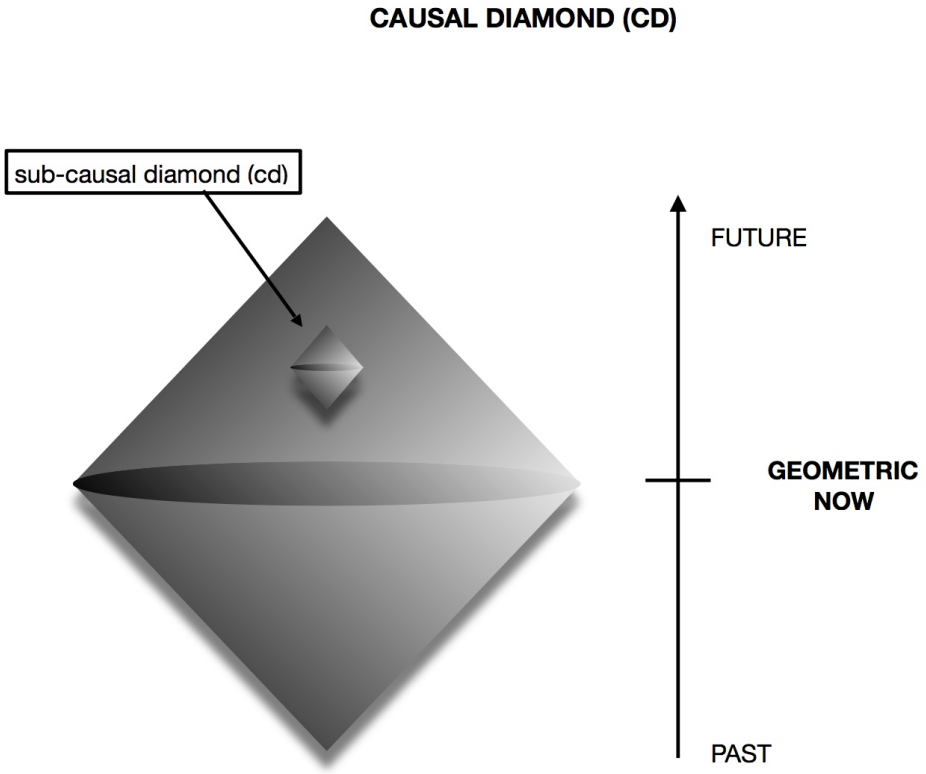
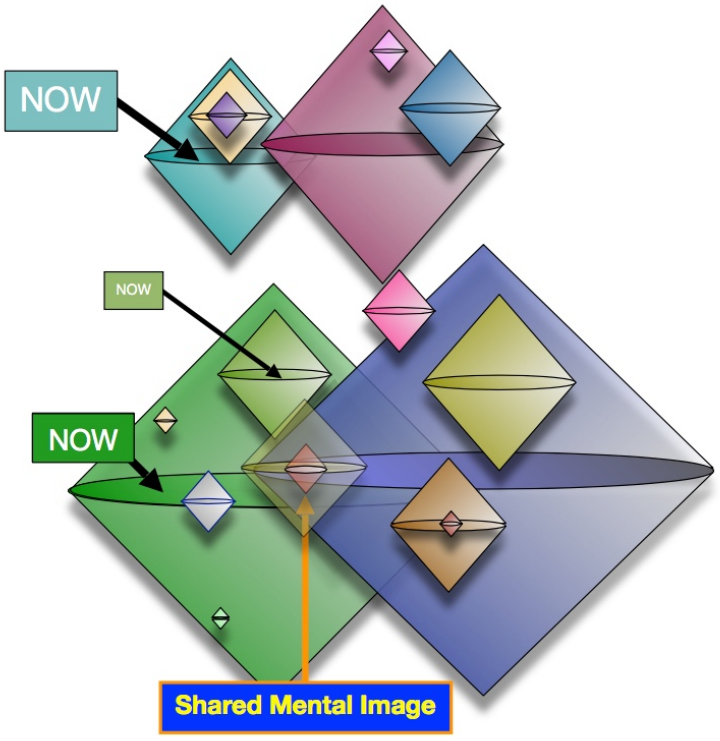


Figure 20: Causal diamond



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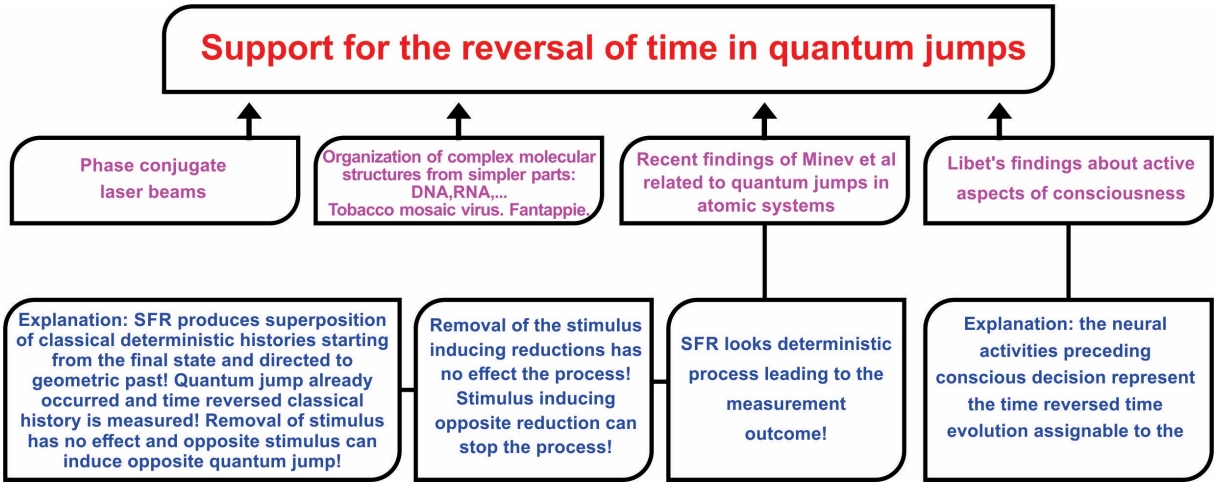

Figure 22: Time reversal occurs in BSFR

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

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Chapter 1

Introduction

1.1 Basic Ideas of Topological Geometrodynamics (TGD)

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

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

1.1.1 Geometric Vision Very Briefly

T(opological) G(eometro)D(ynamics) is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [K1].

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

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

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

Twistor lift of TGD means that one can lift space-time surfaces in H to 6-D surfaces a analogs of twistor space of space-time surface in the Cartesian product of the twistor spaces of M^4 and CP_2, which are the only 4-manifolds allowing twistor space with Kähler structure [A16]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of M^4 and CP_2 must allow identification: this 2-sphere defines the S^2 fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A6] [B7, B4, B5]), 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 [A12, A15, A9, A14].

The identification of the space-time as a sub-manifold [A13, A18] 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 [A17, A19, A21]. 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 [K64]. 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 [K60].

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 [E5] 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 [K86].

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 [K75, K76, K73]) 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 [K93]. 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 [A16]. The twistor space of $M^4 \times CP_2$ is Cartesian product of those of M^4 and CP_2. The obvious idea is that space-time surfaces allowing twistor structure if they are orientable are representable as surfaces in H such that the properly induced twistor structure coincides with the twistor structure defined by the induced metric.

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

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

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

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

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

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

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

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

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

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

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

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

however leads to a new expansion phase. These jerks would replace smooth cosmic expansion of GRT. The discrete coupling constant evolution predicted by the number theoretical vision could be understood as being induced by that of cosmological constant taking the role of cutoff parameter in QFT picture [L54].

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 [L35]. 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 "Evolution in TGD Universe"

The number theoretic vision of physics, which I have referred to as adelic physics, combines real number based physics as physics of sensory experience and various p-adic physics as physics of cognition to a large structure, adelic physics. The basic prediction is that evolution as an increase of algebraic complexity of space-time surfaces and of quantum states is unavoidable and corresponds to the increase of the dimension of algebraic extension associated with a given space-time region. The prediction follows from the requirement of number theoretical universality satisfied if space-time regions are determined by polynomials with integer coefficients smaller than the degree of the polynomial.

The hierarchy of Planck constants is the basic new physics element predicted by adelic physics. Together with zero energy ontology (ZEO) this leads to a general view of biology. In particular, ZEO predicts that the arrow of time changes in the TGD counterparts of ordinary state function reductions and this provides a new view of biological self-organization and homeostasis.

The book "Evolution in TGD Universe" is divided into three parts.

1. The first part is devoted to general ideas and begins with a chapter about adelic physics followed by chapters about prebiotic evolution.

2. In the second part the role of quantum gravitation in evolution is discussed. TGD predicts quantum gravitational coherence even in astrophysical scales and this together with

ZEO has dramatic consequences concerning biology and also other systems since they are expected to couple with the magnetic bodies of the Sun, planets and even moons. I will also consider TGD variant of expanding Earth model explaining several strange findings about Cambrian explosion and suggesting a direct link between biology and cosmic expansion as TGD describes it.

TGD predicts that even very simple systems can possess life-like properties: this is due to the magnetic body, which carries dark matter and serves as the "boss" of the biological body. A system of plastic balls is discussed as an example of this kind of system.

1.3 Sources

The eight online books about TGD [K97, K94, K80, K66, K20, K65, K48, K89] and nine online books about TGD inspired theory of consciousness and quantum biology [K92, K17, K72, K15, K44, K54, K57, K88, K91] 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 GENERAL IDEAS ABOUT EVOLUTION IN TGD UNIVERSE

Philosophy of adelic physics

The p-adic aspects of Topological Geometrodynamics (TGD) will be discussed. Introduction gives a short summary about classical and quantum TGD. This is needed since the p-adic ideas are inspired by TGD based view about physics.

p-Adic mass calculations relying on p-adic generalization of thermodynamics and supersymplectic and super-conformal symmetries are summarized. Number theoretical existence constrains lead to highly non-trivial and successful physical predictions. The notion of canonical identification mapping p-adic mass squared to real mass squared emerges, and is expected to be a key player of adelic physics allowing to map various invariants from p-adics to reals and vice versa.

A view about p-adicization and adelization of real number based physics is proposed. The proposal is a fusion of real physics and various p-adic physics to single coherent whole achieved by a generalization of number concept by fusing reals and extensions of p-adic numbers induced by given extension of rationals to a larger structure and having the extension of rationals as their intersection.

The existence of p-adic variants of definite integral, Fourier analysis, Hilbert space, and Riemann geometry is far from obvious and various constraints lead to the idea of number theoretic universality (NTU) and finite measurement resolution realized in terms of number theory. An attractive manner to overcome the problems in case of symmetric spaces relies on the replacement of angle variables and their hyperbolic analogs with their exponentials identified as roots of unity and roots of e existing in finite-dimensional algebraic extension of p-adic numbers. Only group invariants - typically squares of distances and norms - are mapped by canonical identification from p-adic to real realm and various phases are mapped to themselves as number theoretically universal entities.

Also the understanding of the correspondence between real and p-adic physics at various levels - space-time level, embedding space level, and level of "world of classical worlds" (WCW) - is a challenge. The gigantic isometry group of WCW and the maximal isometry group of embedding space give hopes about a resolution of the problems. Strong form of holography (SH) allows a

non-local correspondence between real and p-adic space-time surfaces induced by algebraic continuation from common string world sheets and partonic 2-surfaces. Also local correspondence seems intuitively plausible and is based on number theoretic discretization as intersection of real and p-adic surfaces providing automatically finite "cognitive" resolution. he existence p-adic variants of Kähler geometry of WCW is a challenge, and NTU might allow to realize it.

I will also sum up the role of p-adic physics in TGD inspired theory of consciousness. Negentropic entanglement (NE) characterized by number theoretical entanglement negentropy (NEN) plays a key role. Negentropy Maximization Principle (NMP) forces the generation of NE. The interpretation is in terms of evolution as increase of negentropy resources.

Evolution in Many-Sheeted Space-Time: Part I

This chapter was originally about prebiotic evolution but gradually extended so that it became natural to drop the attribute "prebiotic". Of course, a collection of ideas rather than detailed history of life is in question. There are many rather speculative ideas such as the strong form of the hypothesis that plasmoid like life forms molecular life forms has evolved in "Mother Gaia's womb", maybe even in the hot environment defined by the boundary of mantle and core. The motivation for tolerating these "too crazy" ideas is that according to recent TGD inspired theory of consciousness life is a completely universal phenomenon appearing in all scales.

1. The basic facts believed to be known about pre-biotic evolution are discussed first.

2. A TGD inspired vision about prebiotic evolution is introduced. The key ideas discussed are the notion of magnetic body and plasmoids as primitive life-forms, emergence of symbolic dynamics as dynamics of dark matter, universal metabolic currencies identified as increments of zero point kinetic energies in many-sheeted space-time, time mirror mechanism giving rise to models of intentional action, memory and remote metabolism and finding justification in zero energy ontology (ZEO) , the idea that primitive life forms evolved in "Mother Gaia's womb" (to be discussed in the fourth part of the article in detail), and possible mechanisms making possible coherence of biochemical activities. Prebiotic chemistry is discussed from the point of new physics: the idea that dark matter makes possible symbolic dynamics justifying the idea that DNA can be seen as written text is the key notion. High energy phosphate bond as a carrier of negentropy is discussed in terms of negentropic entanglement and Negentropy Maximization Principle (NMP). A weaker assumption is that ATP$\rightarrow$ ADP makes only possible to generate negentropic entanglement.

3. Cambrian explosion represents a rather mysterious period in biology: new highly developed phylae emerged out of nowhere. A second strange finding is that continents would fit together to form single super-continent covering entire Earth's surface at time of Cambrian explosion if the radius of Earth would have been one half of its recent value. This finding has inspired Expanding Earth theories but it has not been possible to identify the mechanism causing the expansion. The success of the standard tectonic plate theory requires that possible expansion must have occurred in relatively short geological time scale. The hierarchy of Planck constants implies that cosmic expansion has occurred in quantum leaps increasing the value of h_{eff} and thus of quantum scales by factors which tend to be powers of 2. Cosmic expansion would have occurred as jerks even in the case of planets. In the proposed model Cambrian explosion would have accompanied the expansion of the Earth's radius by a factor of 2: during this period an outburst of highly developed life forms from underground seas to the surface of Earth would have taken place.

4. The notion of generalized Josephson junction is central for the TGD inspired view about EEG. Generalized Josephson junctions of the cell membrane would correspond to various membrane proteins, in particular ion pumps and channels. Cell membrane would communicate with its MB by sending generalization Josephson radiation as dark photons to the MB. The sensory information would be coded by frequency modulation by membrane oscillations for a general cell and also by nerve pulses for neurons. The receiver, which would be cyclotron Bose-Einstein condensate, would receive the signal when in resonance. The FM signal would be transformed to a sequence of resonance peaks, ticks. This vision generalizes

to the idea that generalized Josephson junctions form a length scale hierarchy. For example epithelial sheets consisting of two layersof cells would be this kind of system.

Evolution in Many-Sheeted Space-Time: Part II

This chapter is second part of a chapter devoted for the TGD view about prebiotic evolution but gradually extended so that it became natural to drop the attribute "prebiotic".

1. Quantum aspects of TGD inspired biology are discussed. Number theoretic vision based on the notion of adelic physics predicts a hierarchy of Planck constants giving rise to a hierarchy of phases of ordinary matter behaving like dark matter. The notion of magnetic body (MB) as a many-sheeted structure is introduced: the number theoretic origin of many-sheetedness was not clear when this chapter was written for the first time and I proposed that the embedding space itself could be many-sheeted. The notion of gravitational Planck constant introduced by Nottale is interpreted in the TGD framework as a source of quantum coherence at the gravitational part of MB even in astrophysical scales. Water memory and homeopathy are discussed as manifestations of MB of water and suggesting that water as such is a primitive prebiotic life form.

2. A great vision about biological evolution and evolution of brain is discussed on basis of the wisdom gained from the construction of the models of sensory receptor and generalized EEG.

3. A model for the evolution of the recent genetic code (3-codons) as a fusion of codes for which codons are nucleotides (1-codons) and di-nucleotides (2-codons) is discussed. The symmetries of the genetic code, the observation that tRNA can be seen as a fusion of two hairpin like DNA molecules, and the finding that the first nucleotides of 3-codon code for the reaction path leading from a precursors of the amino-acid to amino-acids for hydrophobic/hydrophilic dichotomy, serve as motivations of the model. 1- and 2-codes corresponding to the two forms of RNA (the exotic $2' - 5'$ RNA and the usual $3' - 5'$ RNA) would have prevailed in RNA world. Amino-acids would have served as catalysts for the copying of RNA on one hand, and RNA molecules would have catalyzed the formation of amino-acids from their precursors on one hand, meaning the presence of a positive feedback loop. In the transition to DNA-amino-acid era RNA began to be translated to amino-acid sequences.

4. TGD based view about the evolution of genetic code is compared to the views of McFadden. This section is a little bit out of date. For instance, the hypothesis that magnetic body of DNA could induce mutations purposefully is not discussed. This hypothesis is natural if one believes that magnetic flux tubes connecting bio-molecules play a key role in bio-catalysis. This idea is discussed in the chapter devoted to protein folding.

More Precise TGD View about Quantum Biology and Prebiotic Evolution

In this work I try to clarify the relation of the basic notions of TGD and of TGD inspired biology to the ordinary bio-chemistry. I also try to improve my understanding about work of Fröhlich, Del Giudice, and Pollack using the notions of TGD. The key idea is the notion of coherence induced by weak em fields with preferred frequencies, which in ordinary quantum theory correspond to energies much below the thermal energy in quantum theory - this creates what is called kT paradox.

In TGD framework one can do without coherence regions (one could perhaps identify them as special cases of Pollacks EZs), which can be much larger. The basic observation is that for a pair of hydrogen bonded water molecules the reaction $2H_2O \rightarrow H_3O_2^- +$ dark proton require UV photon with energy of O-H bond of about 5.15 eV. Water clathrates are good candidates for the precursors of EZs since they have size scale in the same range as EZs and contain hydrogen bonded water. Quantum criticality suggests that this process should occur spontaneously as a chain reaction. This is achieved in the same manner as in nuclear fusion if the dark protons at the flux tube fused to nuclear strings giving rise to dark nuclei.

If dark nuclear binding energy transforms as Coulomb energy, the nuclear energy scale of MeV scales down to 1-10 eV - depending on the value of h_{eff}. An attractive guess is that the energy range of bio-photons corresponds to that for dark nuclear binding and excitation energies. Their

spontaneous transformation back to ordinary nuclei would liberate energy could at least partially explain the evidence for bio-transmutations. Also the relation to cold fusion is interesting.

Dark nuclear binding energy is liberated as dark photons decaying into bunches of ordinary photons inducing further reactions *hydrogen bonded* $2H_2O \rightarrow H_3O_2^- +$ *dark proton* also other kind of dark ionizations. If the size of EZs varies from about 1 micron to 100 microns and if the the size scale of EZ corresponds to the wavelength of dark gamma photon h_{eff}/h varies in the range $10^6 - 10^8$. This would be the total number of dark photons resulting in the decay to ordinary photons. Water clathrates have same size scale range as EZs and consist of hydrogen bonded water molecules and could serve as precursors of EZs: EZ would have different lattice structure than clathrates.

In this process ordinary protons transform dark protons at magnetic flux tubes outside EZ. Dark ionization differs from ordinary ionization only in that the proton is dark. The difference between dark and ordinary ionization would define the borderline between ordinary and bio-chemistry (or dark chemistry). Chemical quantum criticality is possible also for other cations and also anions and all biologically important ions can appear as dark ions.

The Urey-Miller experiment was very successful: it produced a large variety of amino-acids crucial for life from simple basic constituents. The variant of this experiment has even produced adenosine, DNA nucleotide fundamental for ATP. There is however a severe problem. The prebiotic atmosphere was not reducing as in the Urey-Miller experiment simulating it.

Clays are good candidates for the key structures in prebiotic evolution since they can replicate. One can even speculate with an analog of genetic code. Phyllosilicates containing -O-H groups are especially interesting: they can adsorb basic biomolecules and induce their polymerization to oligomers. They also induce a formation of vesicles formed from lipid bilayer and serving as a candidate for a predecessor of cell. DNA is the problem and has led to a scenario known as RNA world. Phyllosilicates are also known to generate radiation with positive health effects. The natural and testable hypothesis is that the presence of EZs allows to circumvent the difficulties of the standard RNA world scenario and also generate DNA and biologically active phosphates containing the mysterious phosphate bond as ionized dark proton. The dark magnetic flux tubes and UV photon energy needed to generate EZs could be provided by gel in Pollacks's experiments and by electric discharges in Urey-Miller experiment. Also dark photons from the formation of dark nuclei decaying to bunches of bio-photons can be considered. Water chlathrates can contain atoms and even micrometer sized phyllosilicate crystals, which could catalyze the formation of biomolecules at their surfaces as dark nuclear fusion chain reaction. Chlathrate could also develop phospholipid bilayer around it - kind of primitive cell membrane.

TGD inspired proposal for prebiotic evolution was inspired by the TGD based realization of Expanding Earth hypothesis and assumes that life evolved in underground oceans and burst on the surface of Earth in Cambrian explosion. This view leads to a more precise view about prebiotic evolution.

Possible technological implications of this picture - if true - are quite impressive. Cold biofusion could make possible artificial generation of technologically important elements and the mechanism generating EZs could make possible creation of artificial intelligent life forms involving silicates and water.

Life-like properties observed in very simple systems

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experimenters that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

One can develop a model for the system based on TGD inpired quantum biology. This

involves the notion of magnetic body carrying dark matter identified as $h_{eff} = n \times h$ phases; a network of magnetic flux tubes (magnetic body) controlling biological body (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and "cold fusion" and serving as source of metabolic energy in prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

There is also second very simple system consisting of particle system with feed of acoustic energy at single wavelength. What happens that the distribution of particles develops synchronous oscillations in wave length band. and the amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

1.3.2 QUANTUM GRAVITATION AND BIOLOGICAL EVOLUTION

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 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.

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.

Dark matter, quantum gravity, and prebiotic evolution

The ideas related to prebiotic evolution have developed rather rapidly after the discovery of the hierarchy of Planck constants around 2003 providing a general manner to understand living organisms as macroscopic quantum systems.

1. Magnetic body as carrier of dark matter realized as phases with non-standard value $h_{eff} = n \times h$ of Planck constant is the key concept in the developments and brings to the description of the living matter a third level besides organism and environment.This has led to developments in the model of EEG as communication tool between biological and magnetic body and led to the interpretation of bio-photons as decay products of dark EEG photons. Also bio-superconductivity is now reasonably well-understood and the model for cell membrane as Josephson junction is generalized to include cyclotron energy besides difference in Coulomb energy. Square root of thermodynamics inspired by Zero Energy Ontology suggests itself as a proper description of Josephson junctions defined by transmembrane proteins. The dark genetic code seems to have so strong explanatory power that it must be taken seriously.

2. Another thread of development relates to the ideas about hierarchy of Planck constants. The findings of Nottale suggest that planets correspond to Bohr orbits with gigantic gravitational Planck constant. It took quite a time to realize that the same predictions follow if h_{gr} is associated with pairs formed by microscopic systems and Sun and that in this case the values of h_{gr} could be identified with those of h_{eff}.

3. Already during first years emerged the idea that the Planck constant characterizes magnetic flux tubes connecting two systems and depends on the quantum numbers of the systems assignable to the interactions in question. Therefore one can speak also about h_{em} assignable to electromagnetic interactions. A vision developed stating that when interaction gets too strong, h_{eff} increases so that the perturbation series in powers of $1/h_{eff}$ converges and perturbation theory works. At space-time level this means non-determinism, which is key feature of the basic varioational principle: the space-time sheets connecting initial and final 3-surface at boundaries of CD are n-sheeted for $h_{eff} = n \times h$ and the sheets co-incide at ends.

4. The model of water memory and homeopathy has led to an evolution of ideas relating to the development of immune system and bio-catalysis. The latest steps of progress were induced by the realization that the replication of magnetic body could be behind that of DNA and cell, the discovery of fourth phase of water and exclusion zones (EZs) by Pollack et al, and by the observation that anomalously high gravimagnetic Thomson field implied by large value of gravitational Planck constant could explain the anomalously large mass measured for electronic Cooper pairs in rotating super-conductor.

5. Zero energy ontology (ZEO) and adelic physics emerged years after the writing of the first version of this chapter. Adelic physics provided a mathematical justification for the hierarchy of Planck constants and p-adic physics. ZEO led to a view about biological evolution as a "must" and reduced allowed to understand self-organization in terms of a new view about quantum measurement predicting time reversal in ordinary state function reductions.

The model for water memory and homeopathy is discussed and shown to lead to a general model for how immune system and bio-catalysis could have developed from their dark primordial versions, how dark proteins might have emerged as concrete representations for invader molecules making it possible to make the invader non-dangerous by attaching to its magnetic body, how DNA and genetic code could have emerged as symbolic representations for the magnetic bodies of invader molecules and later as symbolic representation of the magnetic body of the system itself. ZEO implies that actually time evolution of the magnetic body can be coded by DNA and protein folding could provide a concrete representation for this time evolution.

The vision is applied in various situations.

1. A model for proto-cell as EZ is discussed.

2. M. Root-Bernstein and R. Root-Bernstein proposed the rather brilliant idea that ribosome was the first self-replicator. The idea is discussed and compared to the TGD framework where the natural solution to all hen-egg problems of biology is provided by the predicted dark variants of the basic bio-molecules. The dark variants of replication, transcription, translation, and metabolism would have been part of the fundamental physics and their chemical realizations would have emerged as a kind of shadow dynamics, mimicry.

3. RNA world has also the problem with phosphorylation crucial for metabolic machinery. Proteins are absent and ribozymes are catalysts formed from RNA but they catalyze typically only the reversal of phosphorylation.

   The challenge is to circumvent the problem and the proposal considered suggests that a molecule known as di-amido-phosphate (DAP) could have solved the problem. TGD based view is that both the cell membrane and all basic biomolecules could have emerged more or less simultaneously by pairing with their dark variants. Also the basic catalytic mechanisms would have been present at the level of dark matter as $h_{eff} = nh_0$ phases.

   Remark: If one wants to believe in a TGD variant RNA world, ZEO could come in the rescue. ZEO predicts time reversal in ordinary state function reduction. Could phosphorylation result as a time reversed process? This question is however not considered.

4. Evidence for life in a rather unexpected place - Venus - has emerged. The atmosphere of Venus shows signs of phosphine PH_3 - the analog of ammonium NH_3 -, which cannot be produced by inorganic processes. There are small amounts of phosphine in the Earth's atmosphere and has an organic origin. Same might be true in the case of Venus. Perhaps simple bacterial life is in question. Is it in the atmosphere or somewhere deeper in an open question. TGD based vision about quantum biology suggests several options.

   The most conservative option suggested by TGD relies on the analogy between H_2S and water. The magnetic body (MB) of H_2S realizing also dark variants of basic bio-molecules could play the same role as the MB of water. First proto cell membrane would have formed and led to the development of O-S separation so that the interior of the proto cell would have consisted mostly of water allowing ordinary bio-molecules to evolve.

5. Multi-local viruses are mysterious from the point of view of ordinary biology. The DNA, RNA, and proteins of these viruses divides into segments located at different host cells and can self-assemble back to the ordinary virus. Various partitions of the virus are possible. TGD based view about space-time and quantum theory allows to understand these viruses as connected entities at the level of magnetic body (MB).

6. There is evidence for oil droplets as a primitive life form. The basic objection is that droplets have no genetic code and do not replicate. The TGD inspired model for dark nucleons however predicts that the states of dark nucleon are in one-one correspondence with DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code is naturally realized. The question is whether the realization of the genetic code in terms of dark nucleon strings might provide the system with genetic code and whether the replication could take place at the level of dark nucleon strings rather than droplets. TGD inspired quantum model of biology leads to a model for oil droplets as a primitive life form. In particular, a proposal for how dark genes could couple to chemistry of oil droplets is developed.

Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life

TGD inspired quantum cosmology predicts that astrophysical objects do not follow cosmic expansion except in jerk-wise quantum leaps increasing the gigantic value of the gravitational Planck constant h_{gr} characterizing space-time mediating gravitational interactions between two masses or gravitational self interactions. This assumption provides explanation for the apparent cosmological constant. As a matter fact, gigantic value of h_{gr}. By Equivalence principle and independence of gravitational acceleration on mass it is enough to assume that only microscopic systems have the gravitational flux tube contacts with central mass. In this case the value range of h_{gr} is consistent with the identification as $h_{eff} = n \times h$ introduced with motivations coming from biology and in TGD framework following from the non-determinism of Kähler action.

Also planets are predicted to expand in a stepwise manner allowing to imagine a new version of Expanding Earth theory originally postulated to explain the intriguing findings suggesting that continents have once formed a connected continent covering almost the entire surface of Earth but with radius which was one half of the recent one.

This leads also to a rather fascinating vision about biology. The mysterious Cambrian Explosion in which a large number of new species emerged suddenly (realized already Darwin as the strongest objection against his theory) could be understood if the life would have gone to underground lakes and seas formed during the expansion period as fractures were formed and the underground cavities expanded and were filled with water. This would have allowed the life to escape cosmic radiation, meteoric bombardment, and the extremely cold climate during Proterozoic period preceding the Cambrian Explosion and migrate back as highly developed life forms as the period of glaciations ended.

Before the Proterozoic era the radius of Earth would have been one half of its recent value and started to grow with gradually accelerating rate. This forces to rewrite the entire geological and climate history of Earth during the Proterozoic period.

1. The postulated physically implausible cyclic appearance of single connected super-continent containing all land mass can be given up and replaced with a single continent containing large inland seas. There is no need to postulate the existence of series of super-oceans whose ocean floor would have subduced totally so that no direct information about them would exist nowadays.

2. The dominating model for pre-Cambrian climate is so called Snowball Earth model inspired by the finding that signatures of glaciations have been found at regions of Earth, which should have been near Equator during the Proterozoic. Snowball model has several difficulties: in particular, there is a lot of evidence that a series of ordinary glaciations was in question. For $R/2$ option the regions located to Equator would have actually been near North Pole so that the glaciations would have indeed been ordinary glaciations proceeding from the poles. A killer prediction is the existence of non-glaciated regions at apparent southern latitudes around about 45 degrees and there is evidence for these indeed exists! The model makes also testable paleomagnetic killer predictions. In particular, during periods when the magnetic dipole in the direction of rotation axis the directions of the magnetic fields for $R/2$ model are predicted to be same at South Pole and apparent Equator and opposite for the standard option.

Chapter 2

Empirical support for the Expanding Earth hypothesis

In this article I continue to develop a more detailed TGD version of the Expanding Earth hypothesis explaining Cambrian Explosion (CE). A more detailed view of the pre-Cambrian biology, geology, and thermal evolution emerges and one can relate it to the standard view. This involves topics like faint Sun paradox, the mechanism of Great Oxygenation Event, understanding the TGD counterparts of supercontinents Rodinia and Pannotia preceding CE, snowball Earth, and CE that led to a sudden emergence of highly advanced multicellulars.

Also a more detailed view of what happened in the Cambrian explosion induced by the increase of the radius of Earth by factor 2 emerges (in the TGD Universe, a smooth continuous cosmological expansion is replaced with a sequence of short lasting and fast expansions). One ends up with a detailed model for the phase transition leading to the increase of the Earth radius. This phase transition requires a considerable energy feed provided by the phase transition thickening monopole flux tubes of the magnetic body of Earth and liberating energy. In analogy with the recent Mars, pre-Cambrian Earth had a solid core analogous to the inner core. In the phase transition to a liquid outer core with much larger volume. Part of the newly formed outer core could in turn have transformed to form a part of the mantle increasing its thickness.

I also discuss the empirical support for the Expanding Earth hypothesis that I have become aware of quite recently.

1. There is empirical support for the view that the oxygenation of oceans did not occur before CE. This conforms with the prediction that oxygenation was due to photosynthesis in underground oceans. TGD provides the new physics needed: dark photons from either Earth's core or Sun could have provided the metabolic energy making photosynthesis and therefore oxygenation possible.

2. Anomalously high recession velocities for the tectonic plates during CE have been observed and could be due to the radial expansion of the Earth lasting about 30 million years which corresponds to the duration of Cambrian explosion. A quantitative estimate for the expansion velocity gives an estimate consistent with the findings. Cambrian explosion would correspond to quantum tunnelling in astrophysical scale and involve "big" state function reductions and a temporary change of the arrow of time. The change of the arrow of time in scale of 30 million years could even allow to understand the plant fossils with age about 600 million years conflicting with the fact that the Cambrian explosion (CE) occurred about 540 million years ago.

3. The finding that the mantle-core boundary looks like a seafloor having even mountains has a rather convincing explanation in terms of the subduction of tectonic plates, which sink to the mantle. This however inspired the question whether life in underground oceans as porous structures containing water in some exotic form, most naturally the fifth phase of water studied by Pollack playing a key role in the TGD inspired view of biology, could make possible the needed thermal and chemical isolation. Pollack effect could provide this

isolation and is certainly needed even if the temperature of the underground ocean is not far from the physiological temperature.

Assuming that the Sun was faint so that the temperature at the surface of Earth was below the freezing point, one ends up with conflict with the isotopic determination of the temperature giving a temperature of oceans slightly higher than the temperature 38 C above which marine invertebrates cannot survive. The temperature about 30 degrees allows life but this requires a slightly lower amount of O^{18} isotope than prevailing in the recent oceans. The paradox can be solved if the warm water originated from underground oceans and mixed with the non-oxygenated water (or actually ice) at the surface of Earth so that the isotopic fraction was reduced. The optimal situation for life would have been at depths of order kilometer and one can say that life had no other option than developing underground.

Part I

General Ideas about Evolution in TGD Universe

Chapter 3

Philosophy of Adelic Physics

3.1 Introduction

I have developed during last 39 years a proposal for unifying fundamental interactions which I call "Topological Geometrodynamics" (TGD). During last twenty years TGD has expanded to a theory of consciousness and quantum biology and also p-adic and adelic physics have emerged as one thread in the number theoretical vision about TGD.

Since Quantum TGD and physical arguments have served as basic guidelines in the development of p-adic ideas, the best way to introduce the subject of p-adic physics, is by describing first TGD briefly.

In this article I will consider the p-adic aspects of TGD - the first thread of the number theoretic vision - as I see them at this moment.

1. I will describe p-adic mass calculations based on p-adic generalization of thermodynamics and super-conformal invariance [K56, K24] with number theoretical existence constrains leading to highly non-trivial and successful physical predictions. Here the notion of canonical identification mapping p-adic mass squared to real mass squared emerges and is expected to be key player of adelic physics and allow to map various invariants from p-adics to reals and vice versa.

2. I will propose the formulation of p-adicization of real physics and adelization meaning the fusion of real physics and various p-adic physics to single coherent whole by a generalization of number concept fusing reals and p-adics to larger structure having algebraic extension of rationals as a kind of intersection.

   The existence of p-adic variants of definite integral, Fourier analysis, Hilbert space, and Riemann geometry is far form obvious, and various constraints lead to the idea of NTU and finite measurement resolution realized in terms of number theory. Maybe the only way to overcome the problems relies on the idea that various angles and their hyperbolic analogs are replaced with their exponentials and identified as roots of unity and roots of e existing in finite-dimensional algebraic extension of p-adic numbers. Only group invariants - typically squares of distances and norms - are mapped by canonical identification from p-adic to real realm and various phases are mapped to themselves as number theoretically universal entities.

   Another challenge is the correspondence between real and p-adic physics at various levels: space-time level, embedding space level, and WCW level. Here the enormous symmetries of WCW and those of embedding space are in crucial role. Strong form of holography (SH) allows a correspondence between real and p-adic space-time surfaces induced by algebraic continuation from string world sheets and partonic 2-surface, which can be said to be common to real and p-adic space-time surfaces.

3. In the last section I will describe the role of p-adic physics in TGD inspired theory of consciousness. The key notion is Negentropic entanglement (NE) characterized in terms of number theoretic entanglement negentropy (NEN). Negentropy Maximization Principle (NMP) would force the growth of NE. The interpretation would be in terms of evolution as increase

of negentropy resources - Akashic records as one might poetically say. The newest finding is that NMP in statistical sense follows from the mere fact that the dimension of extension of rationals defining adeles increases unavoidably in statistical sense - separate NMP would not be necessary.

In the sequel I will use some shorthand notations for key principles and key notions. Quantum Field Theory (QFT); Relativity Principle (RP); Equivalence Principle (EP); General Coordinate Invariance (GCI); World of Classical Worlds (WCW); Strong Form of GCI (SGCI); Strong Form of Holography (SH); Preferred Extremal (PE); Zero Energy Ontology (ZEO); Quantum Criticality (QC); Hyper-finite Factor of Type II_1 (HFF); Number Theoretical Universality (NTU); Canonical Identification (CI); Negentropy Maximization Principle (NMP); Negentropic entanglement (NE); Number Theoretical Entanglement Negentropy (NEN); are the most often occurring acronyms.

Chapter 4

Evolution in Many-Sheeted Space-Time: Part I

4.1 Introduction

This chapter was originally about prebiotic evolution but gradually extended so that it became natural to drop the attribute "prebiotic" away. Of course, a collection of ideas rather than detailed history of life is in question.

If was already early that the notion of many-sheeted space-time could allow to understand many puzzles related to the pre-biotic evolution [I54, I117]. There are many constraints on the models for pre-biotic evolution. The models have also many difficulties [I56, I105].

TGD replaces materialistic view about universe with a continual re-creation in which classical universe in 4-dimensional sense is replaced by a new one in each quantum jump. p-Adic length scale hypothesis allows to formulate the notion of evolution more precisely as a generation of increasingly larger space-time sheets characterized by preferred p-adic primes. A second aspect is the emergence of new levels in dark matter hierarchy characterized by effective Planck constant $h_{eff} = n \times h$ making possible macroscopic quantum coherence and inducing great leaps in evolution. Also a hierarchy of dark weak bosons and gluons becomes an essential part of the physics of living matter. The notion of field/magnetic body carrying dark matter is a further key element in the model and has become increasingly important during years, and the vision about DNA-cell membrane system as a topological quantum computer utilizing braids defined by magnetic flux tubes connecting nucleotides to lipids meant a breakthrough in the understanding of the real function of DNA in information processing.

If was already early that the notion of many-sheeted space-time could allow to understand many puzzles related to the pre-biotic evolution [I54, I117]. There are many constraints on the models for pre-biotic evolution. The models have also many difficulties [I56, I105].

4.1.1 Questions And Answers About Evolution

A good way to introduce the essentials of the TGD inspired model for the prebiotic evolution is by a sequence of questions and answers relating to evolution. The progress occurred during last years in the understanding of water as primitive lifeform has modified considerably the original answers and I have comments about this.

Q: Is life as we know it result of an accident?.

A: Quantum TGD predicts a genuine cosmic evolution occurring by quantum jumps for which dynamics is characterized by Negentropy Maximization Principle (NMP) [K60]. The generalization of the notion of space-time implies dark matter hierarchy with levels characterized by arbitrarily large values of effective Planck constant so that macroscopic quantum coherence is possible even in astrophysical length scales. Even astrophysical systems are analogous to atomic systems which implies a strong standardization of planetary system so that Earth like planets are abundant. There are also other good reasons for why the evolution of life would not have been accident in TGD Universe and life should appear everywhere in TGD Universe.

Even stronger conclusions follow from NMP in zero energy ontology (ZEO). The view about quantum jump in ZEO implies that the formation of what might be regarded as generalizations of sensory and other representations defining reflective level of consciousness appearing universally. These representations would be kind of Akashic records. The braiding of the magnetic flux tubes would serve as a geometric correlate of the negentropic entanglement, which together with Negentropy Maximization Principle (NMP) guarantees approximate invariance of representations under quantum jumps. Also the sensory-motor dichotomy characterizing living matter is a universal property of quantum jump sequence in ZEO [K23]. This would strongly suggest that consciousness and even life has not emerged but has been present already at elementary particle level. These ideas are however newcomers and do not yet appear in the formulations represented in the article series.

Q: What were the most primitive living systems?

A: The notion of magnetic body brings to biology several completely new elements. Magnetic flux quanta containing dark charged matter and quantum controlling ordinary matter in plasma phase is perhaps the simplest system which can develop characteristics of a living system. The braiding of magnetic flux tubes makes possible topological quantum computation and a fundamental representation of memories and its presence could be even taken as a definition for what it is to be living. Topological quantum computation (TQC) programs correspond to asymptotic self organization patterns for liquid flows inducing braidings and are non-trivial in presence of external energy feed.

The recent findings about water inspire the vision that primordial life corresponds to the exclusion zones discovered by Pollack and the model of dark protons suggests that vertebrate genetic code could be realized at the this level so that dark proton sequences could define primordial genes.

Q: How metabolic machinery emerged?

A: Many-sheeted space-time concept predicts a hierarchy of universal metabolic energy quanta as differences of zero point kinetic energies for space-time sheets characterized by different p-adic length scales. These energies define an attractive candidate for univeral metabolic quanta. What remains is to understand how chemical energy storage and utilization mechanisms developed. Also the deeper purpose of the metabolic energy must be understood and metabolic energy carrier as a storage of negentopic entanglement or as something making possible the generation of negentropic entanglement (braiding) is an attractive interpretation.

Q: What is behind biocatalytic machinery?

A: The magnetic flux tubes connecting bio-molecules imply long range correlations between molecules and also as correlates of attention meaning fusion of two systems to single quantum coherent unit. The reduction of Planck constant for magnetic flux tubes implying their shortening provides a mechanism making possible for bio-molecules to "find" each other in a very selective way, and explains also why molecules end up to precisely defined conformations necessary for a selective bio-catalysis. Reconnections of flux tubes would change the topology of system formed from negentropically entangled flux quanta.

Q: How symbolic dynamics emerged?

A: There is a temptation to assign the origin of the symbolic dynamics with the magnetic body. The notion of fractional atom [K37] suggested by the fractionization of electron and nucleon quantum numbers for dark matter hierarchy brings in a candidate for a symbolic dynamics assigning to molecules "names" which need not correlate very strongly with the chemical properties of the molecule but would dictate to a high degree its biochemical behavior. Molecular "sex" emerges in the sense that molecules labeled with "names" and "co-names" tend to pair. The model of DNA as TQC assumes a 4-coloring of braid strands realized by an assignment of DNA nucleotides to quarks and anti-quarks. Also this means symbolic dynamics since only molecules connected by colored braids have high probability to participate in same biochemical reaction and do it in a very specific way. Since the quarks involved with braid strands can have fractional charges, molecular sex can be realized also in this way.

The dark DNA coding for dark proteins (both consisting of dark proton sequences) at the magnetic body of the system mimicking the 2-braiding of the magnetic bodies of invader molecules might have defined the prebiotic symbolic representation and could still be a part of immune system.

Q: What selected the bio-molecules during chemical evolution?

A: The proposed symbolic dynamics based on the notions of colored braids and fractional atom poses very strong constraints on the subsets of bio-molecules that can react with considerable rates.

Q: How biochemical pathways emerged?

A: It is now possible to realize in practice sequences of arbitrarily complex self-catalyzing biochemical reactions utilizing DNA hairpins. The mechanism generalizes to more complex molecules. At a given step of the reaction sequence the structure formed during the previous steps acts as a key fitting to a lock represented by some hairpin in the solution, and opens it to a linear molecule and in this way makes it a key. The braids between reactants make it possible for the key and lock to find each other.

The lock and key mechanism can be generalized with key being replaced with a password. In computer languages like LISP lock-key pair corresponds to a memory position represented as a pair formed by its own address and the address to which the memory position points and the program consisting of sequence of this kind of associations. These addresses can be represented also as collections of resonance frequencies.

Q: How genetic code evolved?

A: The symmetries of the third codon of the genetic code allow in DNA as TQC model an interpretation as isospin and matter antimatter symmetries for quarks and antiquarks assigned with DNA nucleotides and representing 4-color of braid strands. These symmetries together with the study of the detailed structure of tRNA lead to a model for the evolution of the genetic code as a fusion of a non-deterministic 1-code and one-to-one 2-code corresponding to the conjugation of mRNA molecules. During RNA era two kinds of RNAs, call them RNA_1 and RNA_2, were present and played the roles of mRNA and amino-acid sequences. 2-code *resp.* 1-code mediated the analog of replication *resp.* translation using hairpin like molecules $tRNA_1$ and $tRNA_2$ to bring in RNA nucleotides and RNA doublets to the growing RNA_i sequence. Amino-acids attached to the stem of $tRNA_2$ acted as catalysts. The transition to RNA-amino-acid era took place via a fusion of the $tRNA_1$ and $tRNA_2$ to the ordinary tRNA and instead of sequences of two kinds of RNAs were replaced by amino-acid sequences were formed. After a period of symbiosis involving all these three tRNAs a transition to DNA-RNA-amino-acid world took place as an amino-acid sequence acting like reverse transcriptase emerged.

More strongly TGD based approach is provided by the vision about water as a primitive life-form inspired by Pollack's findings about fourth phase of water and exclusion zones [L13]. In this framework the dark proton strings defining "dark amino-acid" sequences [L2, K47] could have coded the 2-braiding (braiding in space-time) patterns of invader molecules as their own 2-braidings, and dark DNA would have provided symbolic coding of "dark proteins". Therefore dark DNA would originally have coded dynamical patterns for magnetic bodies of invader molecules. This would make possible pre-biotic immune system, which would be a part of the recent immune system.

This model was the first model proposed in TGD framework for the genetic code and is evolution. Later further models emerged and the recent situation is discussed in a separate chapter.

Q: Did RNA world precede the life as we know it?

A: The model for the evolution of the genetic code forces to conclude tha RNA world [I139] preceded the recent biology and allows also to deduce that the nucleotides involved with second form of RNA where A,T,U,I(nositol). The exotic RNA in question could have been $2', 5'$ form of RNA rather than $3', 5'$ RNA produced also in the classical experiments of Leslie Orgel [I18].

Another and more plausuible option in TGD framework is water as a primitive lifeform with dark counterparts of basic biomolecules realizes as dark protonic strings (dark nuclei). RNA world could have followed this period but the fact that both DNA, RNA, tRNA and aminoacids can have dark counterparts does not suggest special role for RNA.

Q: Does the notion of protocell make sense?

A: The model of DNA as TQC involves essentially the magnetic flux tubes connecting DNA nucleotides and cell membrane. Since topological quantum computation should have taken place also during the RNA era, some kind of cell membrane consisting of exotic RNA should have been present. It has been found that DNA indeed forms membrane like structures which are liquid crystals consisting of sequences of DNA nucleotides with length up to 20 nucleotides [I88] and same might be true in the case of exotic RNA.

Another very attractive option is that the counterparts of exclusion zone carrying negative charge due to the transfer of protons to the flux tubes of the magnetic body of exclusion zone [L13] defines protocell.

Q: How life could evolve in the harsh primordial environment? Does the notion of primordial ocean make sense?

A: Evolving life had to cope with the grave difficulties due to the irradiation by UV light and meteoric bombardment. A simple solution of these problems is to evolve in the interior of Earth, say in underground lakes. This idea conforms nicely with the observation that continents would have formed a single super continent at time of Cambrian explosion provided the radius of Earth at that time was by a factor 1/2 smaller than now. TGD predicts that cosmic evolution does not occur continuously but by quantum jumps in which the Planck constant of appropriate space-time sheet increases. A phase transition of this kind increasing the radius of Earth during a relatively short time interval would have led to a burst of life from underground lakes to the surface of Earth. This would also explain the sudden emergence of a huge variety of highly developed life forms during Cambrian explosion.

Few words about the key ideas behind the chapter are in order.

1. The idea about hierarchy of Josephson junctions discussed in [K36] (cell membrane would provide the basic realization leading to a model of nerve pulse [K78]) is central and emerged already around 2000 as I learned by looking at old CASYS conference proceedings [L1].

2. The considerations rely also heavily on the notion of magnetic body and the identification of dark matter as a hierarchy of phases of ordinary matter (at least) labelled by an effective value of Planck constant $\hbar_{eff} = n\hbar$ coming as an integer multiple of the ordinary Planck constant (this idea [K38, K71] was introduced around 2005). These phases are assumed to reside at flux tubes and sheets appearing as parts of the magnetic body assignable to any physical system.

   The basic implication is that basic quantum scales proportional to $\hbar$ are scaled up so that nanoscopic and even macroscopic quantum phases become possible for sufficiently large values of Planck constant. Magnetic body is assumed to act as an intentional agent receiving sensory data from cell membranes and controlling biological body with the mediation of genome. Signals are realized as dark photons and cyclotron Bose-Einstein condensates at magnetic bodies are central in this picture. Photon with given energy can correspond to arbitrarily long wavelengths and one can understand the effects of ELF radiation on vertebrate brain in terms of dark photons. DNA as topological quantum computer is one of the implications [K2].

3. In [K13] the identification of bio-photons as ordinary photons resulting in decays of (say) dark photons with same energy and frequency in EEG range is discussed. In this and subsequent articles neither bio-photons nor the notions of zero energy ontology [K60] having profound biological implications [K8, K23] are not discussed. The reason is that all the articles in this series are prepared from the chapters of online book "Genes and Memes" [K44] - most of them have been written for the first time for more than decade ago. A fascinating challenge is to find how the considerations are modified by bringing in these new ideas.

4.1.2 Topics Of The Chapter

The topics of the chapter has been restricted to those, which seem to represent the most well-established ideas. The topics of the article have been restricted to those, which seem to represent the most well-established ideas about evolution in TGD Universe. There are many other, more speculative, ideas such as the notion of fractional atom [K37] based on fractalization of electron charge and strong form of the hypothesis that some life forms has evolved in "Mother Gaia's womb", maybe even in the hot environment defined by the boundary of mantle and core.

1. The basic facts believed to be known about pre-biotic evolution are discussed first.

2. A TGD inspired vision about prebiotic evolution is introduced. The key ideas discussed are the notion of magnetic body and plasmoids as primitive life-forms, emergence of symbolic dynamics as dynamics of dark matter, universal metabolic currencies identified as increments of zero point kinetic energies in many-sheeted space-time, time mirror mechanism giving rise

to models of intentional action, memory and remote metabolism and finding justification in zero energy ontology (ZEO) [K23], the idea that primitive life forms evolved in "Mother Gaia's womb" [L46] (to be discussed in the fourth part of the article in detail), and possible mechanisms making possible coherence of biochemical activities. Prebiotic chemistry is discussed from the point of new physics: the idea that dark matter makes possible symbolic dynamics justifying the idea that DNA can be seen as written text is the key notion. High energy phosphate bond as a carrier of negentropy is discussed in terms of negentropic entanglement and Negentropy Maximization Principle (NMP) [K60]. A weaker assumption is that ATP→ ADP makes only possible to generate negentropic entanglement.

Some important topics have been left out since they have been discussed in [K55] and in an earlier article [L6, L7]. In particular, the idea about DNA as topological quantum computer realized in terms of braids defined by flux tubes connecting DNA nucleotides or codons to the lipids of the nuclear and cell membranes is not discussed [L6, L7]. If topological quantum computation really takes place in living matter, the question is when topological quantum computation did emerge. The universality of the braiding defining topological quantum computer programs [K23] gives also rise to a universal representations (sensory -. memory -. etc...) suggests that topological quantum computation like processes must have been present from already during pre-biotic period.

3. Cambrian explosion represents a rather mysterious period in biology: new highly developed phylae emerged out of nowhere. A second strange finding is that continents would fit together to form single super-continent covering entire Earth's surface at time of Cambrian explosion if the radius of Earth would have been one half of its recent value. This finding has inspired Expanding Earth theories but it has not been possible to identify the mechanism causing the expansion. The success of the standard tectonic plate theory requires that possible expansion must have occurred in relatively short geological time scale. The hierarchy of Planck constants implies that cosmic expansion has occurred in quantum leaps increasing the value of $\hbar_{eff}$ and thus of quantum scales by factors which tend to be powers of 2. Cosmic expansion would have occurred as jerks even in the case of planets. In the proposed model Cambrian explosion would have accompanied the expansion of the Earth's radius by a factor of 2: during this period an outburst of highly developed life forms from underground seas to the surface of Earth would have taken place. This topic is discussed in separate chapter [L46].

4. The notion of generalized Josephson junction is central for the TGD inspired view about EEG [K36, K78]. Generalized Josephson junctions of the cell membrane would correspond to various membrane proteins, in particular ion pumps and channels. Cell membrane would communicate with its MB by sending generalization Josephson radiation as dark photons to the MB. The sensory information would be coded by frequency modulation by membrane oscillations for a general cell and also by nerve pulses for neurons. The receiver, which would be cyclotron Bose-Einstein condensate, would receive the signal when in resonance. The FM signal would be transformed to a sequence of resonance peaks, ticks. This vision generalizes to the idea that generalized Josephson junctions form a length scale hierarchy. For example epithelial sheets consisting of two layersof cells would be this kind of system.

To sum up, TGD does not yet provide a unique view about prebiotic evolution. The magnetic body of water carrying dark matter and controlling ordinary biomolecules via their dark analogs is very attractive proposal but it is not clear whether it is natural to assume RNA world could have been its follower since both DNA,RNA, aminoacids, and tRNA seem to have dark counterparts.

4.2 What Is Known About Pre-Biotic Evolution?

In the following the basic facts and ideas about pre-biotic are summarized.

4.2.1 Some Believed-To-Be Facts About The Early History Of Life

The following basic facts allow to get rough view about the time scales of the pre-biotic evolution.

1. The origin of Earth occurs roughly 4.5 Ga (Ga=billion years ago). Bombardment phase, that is the period of large scale impacts, ended roughly 4-3.8 Ga.

2. ^{12}C enrichment is seen as a signature of photosynthesis. By this criterion the oldest known micro-fossils date back to 3.5 Ga and are found in volcanoes. There is a hot debate going on about whether these micro-fossils are really genuine micro-fossils. For instance, they are accompanied by complex quartz structures and this does not conform with what one might expect.

3. Levels of atmospheric oxygen began to increase during second half of precambrian era (2 Ga) and reached 10 per cent level at the eon's end at 1 Ga.

4. There are not many fossils or fossil bearing rocks from the precambrian eon. The simplest explanation is that the precambrian fossils have been soft bodied. Abundant fossils appear at Cambrian period which started.55 Ga. Cambrian explosion meant emergence of extremely rich spectrum of various life-forms.

5. The time interval between bombardment phase and the emergence of the first micro-fossils is only.3 billion years. This means that the time window for the life to develop on the surface of Earth is surprisingly narrow, and one can ask whether the primordial life could really have developed spontaneously in the environment provide by the surface of young Earth.

4.2.2 Standard Approaches Are Mechanistic

Various hard science approaches to the pre-biotic evolution share a common philosophy dating to the beginning of the previous century. This philosophy is reductionistic materialism according to which life can be explained as a purely mechanistic phenomenon which just happened to occur by change ("change and necessity" using the phrase in the title of the classic of Monod). This view is highly questionable and certainly in dramatic conflict with more modern views relying on macroscopic and even astrophysical quantum coherence as basic elements.

At the experimental level the failure of mechanistic approach is easy to see. The components of cell inside test tube do not form a living system. The numerical simulations using computer models have demonstrated convincingly that spontaneous emergence of life is not possible. Empirical facts support completely different conclusion: the emergence of life is unavoidable and occurs everywhere in the universe, and there are good reasons that it has some universal characteristics. The challenge is to develop the conceptual framework so that it can explain this naturally.

4.2.3 The Notion Of Primordial Ocean

The following discussion uses basic facts which I have learned from articles of Chris King [I54] representing updated view about facts and theories about pre-biotic evolution as well as articles criticizing the existing theories [I56, I105].

The generation of biomonomers requires the presence of C, H and O. During 1920′s Oparin and Haldane independently proposed that life, or its chemical precursors including amino-acids, formed spontaneously under the conditions associated with primordial atmosphere. Genetic code was not yet known, and both Oparin and Haldane believed that life evolved from proteins, and that life's precursors including amino-acids were formed spontaneously in a reducing atmosphere whose principal components where CH_4 and/or CO_2, NH_3, and H_2O.

Oparin suggested that methane served as the source of carbon whereas Haldane believed that the source was CO_2. Oparin also suggested that what he called coacervatives were precedessors of the cell. Haldane thought that the gradual increase in the complexity of pre-biotic molecules in the presence of UV radiation led automatically to the generation of a protocell.

The assumption that the atmosphere is reducing is essential: the presence of oxygen would be fatal for the biomonomers. This assumption can be however questioned. The primordial atmosphere was due to the outgassign associated with volcanic eruptions but due to volcanic fumes the atmosphere is oxidizing which means that biomonomers would have been rapidly destroyed by oxidation. Interestingly, the photographs of Earth taken during the Apollo 16 mission allow to conclude that a gigantic cloud of hydrogen, extending 40, 000 miles into space surrounds the Earth.

The only source of hydrogen can be water vapour, bombarded by high energy UV light rays above ozone layer [I135]. If this water has been there during the primordial period, the atmosphere must have contained oxygen so that the basic assumption would be wrong.

Even if the atmosphere was reducing, one encounters a problem. There would have been no shield against UV radiation which according to [I56] would have dissociated COOH whereas CH_4 and heavier hydrocarbons would have polymerized forming an oil slick 1-10 deep over the surface of the Earth. Ammonium would have photo-dissociated into nitrogen and hydrogen so that the conditions of the experiments of Miller [J23] and others to be discussed below would not been satisfied.

4.2.4 Urey-Miller Experiment

Urey-Miller experiment [J23] meant a dramatic step of progress on the experimental side, and for a along time it was believed to conform the vision of Oparin and Haldane. The experiment involved a reducing atmosphere and electric sparks simulating the effect of lightnings. In the later experiments 19 of 20 amino-acids were identified. Also nucleosides A, G were produced. Cyanoacetaldehyde together with urea believed to be accumulated to primordial ponds, allowed to generate U and C as was discovered by Miller 40 years after his classical experiment. These impressive results were interpreted as a support for the view about primordial ocean as a "dilute soup" of organic molecules which precipitated out of the atmosphere.

For a long time it was believed that the synthesis of ribose necessary for the generation of RNA was impossible in these circumstances. It turn out that ribose was generated from glyseralhehyde phosphate in presence of COOH [I60]. Glyseraldehyde phosphate was generated also in Miller's experiments. In case of deoxiribose necessary for DNA no plausible synthesis mechanism has been identified.

Organic compounds (in particular A, U, C, G) and even membrane forming products are present in carbonaceous chondrites (meteorites). Chondrites are essentially what the Earth is made of. Galactic gas clouds contain sugars, amino-acids, nucleic acids. In an experiment of Dworkin and his colleagues [I66] thin ice at temperature of 10 K containing H_2O, ammonia, CO, CO_2 methanol was located in vacuum and bombarded by UV radiation to mimic the situation prevailing in the interstellar space. Contrary to expectations, hundreds of different complex organic molecules appearing also in meteorites were generated. Thus it seems that the molecules generated by pre-biotic evolution appear everywhere in cosmos but ironically, the environment provided by the surface of young Earth's does not seem to favor the pre-biotic evolution.

4.2.5 RNA World

One of the basic questions in theorizing about pre-biotic evolution is which came first: proteins, nucleic acids or both or possibly something else. The vision known as RNA world [I110, I139] is dominating the stage at this moment. It is assumed that RNA polymers serve all the basic functions associated with DNA, RNA and amino-acids. These functions are based on genetic and catalytic capacity of RNA. Later a genetic takeover occurred involving the emergence of DNA and genetic code in which amino-acids replaced RNA somehow.

One can represent good experimental justifications for the RNA world vision (for the summary and for references the article of Chris King [I54] is recommended warmly).

1. Ribose can be synthetized in the same circumstances as amino-acids and nucleosides. The presence of kaolinite clays and volcanic magmas stabilizes RNA polymerization. When montmorillonite, a positively charged clay believed to exist copiously in young Earth, was added to a solution of negatively charged amino-acids, a solution of RNA nucleotides gave rise to RNA 10-15 nucleotides long [I98]. These chains attached to the surface of the clay, and when more nucleotides were fed by washing them with the solution, they grew up to 55 nucleotides long. It seems that reversible dehydration in a medium containing phosphates, bases and sugars provides the routes to polynucleotide formations. Besides water, Mg_{++} plays a key role in stabilizing mono- and oligonucleotides by compensating the negative charges of the phosphates.

2. RNA can form double helices and has 3-dimensional tertiary structures analogous to that of proteins so that one might expect the ability to act as catalyst. The discovery of spontaneous splicing of RNAs in living systems is possible meant a breakthrough in this respect [I136]. Second crucial finding was that these RNAs could act as catalysts in trans-esterifications crucial for the protein synthesis [I110]. Even high fidelity complementary replication of arbitrary short RNA sequences has been demonstrated [I81]. Simple biological RNAs have shown to have autocatalytic self-assembling capacity. The catalytic activity hinges on various forms of proton transfer (perhaps the leakage of protons between space-time sheets is involved). RNA appears to be the agent of peptide-bond synthesis in the modern ribosome [I53] and modified ribozymes are able to act as amino-acyl esterases [I90]. Thus RNA seems able to serve synthetizing, transfer, messenger and ribosomal functions so that it can guide both its own replication and ordered polymerization of proteins.

3. Support for the RNA world pictures comes also from the fact that the ancient fossil nucleotide coenzymes including ATP, NAD, coenzyme A and vitamin B12 are all ribonucleotides. Eucariote organisms continue to posses massive RNA processing within the nucleus. Reverse transcriptase, whose function contradicts the Central Dogma, and encountered in retroviruses (such as HIV), might have ancient origin. Reverse transcriptase is indeed crucial for the transition from RNA→RNA precedessor of genetic code to DNA→amino-acid genetic code in TGD framework.

4.2.6 How Biochemical Pathways And DNA-Amino-Acid Code Emerged?

The traditional viewpoint is that biochemical pathways have developed from some simple basic systems. This approach encounters difficulties when one tries to understand how integrated systems such as electron transport and metabolic machinery could have worked in primitive systems. TGD based solution to the problem is the universality of metabolism and other basic functions relying on super-conductivity and its breakdown by the leakage of various supra currents between space-time sheets.

Furthermore, one can also decompose the evolution to two parts corresponding to the development of genetically controlled structures and self-organizing structures not controlled genetically [K55]. Chris King has formulated the same idea in a more concrete manner in his article [I54] from the point of view of complex systems. According to King, the basic mechanisms developed without genetic control and were finally taken under control as the genetic takeover occurred. These kind of generic structures include proteins and nuclei acids, nucleotide coenzymes, bilayered membrane structures, ion transport and membrane excitability, membrane bound electron transport, glycolysis and the citric acide cycle. In TGD framework one can add to this list topologically quantized classical fields as universal structures.

A second open question is how DNA and amino-acids took the command. Here many-sheeted space-time provides a possible answer. DNA nucleotides are stable only inside regions containing ordered or liquid crystal water forming a macroscopic quantum phase. The transformation of DNA to RNA nucleotide requires water molecule which is not available in this kind of environment. The transition from RNA-RNA precedessor of genetic code to DNA-amino-acid genetic code is also a deep problem and here the trick might be very simple: reverse RNA transcriptase used by retro-viruses (also HIV) could have transformed RNA genes to DNA genes.

The model for the evolution of genetic code as a fusion of singlet and doublet codes in turn allows to understand the emergence of amino-acids as being due to a change in tRNA structure implying that amino-acids acting as catalyzers of the attachment of RNA to tRNA molecule began to stick to tRNA, and were loosened only when tRNA was attached to RNA so that the used amino-acids began to form amino-acid sequences replacing RNA sequences as coded sequences.

4.2.7 Problems With The Polymerization In Primordial Ocean

Polymerization occurs universally by dehydration in case of polynucleotides, polypeptides, polysaccharides and lipids serving as basic building blocks of living structures. The basic difficulty is that polymers are not stable in an aqueous environment. Several cures to this problem have been proposed.

1. Various mineral interfaces could serve as templates for the formation of polymers and the evaporation of water from these structures could give rise to polymers. For instance, mud flats might have made possible polymerization.

2. Fox has proposed that the heat flow from geoactive sites like hot springs, volcanic rims and submarine vents could have caused the dehydration [I70]. Fox has indeed managed to show how to generate protenoids consisting of up to several hundred amino-acids possessing weak catalytic activities. The temperatures needed are typically above 100 C and somewhat too high. Archea as well as nanno-bacteria are indeed found in this kind of environments, and they utilize heat and sulphur compounds as a source of metabolic energy. The first objection is that the high temperature destroys the biological molecules in this kind of environment. Furthermore, the atmosphere around volcanoes contains CO_2 and water and only minor amounts of nitrogen, hydrogen sulfide and sulfur dioxide so that this kind of atmosphere does not give rise to the biomonomers in analogs of Urey-Miller experiments.

3. The un-stability of polymers against hydration is so serious a shortcoming for the primordial soup approach that it has inspired quite radical alternative proposals. For instance, Crick has concluded that pre-biotic life might have extraterrestrial origin. The panspermia hypothesis however only shifts the problem to the outer space. The evolution of life in intra-terrestrial environement is much less radical variant of this approach if one is ready to accept the notion of many-sheeted space-time.

4. Dr. Cairns-Smith has proposed that so called clay genes appeared as precedessors of genes [I47]. For instance, Al atoms in the lattice containing Si and O can have three states at each site so that enormous information storage capacities become available. These structures would have acted as scaffolding for present day bio-molecules of RNA and DNA. This idea might create more problems than it solves. One could however turn the idea around and ask whether primitive life-forms such as nanno-bacteria could express their genetic code with the help of kaolinite clays.

To my personal opinion, an invention of a clever mechanism is probably not enough to solve the basic problem. Polymerization in modern cells is basically a process involving metabolic control, and it seems that the metabolic control must have been present from the beginning in some primitive form. TGD predicts that magnetosphere can perform quantum control in astrophysical length scales from the magnetic flux tubes of the Earth's magnetic field B_E or, rather, from the flux quanta of dark magnetic field accompanying it and having strength $B_E = 2B_E/5$. A further prediction is that metabolism is completely universal and existed in primitive form already during the primordial period. This in turn makes possible the option that the pre-biotic life need not have developed through stages differing dramatically from the recent life forms. One could even assume that a generalization of ontogeny recapitulates phylogeny principle holds true for the intracellular dynamics so that it would give precise information about pre-biotic evolution.

One must also clarify what one really means when one speaks of aqueous environment. Water allows an extremely rich variety of structures. Liquid crystal water/ordered water encountered inside cells might automatically stabilize polymers, and provide also a solution to how DNA and polymers were stabilized. Sol-gel transition giving rise to macroscopic quantum coherence would generate this liquid crystal phase.

4.2.8 The Notion Of Protocell

The emergence of membrane bounded structures has certainly been decisive for the evolution of life. Cell membrane made possible differentiation forced by the competition for metabolic resources. Cell membrane imports metabolics, exports waste products, and acts as a signalling system. In TGD universe the receptors at cell membrane also serve as cellular sensory receptors.

A variety of answers to the question about the precedessor of the cell has been proposed. The natural constraint is that the membrane in question results via self-organization. If one requires consistency with the generalization of ontogeny recapitulates phylogeny principle (ORP), the number of options is reduced dramatically.

1. Lipid bi-layers are certainly a natural guess since they formed spontaneously in solutions on biological conditions. There is thus a consistency with the generalized ontogeny recapitulates phylogeny principle requiring that all primordial structures appear also in modern cells.

2. An elegant an plausible candidate for protocell is the gel phase resulting in sol-gel transition inside cell [I100, I54] . Gel phase has indeed many properties of cell membrane bound region and is routinely generated also inside modern cells. A compact ordered liquid crystal type phase is in question. Negatively charged proteins are generated inside the gel phase and gel phase rejects Na_+ ions and attracts K_+ ions just as cell interior. Also negatively charged proteins are stable inside gel phase. In TGD framework gel phase is a macroscopic quantum phase so that new physics is necessary involved. In particular, the evolution by quantum jumps is expected to lead to this kind of self-organized structures automatically. In TGD framework one expects that the liquid crystal/ordered water phase leads to the stabilization of RNA and that even DNA nucleotides become stable.

3. The proposal of Sidney Fox [I70] is that protocells could correspond to the called micro-spheres formed from protenoids in geolocically active sites like hots springs and volcanic rims. He also demonstrated that this really occurs. Protedoids are amino-acid sequences differing from ordinary peptides in that peptide bonds are different: hence this option is not consistent with the generalization of ORP. When proteneids are washed into a warm water allowed to cool, micro-spheres are formed. Micro-spheres are bilayered structures able to divide. A concentration roughly 10 million times higher than believed to appear in primordial soup is required so that either the idea of protenoid or of primordial soup is wrong. Further objections are that micro-spheres do not perform any functions of cell, and that the structure is like an inpermeable cell wall or spore coat rather than a cell membrane [I56, I105].

The common problem of all these options is that the required concentrations of biomonomers are much higher than those expected in the primordial soup. This forces to question the notion of primordial soup and even the assumption about the occurrence of the pre-biotic evolution at the surface of Earth.

4.3 TGD Based Scenario About Pre-Biotic Evolution

TGD framework leads to a radical view about life. Magnetosphere can be seen as a living system controlling the evolution of life and chicken-egg question can be seen in a totally new perspective. Super-conducting magnetosphere can be seen as a higher level life-form which controls and guides the biological evolution from the very beginning. Second key element is dark matter hierarchy.

4.3.1 Basic Prerequisites

A short summary of basic requirements and problems is in order.

1. A stable star and planet providing appropriate conditions such as temperature for liquid water is needed.

2. Atoms like C, N, and O and smaller amounts of P and S giving rise to bio-monomers, and metals like Al, Fe, and Zn are the basic building blocks. The formation of various chemical bonds like hydrogen bonds, covalent bonds, and peptide bonds is necessary.

3. The formation of biological monomers (amino acids, nucleotides, fatty acids, sugars) is an essential element of life. Except for DNA nucleotides, basic monomers evolve in the circumstances simulating to what have been believed to be the primordial atmosphere. These bio-monomers are found even in the interstellar space and in galactic clouds so that the question is not whether the pre-biotic life can develop but whether our recent day materialistic science allows to understand how it develops. The standard wisdom about primordial atmosphere as a reducing environment (containing no oxygen) indeed leads to grave difficulties. Also the concentrations in the primordial ocean seem to be quite too low for the bio-monomers to be synthesized [I105].

4. The formation of the biological polymers such as proteins, nucleic acids, lipids, and carbohydrates occurs universally by dehydration. The problem is that in water environment polymers are un-stable against decay by hydration: it would seem that a metabolic energy feed is required already at this stage to guarantee non-equilibrium situation. The assembly of these macro-molecules into organized aggregates like chromosomes, micro-tubules and cell organelles suggests the emergence of symbolic representations and only a weak independence of hard facts of chemistry which makes the problem even more difficult from the point of view of standard physics.

5. The emergence of catalysts and metabolism, should be understood. Here one encounters an egg-hen problem. Standardized metabolic currency seems to be necessary for effective catalysis but metabolism according to the standard view involves extremely complex web of reaction pathways needing refined catalytic actions.

6. Membrane bound structures are essential for life and one should understand how they emerge and even predict correctly basic facts about them.

7. The emergence of the genetic code has remained a mystery in various scenarios of pre-biotic evolution.

8. How the incredible ability of the components of bio-systems to co-operate pops up from primordial soup is not always included to the list of mysteries since everything smelling "holism" is regarded as pseudo science in reductionistic circles.

4.3.2 TGD Based Vision About Pre-Biotic Evolution

The prevailing mechanistic world view forces to conclude that life emerged accidentally in young Earth during a relatively short time period of about.3 billion years. On basis of extensive computer simulations, one can fairly say that a spontaneous generation of life in primordial ocean seems extremely implausible [I56] .

TGD replaces materialistic view with a continual re-creation in which classical universe in 4-dimensional sense is replaced by a new one in each quantum jump. p-Adic length scale hypothesis allows to formulate the notion of evolution precisely as a generation of increasingly larger space-time sheets characterized by preferred p-adic primes meaning also a sequence of symmetry breakings. A second aspect is the emergence of new levels in dark matter hierarchy meaning great leaps in evolution. A crucially new element is the predicted fractal hierarchy of copies of electro-weak and color physics. Dark weak bosons and gluons thus become an essential part of the physics of living matter.

Macroscopic and even astrophysical quantum coherence becomes a key feature of living matter. Theory is partially non-deterministic also in classical sense but the variational principle for Kähler action implying that space-time surfaces are analogous to Bohr orbits and self-organization lead to Darwinian selection of selected patterns.

Is life really a result of accident?

Life is often regarded as an extremely improbable accident. The estimates for the probability of the formation of amino-acids, DNA, and of emergence of genetic code from random soup of molecules are indeed found to be extremely small. In TGD Universe the situation is different.

1. Intentional action is basic aspect of TGD Universe. Negentropy Maximization Principle [K60] states that the dynamics of quantum jumps maximizes the information content of the conscious experience and implies evolution as a continual recreation of the Universe eventually leading unavoidably to the emergence of information rich systems and explaining also why the values of "fundamental constants" seem to be tailored for the emergence of life as we are used to identify it. p-Adic dynamics for cognitive space-time sheets implies local randomness but long range fractal correlations for the real dynamics.

2. The hierarchy of Planck constants implies macroscopic and macro-temporal quantum coherence in all length scales. Universe becomes single conscious organism in this framework. This

has many implications. For instance, low frequency photon can have arbitrarily high energy. This makes it possible control of short length and time scales by the dynamics in long scales, say by EEG. The enormous values of gravitational Planck constant for dark matter and the assumption that visible matter condenses around dark matter imply that planetary orbits correspond to Bohr orbits [K86, K68]. Only very few orbital radii are possible and for a star with mass around solar mass planets at distance of Earth are possible and probable irrespective of the mass of the planet. Hence solar systems are standardized to high degree. Also the quantization of masses of stars is highly suggestive and the number of stars with mass not far from solar mass is large. Obviously this raises the probability for having Earth like environments dramatically.

3. TGD based nuclear physics [L2] , [L2] explains cold fusion [C4] , [D15] as well as biological nuclear transmutations for which there is considerable empirical support [C2] . The direct empirical evidence comes from the observation that the abundances of heavier elements in an astrophysical object at distance of order 10 billion light years are essentially the same as in solar system [E15]. If elements are created only in the stellar interiors, the abundances should be much smaller. This suggests that the heavier elements result by cold fusion in the interstellar space. The implication is that environments allowing life have existed much earlier than believed hitherto.

4. The hierarchy of Planck constants and the notion of magnetic body allow a mechanism of topological quantum computation [K2] based on the representation of braids represented as flux tubes of wormhole magnetic field whose presence might provide a definition for what it is to be living. The first implication is an explanation for the miraculous ability of biomolecules to find each other in terms of the reduction of Planck constant inducing a shortening of the flux tubes connecting reactants and catalysts. The structure of flux tube patterns connecting various molecules allows to program complex series of biochemical reactions to the structure of braids connecting the molecules since given spots of molecules can be forced to meet each other in reaction. Conserved braid color allowing to identify whether the braid strand comes from A, T, C or G implies even stronger selection rules. One can assign also to amino-acid a 3-braid corresponding to one of the DNA codons coding for it. These extremely selective interactions between living bio-molecules give good hopes of understanding why DNA and amino-acids were selected as molecules able to co-operate.

5. Many-sheeted space-time concept implies the existence of fundamental metabolic energy currencies [K11] defined by the differences of zero point kinetic energies of particles for space-time sheets labeled by different value of p-adic prime p. The existence of standardized metabolic currencies simplifies the situation dramatically and living matter must face only the problem of storing metabolic energy. Plasmoid like life forms suggest themselves as precedessors of biological life. p-Adic length scale hypothesis $p \simeq 2^k$ is what implies standardization of zero point kinetic energies and follows from zero energy ontology which also assigns to a particle labeled by prime p a time scale $T_p = \sqrt{p}L_p/c = L_p(2)/c$ characterizing the temporal size of the space-time sheet having particle and its negative energy counterpart at its time-like boundaries. The fact that the fundamental 10 Hz biorhythm corresponds to the time scale assignable to electron suggests that fundamental biological time scales are hidden in the space-time structure of fundamental particles.

The notions of magnetic body and plasmoid

The model of high T_c super-conductivity and the general vision about dark matter hierarchy have led to a rather precise model for magnetic body as an intentional agent utilizing biological body or its part as motor instrument and sensory receptor [K36]. Dark matter plasmoids and plasma oscillation patterns as representations of control commands are one important aspect of the model. The prediction is that plasmoids should have been precedessors of ordinary life forms. There is laboratory evidence that plasmoids behave like life forms [I115]. Very high temperatures catastrophic for ordinary life forms could prevail at magnetic flux quanta associated with plasmoids. This forces a radical reconsideration of the question how pre-biotic life have evolved and forces to ask whether even the hot interior of Earth could have served or still serve as a seat of life.

Does the Earth's magnetic field have a dark counterpart?

The notion of dark matter as a hierarchy of phases characterized by arbitrarily large values of Planck constant has established itself as a part of TGD [K38, K36]. This raises several questions. For instance: does the magnetic body of Earth have a dark counterpart and its the dark magnetic body relevant for functioning of living matter?

A partial answer to this question came from a frustrating realization that I had for years erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking Ca^{++} cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for Ca^{++} is .2 Gauss and thus slightly smaller than the minimum value.3 Gauss of B_E. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of B_E at distance 1.4R, R the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [K36] . In principle all integer and even rational values of Planck constant are allowed. Number theoretical arguments suggest a general formula for the favored values of $r \equiv \hbar/\hbar_0$ [K38] as $r = n_1^{\pm 1} n_2^{\pm 1}$, where n_i characterizes the quantum phase $q = exp(i\pi/n_i)$ characterizing Jones inclusion [K99] . The values of n_i for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n_i = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also r-multiples of p-adic length scales are possible as preferred length scales.

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

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K36]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

In the case of magnetic flux simplest quantization suggests the scaling $B \to B/r$ for the magnetic fields. This is assumed to hold true also in more general case when the quantization condition reads as $\oint (p - ZeA)dl = n\hbar$ and involves currents flowing at the boundaries of flux quanta so that magnetic flux need not be anymore quantized to a multiple of Planck constant. For axonal membranes the flux quantization with $n = 0$ is natural since the size of flux quantum does not depend on the value of Planck constant. Assuming flux quantization and standard value of Planck constant $B_{end} = .2$ Gauss would give flux tube radius $L = \sqrt{5/2} \times L(169) \simeq 1.58L(169)$, which does not correspond to any p-adic length scale as such.

Concerning the interpretation of B_{end} there are two options. It could correspond to a personal magnetic body or to a dark variant of the Earth's magnetic field. At this moment it is impossible to say which if any hypothesis is right. However the fact that the ELF fields have no direct effect on conscious experience mildly supports the identification as the dark variant of B_E.

Emergence of symbols at molecular level and new view about hydrogen bond, water, and bio-catalysts

The hierarchy of dark matter leads to novel ideas about what distinguishes living matter from ordinary matter. The emergence of symbols and symbolic dynamics and what might be called "molecular sex" could be a fundamental step in the process and I have considered two visions for how this would take place.

1. First vision

First vision is relies on the model of DNA as TQC based on braids and has quite close contact with empirical reality [K11, K2]. In this case DNA nucleotides are analogous to colors of braid strands and base pairing corresponds to molecular sex for DNA molecules. The color of braid strand implies long ranged highly selective interactions between DNA and distant molecules, such as lipids of the lipid layer of cell membrane or amino-acids. Free amino-acids inherit the colors of the first two nucleotides in the codon XYZ whereas the color of the third nucleotide corresponds to a quantum superposition of colors for codons coding for the amino-acid this defines the quantum counterpart of wobble base pairing. Amino-acids can be divided into amino-acids and their conjugates analogous to opposite sexes and generalized base pairing determines the interactions of the amino-acids to a high degree. Hydrogen bond can be identified as a special case of flux tube. There are also flux tubes connecting acceptors of hydrogen bonds acting as plugs in the connection lines formed by the magnetic flux tubes and Y corresponds to this kind of plug at the level of amino-acids.

2. Second vision

The mathematical realization for the hierarchy of Planck constants leads to a generalization of the notion of embedding space and this leads to four kinds of phases resulting as combinations of phases with increased or reduced unit of spin and quantum numbers associated with CP_2 degrees of freedom. Each phase corresponds to its own Planck constant and is characterized by a discrete symmetry group.

Especially interesting are phases with large value of Planck constant involving charge fractionization and increase of spin unit. The electrons of free electron pairs of aromatic cycle are reasonable candidates for dark electrons of this kind. One can consider variants of hydrogen atom containing $n \leq N$ fractionally charged electrons with with lepton number and electronic charge equal to n/N. The values n/N and $(N-n)/N$ for the fractional charge would correspond "name" and "conjugate name" since their combination would give a maximal charge and a state analogous to a full electron shell. Thermal stability poses strong constraints since atomic and molecular energy scales are reduced as Planck constant increases.

The notion of fractional electron inspires the notion of "half" hydrogen bond for which electron has a fractionized fermion number. The full hydrogen bond would be formed in the fusion of half hydrogen bonds and give rise to a structure analogous to a full electron shell expected to be especially stable. Catalyst sites might correspond to half hydrogen bonds and the basic recognition mechanism could be the fusion of half bond and its conjugate to form a full hydrogen bond. One could speak about "molecular sex". The sequences of half bonds would represent words so that molecules would have names. Also interpretation as quantum computer codes might make sense. The problem of this vision is the lack of direct contact with experimental facts and for this reason it will not be discussed in the sequel.

Universal metabolic currencies

In TGD framework a primitive many-sheeted metabolism is present from the beginning and becomes only refined during evolution. Most importantly, metabolic currencies identified as zero point kinetic energies liberated as particles drop to larger space-time sheets are constants of nature by the p-adic length scale hypothesis.

Phosphate-sugar polymers form the backbone of nucleic acids and metabolism is based on ADP and ATP formed from adenine and phosphate ions. It has been already earlier found that the generation of ATP and its metabolic utilization involve the flow of protons between the atomic space-time sheets and some larger space-time sheets, say magnetic flux tube of Earth [K51]). It will

be found that this mechanism is involved also with the dehydration leading to polymerization and phosphorylation. The reversal of this process also implies the in-stability of DNA in an ordinary aqueous environment.

The interpretation of the role of phosphate ions as metabolic energy batteries seems to be wrong in TGD framework: the main function of negatively charge phosphates would be to make biopolymers critical against local modifications making them thus ideal for catalytic manipulations. Even deeper function would be the role as standard plugs to which magnetic flux tube can attach and which second flux tube can begin. $ATP \rightarrow$ADP would in this framework mean reconnection process for a magnetic flux tubes modifying the hardware of TQC.

Time mirror mechanism, intentional action, memory, and remote metabolism

Time mirror mechanism having negative energy MEs as space-time correlate has phase conjugate laser waves as standard physics counterparts. Essentially negative energy signals propagating to the geometric past and reflecting back is in question. Intentional action realized in terms of negative energy signals to the geometric past and appearing already at the level of molecular magnetic bodies, is expected to become an increasingly important when the complexity of the structures increases. The charge entanglement by negative energy W MEs is especially interesting control mechanism and makes also possible sharing of mental images. Time mirror mechanism allows also remote metabolism by inducing the dropping of population inverted system to the ground state liberating in this manner positive energy photons received by the sender of negative energy signal. What makes this mechanism so elegant is its enormous flexibility (credit card is the counterpart in economy). Time mirror mechanism provides also a mechanism of memory as communications with the geometric past.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

Emergence of membrane bounded structures

Self-organization in many-sheeted space-time is expected to automatically lead to the generation of the ordered water phases which would have evolved to the gel phase defining in turn a natural precedessor of the membrane bounded structures. Self-organization would have also led to the emergence of membrane structures containing liquid crystal water stabilizing also DNA nucleotides.

In fact, the TGD inspired model for high T_c super-conductivity as quantum critical super-conductivity involving simultaneously two kinds of super-conductivities in a narrow range of temperatures around critical temperature (presumably $T \simeq 37$ °C) predicts correctly the double-layered structure of cell membrane and the length scales involved [K18, K19]. A fractal hierarchy of super-conductivities and cell membrane like structures is predicted corresponding to the dark matter hierarchy and p-adic length scale hierarchy [K36]. Josephson junctions and corresponding Josephson currents are in a crucial role in the model for the hierarchy of generalized EEGs responsible for the communication to and control by magnetic body.

According to unexpected findings about behavior of the cell membrane [I100] discussed from TGD viewpoint in [K78], the usual picture based on pumps and channels for ions is not correct. Rather, cell interior is in gel phase in which water is in structured phase around charged biopolymers intermediate between ice and water. One implication of this is stabilization of RNA and DNA polymers since hydrolysis is impossible due to the lack of free water molecules. Cell membrane would have guaranteed the long term stability of gel phase.

Second function of the membrane like structure consisting of lipids or perhaps even DNA or RNA molecules could relate to the topological quantum computation and memory in the manner discussed in [K2]. The phase transitions changing the length of the wormhole magnetic flux tubes defining the braid strands and making possible TQC would also make possible biocatalysis via reconnection of flux tubes and via $\hbar$ changing phase transitions changing the length of flux tube.

In this framework water and lipids molecules playing the role of lipids could have been present in very early stage since they emerge as a result of self-organization process and are not genetically determined.

Did life evolve in Mother Gaia's womb?

The proposed framework poses strong conditions on pre-biotic environment and one ends up to interpretations for the notion of Mother Gaia's womb, which are by no means mutually exclusive.

1. Mother Gaia's womb as underground seas?

Braiding in the proposed sense requires the presence negatively charged polymers and membranes consisting of lipids or their analogs. Water seems to be necessary but also gel phase is needed since free water induces de-polymerization. The coherent structure of gel would be due to the braiding of distant molecules. The phase transitions of gel phase are good candidates for a basic mechanism of bio-control and would stabilize these polymers via the formation of structured water around them preventing hydrolysis. The developing life forms should be shielded from UV radiation and meteor bombardment.

The combination of these constraints leads to the idea that life as we define it could have evolved in the womb of Mother Gaia in underground seas with the Earth's crust shielding from UV and meteors. The necessary ingredients of biomolecules, in particular phosphates making possible phosphorylation making DNA and RNA charged and appearing also in hydrophilic ends of phospholipids, would have dissolved to the water from the ground. Cambrian revolution would have meant the burst of these highly developed life-forms to the Earth surface and resulting as a phase transition increasing the value of Planck constant for Earth's space-time sheet by a factor of two would have occurred. This would also provide a justification of Expanding Earth theory explaining the strange finding that the continents fits nicely together to form a single super continent covering entire Earth's surface if the radius of Earth is one half of its recent value and actually the same as the recent radius of Mars, which is now known to contain reservoirs of underground water.

2. Mother Gaia's womb as mantle-core boundary?

What about the period before the life in underground seas?

1. The plasma like aspects of cytoplasm suggests that some kind of plasma phase must have been present. Also the postulated Bose-Einstein condensates of bosonic ions at dark magnetic flux quanta represent kind of quantum plasma.

2. Plasmoids involving magnetic flux tubes and charged particles could have been precedessors of more complex molecular life forms and could have developed in the interstellar space. Their metabolism could have been based on universal metabolic energy quanta. Simple metabolic cycles and short term chemical storage of energy based on fusion and decay of simple molecules induced by say UV radiation from the nearby stars might have developed during this era. Quite high temperatures can be considered so that after the interstellar period this kind of life forms could have survived and developed in the hot interior of planets receiving their metabolic energy from radiation by high temperature plasma. A possible candidate for the womb of Mother Gaia is the mantle-core boundary, where intensive self-organization processes are expected to take place.

3. Ultimately the charged molecules must have come in contact with ordinary water in underground seas. One can imagine that the polymerization of the charged molecules and the formation of structured water around them stabilizing them and giving rise to a gel phase took place simultaneously in presence of metabolic energy feed.

The primordial womb containing plasmoid like life forms could have been located somewhere below the boundary at which $k = 137$ atomic space-time sheets transform to very hot $k = 131$ space-time sheets: this should occur when the thermal de Broglie wave length becomes equal to the p-adic length scale $L(131)$. The transition occurs above the crust-mantle boundary (1300 K). Mantle-core boundary (4000 K) is a good candidate for a seat of high-T life forms.

The dropping of O, C, N ions from the hot $k = 131$ space-time sheets to larger space-time sheets generates light at visible frequencies replacing solar light so that even intra-terrestrial

counterpart of photosynthesis could develop. The dropping of oxygen atoms could make also possible development of oxygen based metabolism.

Magnetic flux quantum structure of the magnetosphere acting as a nervous system and a metabolic circuitry of the magnetic Mother Gaia could make possible controlled metabolism already during the pre-biotic period and allow to circumvent these difficulties.

Model for the genetic code

The emergence of genetic code is one of the basic mysteries of models for pre-biotic life. The exact A-G symmetry and slightly broken T-C symmetry of the genetic code strongly suggest that the evolution of the triplet code occurred as a fusion of singlet and doublet codes. One ends up with a detailed model for how this happened by studying the structure of tRNA molecule carrying in its fossilized parts detailed information about the evolution of the code.

Nanno-bacteria [I127, I82] might correspond to some precedessor of the recent genetic code. Nanno-bacteria accompany mineral structures and actively manipulate them: this conforms with the view that mineral interfaces have been indeed important for the evolution of polymers.

Introns are the basic mystery of DNA. TGD predicts that language is a universal phenomenon appearing at level of eukaryotes. Memes represented as sequences of 21 DNA triplets and expressing themselves as field patterns associated with MEs would realized this universal language.

What makes possible the coherence of bio-chemical activities?

In TGD Universe the control of genome by magnetic body relies on magnetic flux sheets traversing through DNA strands [K55, K36]. The model implies a generalization of the notion of gene. Super-genes correspond to sequences of genes inside single organism belonging to single magnetic flux sheet and organize like text lines at a page of a book. The expression of super-genes as an intentional action of magnetic body occurs therefore coherently at the level of entire organs. This explains to the miraculous coherence of bio-chemical activities at the level of single organism. Also hyper-genes involving genomes of several organisms, not necessary belonging to even same species, become possible. Collective gene expression at this level makes possible the development of co-operation and social structures and are predicted to be present already at the bacterial level.

Braiding defined by magnetic flux tubes of their wormhole counterparts carrying dark variants of charged particles seem to represent especially important part of the magnetic body and this leads to models of topological quantum computation and bio-catalysis.

4.3.3 Pre-Biotic Chemistry And New Physics

The emergence of symbolic representations at dark matter level is certainly the most fascinating possibility suggested by dark matter hierarchy.

Overall view

The most important implications can be deduced readily.

1. The dropping of ions and atoms between space-time sheets involves a liberation of zero point kinetic energy. By p-adic length scale hypothesis these energies define a fractal hierarchy of universal metabolic currencies which have not changed at all during evolution and are the same in the entire universe. The presence of the metabolic machinery from the beginning helps enormously in the attempts to understand how life has evolved.

2. Chiral selection resulting in bio-polymers having a definite handedness is a deep mystery in standard physics framework. TGD predicts entire hierarchy of standard model physics meaning scaled up variants of electro-weak and color physics and dark variants of these. The hierarchy of dark weak gauge bosons predicted by TGD imply strong parity breaking effects in arbitrarily long length scales above atomic length scales, and the presence of the chiral selection supports the view that also dark weak bosons play key role in bio-control. Indeed, charge entanglement generated by W MEs would be in central position in TGD based model for how magnetic bodies control biological bodies.

3. The emergence of life means emergence of symbolic representations (including names), and also what might be called "molecular sex". Formation of wormhole magnetic flux tubes between biomolecules having quark pair and its conjugate is an attractive candidate for this process and means coding of DNA nucleotides to quarks and antiquarks appearing as dark matter at the flux tubes. This leads to a new view about bio-catalysis based on the temporary dropping of the liberated proton to a larger space-time sheets and ensuing liberation of metabolic energy quantum kicking the complex formed by reactants over the potential wall separating it from the final state. A new view about water and its role in bio-catalysis emerges. Stability considerations allow a general model for how first bio-polymers able to replicate emerged.

Dark matter and the emergence of symbolic representations at molecular level

The most important new physics element of pre-biotic chemistry has been already discussed and corresponds to the presence of dark matter hierarchy suggesting new views about hydrogen bond, water, and catalytic action. A highly attractive hypothesis is that symbolic representations at molecular level in the sense that quarks and antiquarks code for DNA nucleotides [K2] and also for amino-acids [K6].

Evolution of pre-biotic chemistry as a sequence of bifurcations

In his article "Biocosmology" [I54] Chris King discusses biochemistry from the point of view of mathematician using the notions of symmetry breaking and bifurcation. This discussion allows for a physicists to get a wider perspective to the complexities of biochemistry. In the following I modify the arguments of King to TGD framework. The first basic new element is that generation of new space-time sheets corresponds to a sequence of symmetry breakings.

Besides hydrogen C, N, and O atoms with charges 6, 7, and 8 are the most important elements appearing in basic bio-monomers. The bonds with hydrogen are formed between 1s and $2p^3$ orbitals. The covalent bonds between C, N, and O atoms are the bonds appearing in various bio-monomers like ribose. Also peptide bonds between C and N in amino-acid sequence are covalent bonds. In standard chemistry one can characterize the atom in given molecule by its electronegativity telling how effectively it attracts electrons.

Electronegativity increases in the sequence C, N, O so that the bonds are more and more polar. Also Si, P, and S in the next row of the periodic table form covalent bonds but the bond energy tends to be lower which reflects itself as lower boiling points. For instance, the boiling point of H_2S is below the freezing point of water). Consider now the bifurcations.

1. Polar-non-polar bifurcation is fundamental in biology. Non-polar molecules are hydrophobic and are not water-soluble whereas polar molecules are hydrophilic and water-soluble. For instance, the formation of biological membranes is based on hydrophobic character of the second ends of lipids. A rough characterization of amino-acids is by polar-non-polar dichotomy. Also DNA base stacking is based on polarity.

2. Second bifurcation corresponds to acid-base dichotomy. Acids are able to act as donors of positive and bases donors of negative charge. For instance, this allows to classify polar amino-acids to acidic and basic ones. A working hypothesis worth of studying is that many-sheeted physics is involved in the sense that the protons in acid and electrons in base have dropped to some larger space-time sheet from the atomic space-time sheet.

3. The third bifurcation corresponds to that between second and third row of the periodic table that is Na^+-K^+ and Mg^{++}-Ca^{++} bifurcations. The covalent bonds involving K and Ca are in general weaker. Na^+ concentration is higher outside cell whereas K^+ concentration is higher inside cell. Same applies to gel phase, a possible precedessor of cell membrane bound regions. Mg^{++} acts as stabilizer of polymers and Ca^{++} ions are key players in cellular and intracellular control. In particular, Ca^{++} waves appear in extremely wide range of frequencies and conduction velocities.

4. The fourth bifurcation corresponds to the d-orbital elements forming a catalytic group. Almost all transition elements Mn, Fe, Co, Cu, Zn are essential biological trace elements,

promote pre-biotic synthesis and are optimal in their catalytic ligand-forming capacity and valency transitions. For instance, Zn^{2+} catalyzes RNA polymerization in pre-biotic synthesis and occurs in both polymerases and DNA binding proteins.

5. The fifth bifurcation corresponds to chiral symmetry breaking not easy to understand in standard model predicting extremely small parity breaking. There is empirical evidence such as circular polarization of light from the region of star formation in the constellation of Orion suggests that parity breaking occurs also in interstellar space. Also the amino-acids in Murchison meteorite were found to be dominantly left handed.

In TGD Universe the interpretation of bifurcations is not quite the same as in the world obeying standard chemistry.

1. The polar-non-polar bifurcation corresponds to hydrophilic-hydrophobic dichotomy. The model for protein folding and bio-catalysis relies on the hypothesis that wormhole flux tubes connect conjugate amino-acids. This process is analogous to base pairing. Stating it roughly, amino-acid and its conjugate correspond hydrophilic and hydrophobic amino-acid. This bifurcation is thus important from the point of view of molecular symbolism and bio-catalysis if is based on the coding of DNA are nucleotides and amino-acids by quarks and antiquarks at the ends of wormhole magnetic flux tubes connecting them to other molecules. The emergence of wormhole magnetic flux tubes could be seen almost as a definition of emergence of life. This might have happened already during prebiotic molecular evolution if water molecules have been present from the beginning.

2. Acid-non-acid bifurcation brings in protons and there is obviously a connection with the role of protons in the basic mechanisms of metabolism and catalysis. What is also essential is the role of negative charge of bio-polymers making bio-polymers critical against local deformations so that a wide repertoire of catalytic actions using $\hbar$ changing phase transitions of wormhole magnetic flux tubes and their reconnections becomes possible. Phosphate ions would not serve as batteries of metabolic energy but make bio-polymers sensitive to catalytic actions.

3. Fifth bifurcation is difficult to understand in standard physics framework but is consistent with the presence long ranged weak fields predicted by TGD and possibly associated with dark matter. This bifurcation is not the last one in TGD Universe since already plasmoids identified as rotating magnetic systems break parity because the sign of the charge density generated by the induced radial ohmic current depends on the orientation of rotation and only the second orientation is favored energetically. W MEs induce charge entanglement giving rise to plasma oscillation patterns in turn inducing various physiological waves. This mechanism can be used as a control tool by magnetic bodies at various levels of hierarchy. Long range weak forces due to the exotic ionization of atomic nuclei could provide a tool for controlling conformations of nucleic acid polymers. Same applies to kaolinite clays consisting of Al, Si, O suggested to be of biological importance (Al can have three different states at a given lattice site): in this case the state of Al atoms in the lattice might be manipulated using weak forces.

4. The hierarchy of bifurcations defines also a hierarchy of decreasing cyclotron frequencies. The cyclotron frequencies would be associated with both with Bose-Einstein condensates of ordinary and exotic bosonic ions at magnetic flux sheets. For the bosonic ions cyclotron frequencies in the $B_{end} = 2B_E/5$ are in alpha band and in TGD Universe they play a fundamental role in communications to and control by magnetic body using hierarchy of generalized EEGs. Ca^{++} and other waves associated with bosonic ions are of special importance in the bio-control by magnetic body using plasmoids and plasma oscillation patterns.

What selected the bio-molecules?

The extremely low probabilities for the selection of bio-molecules from a super-astrophysical number of alternatives represents one of the bottleneck problems of biology relying on the prevailing view about biochemistry. The notion of braid could resolve this problem.

Suppose that the presence of braids distinguishes between living and dead matter, that the four nucleotides are mapped to colored braid strands (that is to 2 quarks + 2 anti-quarks), and that a given amino-acid is mapped in a non-deterministic manner to one of the 3-braids associated with the DNA triplets coding for it. Braids could be associated besides DNA, amino-acids, and lipids also to other bio-molecules and define more general analogs of genetic codes as correspondences between bio-molecules able to react.

The implication would be that the step of catalytic reactions bringing together the catalyst and reactants would occur by a temporary reduction of Planck constant only for subsets of bio-molecules connected by braid strands and the pattern of braid strands involved would define the geometro-dynamical pattern of the reaction. The outcome would be a selection of very restricted subsets of bio-molecules able to form reaction networks and of reaction pathways. This would imply Darwinian selection of subsets of bio-molecules able to co-exist and dramatically enhance the probability for the emergence of life as we know it.

One challenge is to predict what kind of braids can begin from a given bio-molecule, say nucleotide or amino-acid. The physicist's guess would be that the (electromagnetic only?) interaction energy between bio-molecule and given pattern of wormhole contacts having quark and anti-quark at its throats should select the preferred braids as minima of the interaction energy. How closely the presence of hydrogen bond relates to this is also an interesting question.

Polymerization, dehydration, phosphorylation, and new physics

The generation of phosphate polymers and polymers in general occurs by dehydration which quite generally seems to involve dropping of a proton to larger space-time sheet and liberation of metabolic energy quantum. It is interesting to find how one could understand these processes in TGD framework. Since the notion of wormhole magnetic flux tube playing a central role in the model of DNA as topological quantum computer and in the model of bio-catalysis, it is natural to look whether the basic steps of these processes could be understood in this conceptual framework.

1. $ATP \to ADP$ process

AMP, ADP, ATP are phosphorylated RNA nucleosides [I2] and the hydrolysis of ATP to ADP [I4] plays a key role in the metabolism. Obviously also the molecules XMP, X=U, C, G are important biologically. Each PO_3 in ATP corresponds to one unit of negative charge except for the last one which carries two units of negative charge. According to the standard chemistry $ATP \leftrightarrow ADP$ corresponds to the hydrolysis

$$ATP^{4-} + H_2O \leftrightarrow ADP^{2-} + P_i$$

where P_i denotes orthophosphate HPO_4^{-2}. In ADP the last phosphate group is $HO-PO_2^{-2}$ rather than $O = PO_2^{-2}$ as in the case of ATP.

The actual process is however much more complex than this.

1. The process involves several steps such that energy is liberated in two steps in which the change of Gibbs free energy is $\Delta G = .42$ eV and $\Delta G = .31$ eV making altogether.73 eV, which should closely relate to the liberated metabolic energy.

2. Three protons are accelerated in electric field during the generation of ATP. The interpretation would be in terms of driving of electrons from larger space-time sheet to $k = 137$ atomic space-time sheet. If the larger space-time sheet corresponds to $k = 139$, the increment of the zero point kinetic energy of proton is $(1 - 1/4) \times \times E_0(137) = .375$ eV for $E_0(137) = .5$ eV of metabolic energy quantum. Three protons would give net zero point kinetic energy increment of 1.125 eV which is higher than $\Delta G_{tot} = .73$ eV. The explanation of the discrepancy should relate to Coulomb binding energy of protons with ATP and F_1. This interpretation conforms with the observation that the liberated energy is higher for the third proton.

Consider now a more detailed model for the process. The binding of ATP to the catalytic site involves several steps.

Step 1: The binding $ATP + F_1 \to \mathrm{ATP}\cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and

catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves liberation of Gibbs free energy about $\Delta G_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [I121].

Step 2 Hydrolysis: F_1·ATP$\rightarrow$ F_1·ADP·P_i. The change of free energy is small during this step: $\Delta G \sim 0$.

Step 3: Ortophosphate is released from the catalyst site: F_1·ADP·$P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Step 4: ADP is released from the catalyst site: F_1·ADP+$P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

This picture suggests that the notion of the high energy phosphate bond is not quite correct as suggested also by some empirical findings [D16, D10], [I103]. The metabolic energy could be stored as the zero point kinetic energy of protons rather than in phosphate bonds. Perhaps one fundamental function of phosphates would be to make DNA and RNA polymers charged in turn making possible the formation of wormhole magnetic flux tubes and braiding making possible a wide repertoire of catalytic actions. Phosphorylation of say protein could mean a reconnection process for magnetic flux tubes with flux tubes attached to O= atom transferred from ATP to the target to which phosphate is attached.

2. Model of $ATP \rightarrow ADP$ based on wormhole magnetic flux tubes

Consider first the basic philosophy behind model.

1. In the model of DNA as topological quantum computer XMPs, $X = A, T, C, G$ can be connected to oxygen atoms by wormhole magnetic flux tubes having quark and antiquark at opposite throats of wormhole contact and charge conjugated quark-anti-quark pairs at the ends of the flux tubes. Dark u quark and its charge conjugate code for A, T and d quark and its conjugate for G, C so that the conjugation for nucleotides corresponds to charge conjugation for quarks and $A - G$ and $T - C$ symmetries of the third nucleotide of the codon to isospin symmetry.

2. Basic bio-catalytic processes are identified as a reconnection of the wormhole magnetic flux tubes and change of the length of the flux tube induced by the change of the value of Planck constant associated with it. It would not be too surprising if this kind of mechanism were involved also in $ATP \rightarrow$ADP+P_i. The reason for the special role of ATP among XTP might be that the positive charge $q(u) = 2/3$ of u-quark maximizes the attractive interaction between u quark and phosphate.

3. Flux tubes connect to oxygen atoms in the proposed model of bio-catalysis and protein folding [K6]. The model is relies on ideas inspired by the model of DNA as topological quantum computer [K2]. In this model hydrogen bonds are assumed to correspond or to be accompanied by (wormhole) magnetic flux tubes. Also flux tubes connecting acceptor atoms or molecules of hydrogen bonds are assumed to be connected long flux tubes and represent genuinely new physics. Examples of acceptors are $O =$ atoms in phosphates and amino-acids and aromatic rings in DNA and also in some amino-acids. The model for protein folding has tight connections with existing chemistry and leads to a very simple criterion for the formation of hydrogen bond between $N - H$ and $O =$ in the constant part of amino-acid and to a proposal for the folding code.

4. DNA as TQC model gives further constraints. The structure of the phospholipids suggest that in the case DNA nucleotides long flux tubes connect the aromatic ring of the nucleotide to the $O =$ atom at the hydrophilic end of the lipid acting as a standard plug which in turn can be connected to another acceptor and eventually terminates to a donor of hydrogen bond. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide.

Not surprisingly, phosphorylation would be absolutely essential for the operation of DNA as topological quantum computer. $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer.

A possible model (perhaps the simplest one found hitherto) for the reaction $ATP \to ADP + P_i$ is based on the assumption that it splits a flux tube connection defining strand of a braid defining topological quantum computation. A change of the hardware of topological quantum computer would be therefore in question.

1. Suppose that ATP defines a standard plug in flux tube connections. This would mean that aromatic ring and the oxygen atoms $O = 1$, $O =_2$, and $O =_3$ of the phosphates are connected by magnetic flux tubes to some molecules. These flux tubes represent genuinely new physics in accordance with the fact that "high energy phosphate bonds" are not really understood in the standard chemistry. Suppose that the flux tube associated with $O =_2$ connects it with $O =_3$ and defines the somewhat mysterious high energy phosphate bond. This bond would be formed during cellular breathing and the metabolic energy would go the formation of the magnetic flux tube between $O =_2$ and $O =_3$. Suppose that $O =_1$- the innermost O has a flux tube connecting it to catalyst in this case F_1.

2. At Step 1 F_1 and ATP molecule would find each other. This would be due to the shortening of the magnetic flux tube connecting them and associated with the innermost phosphate. This would liberate.42 eV of metabolic energy.

3. At Step 2 hydrolysis would induce $F_1 \cdot \mathrm{ADP} \cdot P_i \to F_1 \cdot ADP + P_i$. Since no energy is released at this step, there is temptation to conclude that a reconnection of $O_2 - O_2$ fluc tube and a flux tube associated with catalyst occurs. ADP and P_i fors now a high energy bond with catalyst. the reconnection of $(O =_2) - (O =_3)$ flux tube with the hydrogen bond connecting two water molecules leads to the disappearance of this flux tubes so that the incoming and outgoing the flux tubes are shortcut by $(O =_2) - -H - (OH)$ *resp.* $(O =_3) - -H - (OH)$ hydrogen bonds (connection to ground is the analog in circuit theory). This would correspond in the usual terminology the liberation of the third phosphate: $ATP \to ADP + P_i$. P_i however remains at the end of flux tube to be attached later to another ADP. The resulting bonds to water molecules would have low energy and the liberated energy would be usable metabolic energy. In this case the function of the splitting would be purely energetic.

4. One can imagine also a function related to information processing. P_i could be also attached to some other molecule in phosphorylation process so that the outcome would be a reconnection in the web of magnetic flux tubes. Phosphorylation is infeed known to play a key role in activation and deactivation of proteins and in the formation of signal pathways. In the case of AMP associated with DNA there would be only single flux tube involved and it could connect DNA nucleotide to nuclear or cell membrane.

5. The process involves also hydration. $(OH)^-$ ion joins to the third P to give P_i^{-3} and H^+ to $O - P$ in second P to give $H^+ - O$ in ADP^{-1}. The exchange of electron would lead to the final state $ADP^{-2} + P_i^{-2}$.

A possible model for the dropping of protons would be following.

1. It is absolutely essential to realize that F_1 is an open system and that naïve thermodynamic considerations can lead to misunderstandings. In particular, the notion of high energy phosphate bond does not make sense. The source of the metabolic energy is the chemical energy used to drive protons to the atomic space-time sheets of F_1. The function of the large negative charge of ATP is to increase the rate for the binding of ATP^{-4} to F_1. In the classical picture the binding to F_1 is followed by the dropping of two protons to larger space-time sheet. The value of the metabolic quantum could be reduced from .5 eV to about .21 eV by the Coulomb energy of proton with PO^{4-}. The Coulomb binding energy of the remaining protons at F_1 with $ADP + P_i$ is smaller and the dropped proton liberates larger energy about

.31 eV. In quantum picture the division of the process to this kind of sequence might not be a good approximation.

2. One function of the $ATP \to ADP$ would be to induce the dropping of the third proton from F_1 space-time sheet. Second function would relate to the topological quantum computation like process since the decay would correspond to a splitting of a braid strand coming to the aromatic ring of A and proceeding along string defined by the ring and three $O =:$ s of phosphates and continuing further. This would make possible TQC as a braiding for both halves of the split flux tubes. After the reconnection the total braid structure would be different. Quite generally, reconnection process would make possible to modify the hardware of topological quantum computer.

3. The reason for why P_i leaves the catalyst site and proton is dropped (step 2) should be the in-stabilization of the bound state of positively charged proton with $ADP^{-2} + P_i^{-2}$ which does not have so strong Coulomb interaction energy with proton as ATP^{-4} As a consequence, proton can drop to the larger space-time sheet.

4. What remains open are the details of the transformation of the chemical energy to zero point kinetic energy of protons. Remote metabolism suggests that protons send negative energy phase conjugate photons to the geometric past inducing a transition of an energy carrying molecule to a lower energy state (zero energy ontology gives justification for this picture). This would mean the failure of the standard description in terms of reaction kinetics. The catabolism of nutrients is the eventual provider of the metabolic energy and the coenzyme nicotinamid adenic dinucleotide NAD^+ [I23] receives electron and the energy liberated in the catabolic reaction. In the proposed framework it is not an surprising that NAD^+ is analogous to RNA dinucleotide (perhaps as remnant from RNA era when dinucleotides defined the 2-codon code) and consists of two phosphates and adenine and nicotinamide nucleosides. The oxidation reaction $NADH \to NAD^+$ in turn liberates this energy. Protons could gain their energy by sending negative energy photons to $NADH$. Negative energy photons would propagate along "topological light rays" parallel to the flux tubes connecting the system in a precisely targeted manner to NADH aromatic rings. Alfven waves propagating along magnetic field lines would be the standard electrodynamics counterpart for these topological light rays.

Many details of the process remain open but it would seem that the key ideas of TGD based quantum vision about living matter are fused together in rather detailed manner in this picture.

3. Polymerization of DNA and RNA

The polymerization of RNA and DNA by dehydration involves the fusion of $PO_4H_2^{2-}$ phosphate molecule with ribose. In this process the stub...-O-H of the phosphate ion combines with H-O-C-... stub of ribose (here C is the carbon atom not belonging to the ribose cycle). This gives rise to..-O-$(H\text{-}O)^-$-C-... plus proton dropping to a larger space-time sheet and liberating metabolic energy quantum. Too large negative charge of three units makes the complex unstable and $(H\text{-}O)^-$ ion splits out. Metabolic energy quantum might be also used in the process.

DNA as TQC model would suggest a possible interpretation. Perhaps the polymerization creates flux tube connections from nucleotides to to other molecules -say lipid molecules of the nuclear membrane or some catalyst molecule- via the attached O= attached to phosphate. Also the phosphorylation of proteins could involve this kind of reconnection process creating flux tube connection of protein with some other molecule.

Hydration de-stabilizes long polymers unless there is a continual feed of protons to the atomic space-time sheets. This could be achieved by irradiation with photons with energy equal to the metabolic energy currency. Situation changes also if water is ordered/structured water, in liquid crystal form, or as ice, and therefore unable to provide the water molecules needed for the hydration. Stabilization of RNA and DNA polymers could be achieved in this manner in gel phase.

Clay structures are known to act as catalyzers of RNA polymerization. The general model of catalysis based on the recombination and $\hbar$ changing transition for magnetic flux tubes should explain also this.

Why DNA is stable inside cell nucleus?

Inside membrane bound surface both DNA and RNA nucleotides and polymers are stable. The un-stability of the DNA nucleotides and polymers outside membrane bound surfaces could involve many-sheeted physics.

1. What one expects that DNA transforms to RNA unless it is inside a membrane bound region. A possible reason is that water molecule is needed to transform DNA to RNA but not available inside membrane bound structure where water is structure water in gel phase.

2. In the case of A, G, and C nucleotides DNA$\rightarrow$ RNA transformation means simply an addition of one oxygen atom to the de-oxyribose ring, that is replacement of one C-H with C-O-H. If ordinary water is present this could be achieved by the dissociation of the water molecule to $OH^- + H^+$ followed by the replacement of C-H in the de-oxyribose cycle with C-OH^- so that a negative1ly charged ribose results. The outcome is free hydrogen atom. If H^+ drops to a larger space-time sheet, the liberated zero point kinetic energy is of order .5 eV. This process is basically the same which should occur when single ATP molecule is utilized in metabolism.

3. In the case of T nucleotide also CH_3 group differentiating T from U must be de-attached. This is achieved if the hydrogen atom from the water molecule is taken by the de-attached CH_3 group to give CH_4 molecule. As a result a negatively charged U results. Inside cell nucleus or in gel phase this process is not favored because the water is in liquid crystal form and it costs energy to take the needed H_2O molecule from it.

4.3.4 Could High Energy Phosphate Bond Be Negentropic Bond With Negative Binding Energy?

Most people assign the word "love" to the word "life" as their first association. There is a notable exception to this: scientists including biologists. Un-educated layman might however wonder whether one can understand life without identifying any physical counterpart for this notion (, which could be replaced with that of compassion, sex, or ability to act synergetically or just X if some of these notions sounds less un-scientific). Certainly the word "love" stimulates a deep feeling of disgust in a reductionistically conditioned scientist. But isn't the duty of scientist to win this kind of feelings and try to see whether this identification might be possible after all? The prize could be high: the understanding of what distinguishes between living and dead matter could change the entire culture. Who knows, maybe it could be possible to identify some poorly understood fundamental biological process allowing a quantitative model using a guess for what this physical correlate could be. The basic step of metabolism is at the core of life and indeed poorly understood, and I shall argue that the identification of the negentropic entanglement as the counterpart for the notion of love could allow to model quantitatively what happens in this process.

Basic ideas

Before continuing general motivating comments about implications of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) are in order.

1. Ordinary bound states are stable because they have positive binding energy. One can visualize this kind of binding as a jail: the second particle resides near the bottom of a potential well. Organized marriage is a social analogy for this situation. Negentropic entanglement makes possible bound states for which binding energy can have and perhaps even has always a wrong sign. The state is not prevented from decaying to free particles in state function reduction by energy conservation: Negentropy Maximization Principle (NMP) [K60] takes care that they remain correlated. The social analogy would be a voluntary marriage based on love. Partners are completely free to leave but want to stay together. One implication could be explanation for the stability of highly charged basic molecules of life such as DNA and ATP.

2. The presence of the negentropic entanglement implies the directedness of the biological processes since the outcome of the state function reduction would be far from random since the behavior of negentropic bonds could be almost deterministic. In the case of time-like entanglement this would select only particular initial final state pairs so that determinism would emerge also in this sense and could lead to almost deterministic irreversible cellular automaton behavior characteristic for the living matter very different from the reversible determinism of classical physics and very difficult to understand in quantum context.

3. The determinism would of course be only partial and would allow volition not spoiled by randomness of quantum jump. This would provide a general explanation for the ability of the living matter to overcome the second law basically implied by quantum randomness predicted by the standard quantum theory. This would happen in time scales shorter than the time scale of the appropriate causal diamond (CD) only but one would have hierarchy of CD meaning that in arbitrary long time scales there are levels of hierarchy at which second law is broken. The hierarchy of Planck constants would be also crucial since it would allow zooming up to arbitrarily long time scale. Non-equilibrium thermodynamics and cellular automaton models could be seen as phenomenological descriptions for the actual breaking of second law in the intersection of real and p-adic worlds.

4. High energy negentropic bonds need not be present only in phosphates. O=s are are present in all important biomolecules. Phosphates are present in DNA. Each peptide bond in amino-acid polymer contains O=. Also sugars contain it. Maybe O= indeed acts as a universal plug defining then ends of negentropic flux tube bonds between biomolecules. For instance, protein folding for which a possible model is discussed in [K6] from different view point could be more or less deterministic cellular automaton like process if the bonds are negentropic. Negentropic entanglement would also guarantee the stability of the folding pattern. Certainly the assumption that the process is random -as standard quantum theory would suggest- leads to Levinthal paradox stating that the rate of the process is quite too slow. The simplest possibility is that the flux tube bonds are between O=s of subsequent amino-acids before folding and the folding process involves formation of reconnections possibly drawing by a reduction of Planck constant certain amino-acids near to each other. O=s could also act as plugs connecting protein to other biomolecules. One must however notice that many neurotransmitters, hallucinogens, and alcohol having strong effects on consciousness have O-H groups instead of O=s. This inspires the question what happens to the flux tube in O=$\leftrightarrow$ O-H process.

General formulation of the model

Consider now the model. High energy phosphate bond (see `http://tinyurl.com/yar7zv7j`) [I14] assigned with the two outer-most phosphates of ATP (see `http://tinyurl.com/clnu4`) [I2] is fundamental for the basic processes in living matter. The $ATP \to ADP + P_i$ liberates metabolic energy loaded to ATP in the cellular respiration process (see `http://tinyurl.com/yyvrbp`) [I7] or its equivalent and occurs again and again and defines a kind of Karma's cycle in living matter. The phosphate bond is assumed to have a high energy content liberated as ATP is hydrated to ADP (see `http://tinyurl.com/5w7cud`) [I1] and phosphate ion (see `http://tinyurl.com/2xbv3y`) $P_i = PO_4^{3-}$ [I30]. The notion of high energy phosphate bond has been however challenged as being meaningless [D16, D10], [I103].

1. One can of course consider a high energy bond for which the interaction potential looks like a well at the top of mountain and spin glass degeneracy of quantum TGD would certainly allow to consider this kind of notion. I do not know whether models realizing this idea concretely have been really constructed.

2. My earlier proposal for $ATP \to ADP + P_i$ process is inspired by the notion of many-sheeted space-time and p-adic length scale hypothesis making sense in the intersection of real and p-adic worlds and involves the dropping of protons (or electrons) to larger space-time sheets and driven back in oxidative metabolism. The energy liberated in this process corresponds to the zero point kinetic energy of protons (or electrons), which is smaller at the larger space-time sheet. The maximum value of zero point kinetic energy is predicted to be $E_0 \simeq .5$ eV

for $k = 137$ in the case of proton and for $k = 148$ in the case of electron (for electron the energy would be by a factor $2^{-11}m_p/m_e \simeq .94$ smaller).

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

3. With an inspiration coming from DNA as topological quantum computer model [K2] I have also proposed that the magnetic flux tubes connecting bio-molecules to each other define a kind of Indra's net plays a key role in the biological information processing. For instance, topological quantum computations could be realized in terms of braids formed by flux tubes [K2, K6]. O=: s associated with phosphates wold serve as universal plugs to which flux tubes could be connected connecting intronic nucleotides and lipid layers of nuclear or cell membrane. In particular, the innermost O= of ATP could be connected by a flux tube to any biomolecule needing metabolic energy- say some catalyst or the F_1 machine central for energy metabolism. The reduction of Planck constant would bring ATP and biomolecule near each other and lead to a formation of a weakly bound state making catalytic processes possible. The outer O=: s of the ATP molecule could be connected by a flux tube to each other, which could be rather long loop. This flux tube could provide the new physics realization of the high energy phosphate bond.

4. ATP (P_i) has 4 (3) units of negative charge and at least ordinary layman might wonder why this does not induce instability. Similar problem is encountered in the case of DNA, which contains two units of negative charge per nucleotide. This particular problem is regarded as completely real. The idea about life as something in the intersection of real and p-adic worlds [K81] raises the question whether these high energy states could be made possible by the presence of negentropic bonds- most naturally associated with the flux tubes with large $\hbar$. This love marriage would stabilize ATP, ADP, and DNA and other charged biomolecules. The presence of phosphates would be a clear-cut signature of this stabilization mechanism. Also proteins involve phosphates playing a key role in the bio-control: typically phosphorylation activates or de-actives the protein and is also involved with the generation of signal pathways. Why this happens would be easy to understand in Indra's net model.

5. In $ATP \to ADP + P_i$ transformation the energy carried by the negentropic bonds would be liberated but leave the flux tube bonds negentropic. Cell respiration would take care of the loading of the batteries with negentropic metabolic energy. This would involve also the kicking of protons back to the smaller space-time sheets. Also the molecular lovers ADP and P_i would find each other again as the Planck constant for the flux tube connecting them would be reduced during the cellular respiration transform ADP and P_i back to ATP.

Quantitative estimates

Consider now a more detailed model for $ATP \to ADP + P_i$. The binding of ATP to the catalytic site involves several steps. I have described them in the previous section and in the following add to this template the interpretation suggested by the proposed picture.

1. **Step 1** : The binding $ATP + F_1 \to ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

   This process involves a liberation of Gibbs free energy per single attachment, which is about $\Delta g_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang

to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [I121].

Comment: One can question the assumption that strong binding is generated. Instead of binding proton or electron would be dropped to a larger space-time sheet and liberate zero point kinetic energy.

(a) The simplest interpretation in the proposed picture is that the negentropic flux tube connecting ATP and F_1 molecule and behaving as high energy phosphate bond associated with the innermost O= is contracted via the reduction of Planck constant. Then proton is dropped from $k = 137$ space-time sheet to a much larger space-time sheet and liberates metabolic energy quantum $E(137) \simeq .5$ eV. Another possibility is that electron at $k = 148$ space-time sheet is dropped. This process would replace the instantaneous generation of binding energy and in zero energy ontology the time scale for this process would correspond to the time scale of appropriate causal diamond (CD).

(b) Instead of single particle energy macroscopic Gibbs energy $G = E + PV - TS$ is the useful notion now since macroscopic quantities of matter are studied and pressures and temperature are typically constant in the situations considered ($dG = -SdT + VdP$). G is minimized for constant T and P prevailing in the situation considered.

(c) In the attachment of ATP to catalyst S is reduced and a good guess is that volume is not affected so that PV term does not change. From this one can deduce that the liberated energy per catalyst particle -call it $\Delta e = e_i - e_f = \Delta g - T\Delta s$ (i and f refer to initial and final states) satisfies $\Delta e > \Delta g = .42$ eV.

(d) One must estimate the value of Δe. The attachment reduces the kinetic energy of relative motion of catalyst and ATP to zero. If it makes sense to speak about thermal equilibrium for ATP an catalyst in translational degrees of freedom the reduction of kinetic energy is $\Delta e_K = 3T/2$, which is of order.045 eV at room temperature. Whether this energy remains in the catalyst-ATP system or is it liberated in the process is not clear. The energy liberated in the dropping of the proton or electron gives a contribution $\Delta e = E_0 = .5$ eV. This gives the condition

$$\Delta g_1 = E_0 + 3T/2 - T\Delta s = .42 \ \ eV \ \ . \tag{4.3.1}$$

If the liberated kinetic energy remains in the system, the first guess is $\Delta e = E_0 = .5$ eV, where E_0 is the nominal value of zero point kinetic energy. This would give for $T\Delta s$ the estimate $T\Delta s = .08$ eV about 3 times thermal energy corresponding to three translational degrees of freedom. This looks rather reasonable order of magnitude estimate.

(e) NMP suggests-maybe even requires- that the bond remains negentropic. The binding energy associated with ATP- catalyst binding could be small- of the order of thermal energy about .045 eV.

2. **Step 2** Hydrolysis: $F_1 \cdot ATP \to F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

   Comment: The simplest option explaining the fact that the change of energy is small is that hydrolysis leaves the flux tube between outer O=: s of ATP intract and removes only the P-O-P bond. This flux loop could have rather large $\hbar$.

3. **Step 3** : Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \to F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

   Comment: The simplest option is that the negentropic flux tube liberates its energy but remains negentropic. The increase of Planck constant might be involved.

(a) The value of Δe is now smaller than ΔG, which suggests that the metabolic energy quantum in the case of proton corresponds to $\Delta e = E(139) \simeq .25$ eV. The average change of kinetic energy can be assumed to be equal to thermal energy in final state and is same as above. This gives the condition

$$\Delta g_2 = E_0/2 - 3T/2 + T\Delta s = .32 \ \ eV \ \ .$$

(b) By adding this equation with the similar equation for Step 1 (see Eq. 4.3.1) one obtains the condition

$$\Delta g_1 + \Delta g_2 = 3E_0/2 = .74 \ \ eV \ \ .$$

This gives $E_0 = .49$ eV so that the model seems to be internally consistent.

4. **Step 4** : ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

   Comment: $\hbar$ increases back to the original value for the innermost flux tube which could it still have small positive energy and be negentropic.

The model would predict that ADP and P_i and remain highly correlated (connected by flux tubes) as do also AXP and F_1. These predictions should be testable by marking ADP and P_i of ATP with the same "color" (say radioactively) and finding whether the colors of ADP and P_i remain the same during the subsequent cycles or whether they mix immediately. These love affairs at molecular level could be modified only by reconnections of flux tubes as also in human relationships. For instance, two ADPs could exchange their P_is or F_1s. Negentropic entanglement could guarantee the highly organized and directed nature of basic bio-catalytic processes.

4.3.5 Water Memory And Braids

There are several grand visions about TGD Universe. One of them is as a topological quantum computer in a very general sense. This kind of visions are always oversimplifications but the extreme generality of the braiding mechanism suggest that also simpler systems than DNA might be applying TQC.

Water memory: general considerations

With few exceptions so called "serious" scientists remain silent about the experiments of Benveniste and others relating to water memory [I40, I42, I61, I62] in order to avoid association with the very ugly word "homeopathy".

The Benveniste's discovery of water memory initiated quite dramatic sequence of events. The original experiment involved the homeopathic treatment of water by human antigene. This meant dilution of the water solution of antigene so that the concentration of antigene became extremely low. In accordance with homeopathic teachings human basophils reacted on this solution.

The discovery was published in Nature and due to the strong polemic raised by the publication of the article, it was decided to test the experimental arrangement. The experimental results were reproduced under the original conditions. Then it was discovered that experimenters knew which bottles contained the treated water. The modified experiment in which experimenters did not possess this information failed to reproduce the results and the conclusion was regarded as obvious and Benveniste lost his laboratory among other things. Obviously any model of the effect taking it as a real effect rather than an astonishingly simplistic attempt of top scientists to cheat should explain also this finding.

The model based on the notion of field body and general mechanism of long term memory allows to explain both the memory of water and why it failed under the conditions described.

1. Also molecules have magnetic field bodies acting as intentional agents controlling the molecules. Nano-motors do not only look co-operating living creatures but are such. The field body of

molecule contains besides the static magnetic and electric parts also dynamical parts characterized by frequencies and temporal patterns of fields. To be precise, one must speak both field and relative field bodies characterizing interactions of molecules. Right brain sings-left brain talks metaphor might generalize to all scales meaning that representations based on both frequencies and temporal pulse with single frequency could be utilized.

The effects of complex bio-molecule to other bio-molecules (say antigene on basofil) in water could be characterized to some degree by the temporal patterns associated with the dynamical part of its field body and bio-molecules could recognize each other via these patterns. This would mean that symbolic level in interactions would be present already in the interactions of bio-molecules.

If water is to mimic the field bodies of molecules using water molecule clusters, at least vibrational and rotational spectra, then water can produce fake copies of say antigenes recognized by basofils and reacting accordingly.

Also the magnetic body of the molecule could mimic the vibrational and rotational spectra using harmonics of cyclotron frequencies. Cyclotron transitions could produce dark photons, whose ordinary counterparts resulting in de-coherence would have large energies due to the large value of $\hbar$ and could thus induce vibrational and rotational transitions. This would provide a mechanism by which molecular magnetic body could control the molecule. Note that also the antigenes possibly dropped to the larger space-time sheets could produce the effect on basofils.

2. There is a considerable experimental support for the Benveniste's discovery that bio-molecules in water environment are represented by frequency patterns, and several laboratories are replicating the experiments of Benveniste as I learned from the lecture of Yolene Thomas in the 7: th European SSE Meeting held in Röros [J10]. The scale of the frequencies involved is around 10 kHz and as such does not correspond to any natural molecular frequencies. Cyclotron frequencies associated with electrons or dark ions accompanying these macromolecules would be a natural identification if one accepts the notion of molecular magnetic body. For ions the magnetic fields involved would have a magnitude of order.03 Tesla if 10 kHz corresponds to scaled up alpha band. Also Josephson frequencies would be involved if one believes that EEG has fractally scaled up variants in molecular length scales.

3. Suppose that the representations of bio-molecules in water memory rely on pulse patterns representing bit sequences. The simplest realization of bit would be as a laser like system with bit 1 represented by population inverted state and bit 0 by the ground state. Bits could be arranged in sequences spatially or by variation of zero point energy defining the frequency: for instance increase of frequency with time would define temporal bit sequence. Many-sheeted lasers are the natural candidates for laser like systems are in question since they rely on universal metabolic energy quanta. Memory recall would involve sending of negative energy phase conjugate photons inducing a partial transition to the ground state. The presence of metabolic energy feed would be necessary in order to preserve the memory representations.

Water memory in terms of molecular braidings

It is interesting to look water memory from the point of view of TQC. Suppose that the molecules and water particles (space-time sheet of size of say cell length scale) are indeed connected by color flux tubes defining the braid strands and that splitting of the braid strands can take place so that water flow can gives rise to a braiding pattern and TQC like process.

The shaking of the bottle containing the diluted homeopathic remedy is an essential element in the buildup of water memories also in the experiments of Benveniste [I61]. Just like the vigorous flow of sol near the inner monolayer, this process would create a water flow and this flow creates a braiding pattern which could provide a representation for the presence of the molecules in question. Note that the hardware of braiding could carry information about molecules (cyclotron frequencies for ions for instance.

The model for the formation of scaled down variants of memories in hippocampus discussed above suggests that each half period of theta rhythm corresponds to TQC followed by a non-

computational period during which the outcome of TQC is expressed as 4-D nerve pulse patterns involving cyclotron frequencies and Josephson frequency. Josephson currents at the second half period would generate dark Josephson radiation communicating the outcome of the calculation to the magnetic body. Entire hierarchy of EEGs with varying frequency scale would be present corresponding to the onion like structure of magnetic body. This pattern would provide an electromagnetic representation for the presence of the antigene and could be mimicked artificially [I62], [J10].

This picture might apply be the case also in the case of water memory.

1. The shaking might drop some fraction of antigene molecules to dark space-time sheets where they generate a dark color magnetic field. Because of the large value of Planck constant super-conductivity along color flux tubes running from molecular space-time sheets could still be present.

2. TGD based model of super conductivity involves double layered structures with same p-adic length scale scale as cell membrane [K18]. The universality of p-adic length scale hierarchy this kind of structures but with a much lower voltage over the bilayer could be present also in water. Interestingly, Josephson frequency $ZeV/\hbar$ would be much lower than for cell membrane so that the time scale of memory could be much longer than for cell membrane for given value of $\hbar$ meaning longer time scale of memory recall.

3. Also in the case of homeopathic remedy the communication of the result of TQC to the magnetic body would take place via Josephson radiation. From the point of view of magnetic body Josephson radiation resulting in shaking induced TQC induced would replace the homeopathic remedy with a field pattern. The magnetic bodies of basophils could be cheated to produce allergic reaction by mimicking the signal representing the outcome of this TQC. This kind of cheating was indeed done in the later experiments of Benveniste involving very low frequency electromagnetic fields in kHz region allowing no identification in terms of molecular transitions (magnetic body and cyclotron frequencies) [I62].

Why experimenter had to know which bottle contained the treated water?

Why experimenter had to know which bottle contained the treated water? The role of experimenter eliminates the possibility that the (magnetic bodies of) clusters of water molecules able to mimic the (magnetic bodies of) antigene molecules electromagnetically are present in the solution at geometric now and produce the effect. The earlier explanation for experimenter's role was based on the idea that memory storage requires metabolic energy and that experimenter provides it. The vision about living matter as topological quantum computer (TQC) suggests a variant of this model in which experimenter makes possible the recall of memories of water represented as braiding patterns and realized via TQC.

1. Does experimenter provide the metabolic energy needed to store the memories of water?

What could be then the explanation for the failure of the modified experiment? Each memory recall reduces the occupation of the states representing bit 1 and a continual metabolic energy feed is needed to preserve the bit sequence representations of antibodies using laser light systems as bit. This metabolic energy feed must come from some source.

By the universality of metabolic energy currencies population inverted many-sheeted lasers in living organisms define the most natural source of the metabolic energy. Living matter is however fighting for metabolic energy so that there must be some system willing to provide it. The biological bodies of experimenters are the best candidates in this respect. In this case experimenters had even excellent motivations to provide the metabolic energy. If this interpretation is correct then Benveniste's experiment would demonstrate besides water memory also psychokinesis and direct action of desires of experimenters on physics at microscopic level. Furthermore, the mere fact that we know something about some object or direct attention to it would mean a concrete interaction of our magnetic with the object.

2. Does experimenter make possible long term memory recall?

The alternative explanation is that experimenter makes possible long term memory recall which also requires metabolic energy.

1. If braiding pattern represents, the water memory the situation changes since the robustness of the braiding pattern suggests that this representation is still in the geometric past (which is replaced with a new one many times). If the dark variants of molecules created in the process are still in the water, the braid representation of water memories could be available even in the geometric now but it is better to not make this assumption. The challenge is to understand how this information can be made conscious.

2. What is certainly needed is that the system makes the TQC again. This would mean a fractal quantum jump involving unitary U process and state function reduction leading to the generation of generalized EEG pattern. Only the sums and differences of cyclotron frequency and Josephson frequency would matter so that the details of the flow inducing braiding do not matter. The shaking process might be continuing all the subjective time in the geometric past so that the problem is how to receive information about its occurrence. Experimenter might actually help in this respect since the mechanism of intentional action initiates the action in the geometric past by a negative energy signal.

3. If the magnetic body of the water in the geometric now can entangle with the geometric past, TQC would regenerate the experience about the presence of antigene by sharing and fusion of mental images. One can however argue that water cannot have memory recall in this time scale since water is quite simple creature and levels with large enough $\hbar$ might not be present. It would seem that here the experimenter must come in rescue.

4. The function of experimenter's knowledge about which bottle contains the homeopathic solution could be simply to generate time-like entanglement in the required long time scale by serving as a relay station. The entanglement sequence would be *water now - experimenter now - water in the past* with "now" and "past" understood in the geometric sense. The crucial entanglement bridge between the magnetic body of water and experimenter would be created in the manufacturing of the homeopathic remedy.

   Note that this explanation does not exclude the first one. It is quite possible that experimenter provides also the metabolic energy to the bit representation of water memories possibly induced by the long term memory recall.

This picture is of course just one possible model and cannot be taken literally. The model however suggest that magnetic bodies of molecules indeed define the braiding; that the generalized EEG provides a very general representation for the outcome of TQC; that liquid flow provides the manner to build TQC programs - and also that shaking and sudden pulses is the concrete manner to induce visible-dark phase transitions. All this might be very valuable information if one some day in the distant future tries to build topological quantum computers in laboratory.

4.3.6 How Bio-Polymers Were Associated With Their Dark Counterparts?

The experiments of Pollack [L13] demonstrating what he calls fourth phase of water is characterized by negatively charged regions - exclusion zones (EZs). The stoichiometry of water inside EZ is $H_{1.5}O$. TGD based model assumes that part of protons in these regions have been transferred to magnetic flux tubes were they form sequences identifiable as dark nuclei. The surprising finding is that a simple model for dark proton allows to assign its states to multiplets for which numbers of states are those assignable to DNA, RNA, and tRNA codons, plus amino-acids. Also the vertebrate genetic code can be realized in a simple manner. This leads to a vision about prebiotic life as dark life evolved in water before the ordinary life. Dark life would be present also in ordinary life forms.

If one believes that dark proton sequences [K47] define the counterparts of DNA, RNA, tRNA, and amino-acids realized at magnetic flux tubes, the question is how this form of life was transformed to the bio-chemical life.

The article "Hydrogen cyanide polymers, comets and the origin of life" (`http://tinyurl.com/ybfuwneq`, thanks to Ulla for the link) helped me to discover a new big gap in my knowledge about biology and this in turn led to a more detailed vision about how the transition could have taken place. HCN is everywhere and Miller demonstrated in his classic experiments that 11 out of 20 amino-acids emerged in presence of HCN. It has been later found that well over 20 amino-acids

were produced. (http://tinyurl.com/y9at46fe). In my own belief system amino-acids could have appeared first as concrete something "real" and DNA as symbolic representations of this something "real". First at dark matter level and then biochemically.

In TGD Universe one can imagine - with inspiration coming partially from Pollack's experiments [L13] (http://tinyurl.com/oyhstc2) - that dark variants DNA, RNA and amino-acids were realized first as dark proton sequences at flux tubes- dark nuclei - I call them just dark DNA, RNA and amino-acids although dark proton sequences are in question. The genetic machinery involving translation and transcription was realized as dark variant and dark DNA was a symbolic representation for dark amino-acids.

How did this dark life give rise to bio-chemical life as its image? This is the question! I can only imagine some further questions.

1. Was this process like master teaching to a student a skill? Master does it first, and then student mimics. If so, the emergence of amino-acids, mRNA and DNA polymers would *not* have been purely chemical process. Dark variants of these polymers would have served as templates for the formation of ordinary basic biopolymers, for transcription, and for translation. These templates might have been necessary in order to generate long RNA and DNA sequences: mere chemistry might have not been able to achieve this. Without dark polymers one obtains only bio-monomers, with dark polymers as template one obtains also bio-polymers. Dark polymers would have been the plan, biopolymers the stuff used to build.

2. Are dark DNA, RNA, amino-acids, etc indeed still there and form binary structures with their biochemical variants as I have indeed proposed?

3. Are dark translation and transcription processes still an essential part of ordinary translation and transcription? Master-student metaphor suggest that these dark processes actually induce them just like replication of magnetic body could induce the replication of DNA or cell. Visible chemistry would only make visible the deeper "dark chemistry". Apologies for all biochemists who have done heroic work in revealing chemical reaction paths!

How the process assigning biochemical life to dark life could have proceeded? The minimalistic guess is that the only thing that happened was that dark life made itself gradually visible! As a consciousness theoretician I have a temptation to see religious statements as hidden metaphors, at least they provide an excellent manner to irritate skeptics: Dark matter - the "God" made us- the biological life - to its own image.

1. First dark amino-acid sequences were accompanied by ordinary amino-acid sequences so that the dark translation process had now a visible outcome. At this step the presence of HCN was crucial and made the step unavoidable. Also the presence of template was necessary.

2. Dark mRNA got a visible counterpart in the same manner: the presence of template made possible long RNA polymers. The translation remained basically dark process but made visible by mRNA.

3. Dark DNA got a visible companion: again the presence of the template was - and still is - crucial.

What about generation of DNA and RNA? It is known that in reducing atmosphere DNA and RNA nucleobasis are obtained in an environment believed to mimick prebiotic situation: the presence of HCN and ammonia are necessary (http://tinyurl.com/y9at46fe). Reducing atmosphere http://tinyurl.com/yc62g22f does not oxidize, in other worlds does not contain oxygen and other oxidizing agents and can contain also actively reducing agents such as hydrogen, carbon monoxide. There are however some problems.

1. There is evidence that early Earth atmosphere contained less reducing molecules than thought in times of Miller. If life emerged in the underground water reservoirs as TGD strongly suggests, the usual atmosphere was absent and there are good hopes about reducing atmosphere.

2. The experiments using reducing gases besides those used in Miller's experiments produce both left and right handed polymers so that chiral selection is missing. This is not a surprise since weak interactions generate extremely small parity breaking for visible matter. If dark proton strings or even dark nuclei are involved, the Compton length of weak gauge bosons can be of the order of atomic length scale or even longer and weak interactions would be as strong as electromagnetic interactions. Therefore chiral selection becomes possible. The simplest option is that chirality selection occurred already for the helical magnetic flux tubes and induced that of biopolymers.

Two highly interesting findings providing insights about the origins of life have emerged and it is interesting to see how they fit to the TGD inspired vision.

The group led by Thomas Carell has made an important step in the understanding the origins of life. They have identified a mechanism leading to the generation of purines A and G which besides pyrimidines A,T (U) are the basic building bricks of DNA and RNA. The crucial step is to make the solution involved slightly acidic by adding protons. For year later I learned that a variant of Urey-Miller experiment with simulation of shock waves perhaps generated by extraterrestrial impacts using laser pulses generates formamide and this in turn leads to the generation of all 4 RNA bases.

These findings represent a fascinating challenge for TGD inspired quantum biology. The proposal is that formamide is the unique amide, which can form stable bound states with dark protons and crucial for the development of life as dark matter-visible matter symbiosis. Pollack effect would generate electron rich exclusions zones and dark protons at magnetic flux tubes. Dark protons would bind stably with unique amine leaving its chemical properties intact. This would lead to the generation of purines and the 4 RNA bases. This would be starting point of life as symbiosis of ordinary matter and dark matter as large $h_{eff}/h = n$ phases of ordinary matter generated at quantum criticality induced by say extraterrestrial impacts. The TGD based model for cold fusion and the recent results about superdense phase of hydrogen identifiable in TGD framework as dark proton sequences giving rise to dark nuclear strings provides support for this picture.

There is however a problem: a reductive environment (with ability to donate electrons) is needed in these experiments: it seems that early atmosphere was not reductive. In TGD framework one can imagine two - not mutually exclusive - solutions of the problem. Either life evolved in underground oceans, where oxygen concentration was small or Pollack effect gave rise to negatively charged and thus reductive exclusion zones (EZs) as protons were transferred to dark protons at magnetic flux tubes. The function of UV radiation, catalytic action, and of shock waves would be generation of quantum criticality inducing the creation of EZs making possible dark $h_{eff}/h = n$ phases.

The first step: binding of dark protons to formamido-pyrimidine

I learned about very interesting discovery related to the problem of understanding how the basic building bricks of life might have emerged. RNA (DNA) has nucleotides A,G,C,U (T) as basic building bricks.

The first deep question is how the nucleotides A,G,C,U, and T emerged.

1. There are two types of nucleotides. Pyrimidines C and T/U (see `http://tinyurl.com/k3vxl9b`) have single carbon 6-cycle. Purines A and G (see `http://tinyurl.com/odvqw2p`) in turn have single 6-single and 5-cycle fused attached together along one side. Purines are clearly more complex than pyrimidines.

2. U.K. chemist John Sutherland demonstrated a plausible sequence of steps leading to the emergence of pyrimidines. Purines turned out to be more problematic. Leslie Orgel and colleagues suggested a possible pathway but it produces purines in too tiny amounts.

Now a group led by Thomas Carell in Ludwig Maximilian University have found a more plausible mechanism [I63] (see `http://tinyurl.com/z65kpyo`).

1. Carell and colleagues studied the interaction of biomolecule formamido-pyrimidine (FaPy) with DNA and found that it also reacts to produce purines. Could FaPys have served as

precedessors of purines? (For formamide see http://preview.tinyurl.com/lwqyqnu and for the class of chemical compounds known as amines see http://tinyurl.com/mad6c2u).

2. The first step would have been a copious production of amino-pyrimidines containing several chemical groups known as amines. The problem is that the are so many amines and they normally react indiscriminantly to produce many different compounds. One wants mostly purines so that only one critical amine is wanted.

3. When Carell and his team added some acid to the solution to decrease its pH, a miracle happened. The extra protons from acid attached to the amines of the amino-pyrimidine and made them non-reactive. There was however one exception: just the amine giving rise to purine in its reactions! The reactive amine also readily bonded with formic acid acid (see http://tinyurl.com/lmstt7n) or formamide. Hence it seems that one big problem has been solved.

The second challenge is to understand how the building bricks of RNA and DNA combined to form longer polymers and began to replicate.

1. One prevailing vision is that so called RNA world preceded the recent biology dominated by DNA. The goal has been to achieve generation of RNA sequence in laboratory. Unlike DNA RNA sequences are not stable and long sequences are difficult to generate. DNA in turn replicates only inside cell and the presence of what is known as ordered water seems to be essential for this.

2. This step might involve new physics and chemistry and I have considered the possibility that the new physics involves magnetic bodies and dark proton sequences as a representation of the genetic code at the level of dark nuclear physics. There is no need to add that the fact that dark proton states provide representations for RNA, DNA, tRNA, and amino-acids [K47, L2] looks like a miracle and I find still difficult to believe that it is true and for genetic code. Also the representation of vertebrate code emerges in terms of correspondences of dark proton states.

   This suggests that the replication of DNA and takes place at the level of dark proton sequencies - dark nuclear strings - serving as a dynamical template for the biological replication. Also transcription and translation would be induced by dark process. Actually all biochemical processes could have as template the dynamics of molecular magnetic bodies and biochemistry would be kind of shadow of deeper dynamics.

3. There is actually support for dark proton sequences. Quite recently I learned about the article of Leif Holmlid and Bernhard Kotzias [L28] (see http://tinyurl.com/hxbvfc7) about the superdense phase of hydrogen. In TGD superdense phase has interpretation as dark proton sequences at magnetic flux tubes with the Compton length of dark proton coded by $h_{eff}/h \simeq 2^{11}$ to electron's Compton length [L16]. Remarkably, it is reported that the superdense hydrogen is super-conductor and super-fluid at room temperatures and even above: this is just what TGD predicts.

   The dark protons in TGD inspired quantum biology [L18] should have much longer Compton length of order of the distance between nucleotides in DNA sequences in order to serve as templates for chemical DNA. This gives a dark Compton length of order $\simeq 3.3$ Angstroms from the fact that there are 10 codons per 10 nm. This gives $h_{eff}/h \simeq 2^{18}$.

One can return back to the first step in the genesis of DNA and RNA. The addition of protons to the solution used to model prebiotic environment to make it slightly acidic was the key step. Why?

1. Here cold fusion might help. Cold fusion is claimed to take place in electrolysis involving ionization and charge separation. The electric fields used in electrolysis induce ionization and thus charge separation. For me it has however remained a mystery how electric fields, which are extremely tiny using the typical strength of molecular electric field as standard are able to induce a charge separation. Of course, every chemist worth of his salt regards this as totally trivial problem. I am however foolish enough to consider the possibility that some new physics might be involved.

2. The mechanism causing charge separation could be analogous to or that discovered by Pollack as he irradiated water bounded by a gel phase [L13] [L13]: in the recent case the electric field would take the role of irradiation as a feeder of energy. Negatively charged exclusion zones (EZs) were formed and 1/4 of protons went somewhere.

   The TGD proposal is that part of protons went to magnetic flux tubes and formed dark proton sequences identifiable as dark nuclear strings. The scaled down nuclear binding energy favours the formation of dark nuclear strings perhaps proceeding as analog of nuclear chain reaction. This picture allows to ask whether dark proton sequences giving rise to a fundamental representation of the genetic code could have been present already in water [L18]!

3. How DNA/RNA could have then formed? Could the protons making the solution acidic be dark so that the proton attaching to the amine would be dark? Could it be that for all amines except the right one the proton transforms to ordinary proton and destroys the chemical reactivity. Could the attached dark proton remain dark just for the correct amine so that the amine would remain reactive and give rise to purine in further reactions? Could A,G,C,T and U be those purines and pyrimidines - or even more general biomolecules - for which the attachment to dark proton does not transform it to ordinary proton and in this manner affect dramatically the chemical properties of the molecule? What is the condition for the preservation of the darkness of the proton?

Second step: Could shock waves due to extraterrestrial impacts have produced RNA bases?

About year later I learned about a further interesting finding related to the prebiotic evolution (see the popular article at `http://tinyurl.com/m8npeor`). The conclusion of the research article (see [I69]) is that that the extraterrestrial impacts on Earth's early atmosphere might have generated all 4 RNA bases (see `http://tinyurl.com/kxxc7db`). Also now the formamide is involved and my layman guess is that the motivation for this comes from the experiment of Carell *et al* [I63] (see `http://tinyurl.com/z65kpyo`) discussed above. If formamide is generated then it becomes possible to generate formamido-pyridine and from this the RNA bases can be generated.

The experiment was a modern version of Urey-Miller experiment originally intended to simulate the situation at the surface of the early atmosphere modelled as a mixture a water H_2O, carbon-monoxide CO, and ammonium NH_3. The shock waves generated by the impacts were modelled in the experiment using terawatt laser pulses.

In the original Urey-Miller experiment amino-acids were generated. In the modern version of the experiment it was found that also formamide $CONH_3$ is formed, whose presence under suitable circumstances can lead to the generation of all 4 RNA bases. The presence of UV radiation, shock waves caused by extraterrestrial collisions, or of catalyst is the necessary condition.

In TGD Universe the additional condition could guarantee quantum criticality accompanied by dark $h_{eff}/h = n$ phases leading to the generation of dark protons and their stable binding with formamido-pyrimidine. The stable binding would not be possible for other amido-pyrimidines since dark protons would transform to ordinar protons for them. All 4 RNA bases would emerge from formamido-pyrimidine. All basic molecules of life could be produced in the reductive atmosphere.

The atmosphere was assumed to be reductive and this is a problem: the best that one can hope is that the early atmosphere was weakly reductive. Chemical compound is reductive (see `http://tinyurl.com/m9cqnob`) if it tends to donate electron. Reduction means receiving electron - and in chemistry hydrogen atom. To obtain a reducing atmosphere (see `http://tinyurl.com/lx4tat2`) one should remove oxygen from it. It however seems that the early atmosphere has contained oxygen and was oxidative rather than reductive. How could one overcome the problem?

1. In the experiment of Carell *et al* protons were added to reduce the pH of water. The basic experimental rule is that this makes the environment more reductive. The TGD proposal is that it led to a formation of dark proton-amine pair for the amine leading to the formation of purine. Charge separation by Pollack effect [L13] [L18] leading to the generation of dark proton sequences (dark nuclei) at magnetic flux tubes could have been due to the IR radiation, and maybe also by UV radiation, catalytic action, or by shock waves. The presence of electrons in the exclusion zones (EZs) could have made them electron donors and therefore reductive.

The addition of protons in the experiment of Carell reducing the pH of water could have induced a transformation of dark protons at magnetic flux tube to ordinary protons. Dark protons bound to the amines would have transformed to ordinary protons and inducing their chemical inactivity. Only for the amine formamide serving as a precursor of purine the dark proton-amine bound state was stable and remained chemically reactive since dark proton did not affect the properties of visible matter part of the compound. Symbiosis between dark and ordinary matter began. This view conforms also with the vision about the pairing of DNA/RNA and dark DNA/RNA formed by sequences of proton triplets representing DNA/RNA codons [L20]. DNA is indeed negatively charged and dark proton could neutralize it but allow it to remain chemically active.

2. Second possibility is suggested by the conjecture that prebiotic life evolved in the crust of Earth, perhaps in the underground oceans or regions related to volcanoes [L46, L18]. The content of oxygen of this environment could have been much lower than at the surface making it reductive: it would not be possible to even talk about atmosphere. But where did the metabolic energy come from? Could volcanic energy emitted as dark long wave photons with energies in the range of bio-photon energies help here? There are indeed a theories assuming that first life forms emerged from volcanoes. These problems are discussed in [L46, L18] from TGD viewpoint. Note that these two explanations do not exclude each other.

4.3.7 Could the replication of mirror DNA teach something about chiral selection?

I received a link to a very interesting popular article (see `http://tinyurl.com/zqgutdv`) from which I learned that short strands of mirror DNA and mirror RNA - known as aptamers - have been be produced commercially for decades - a total surprise to me. Aptamers bind to targets like proteins and block their activity and this ability can be utilized for medical purposes.

Now researchers at Tsinghua University of Beijing have been able to create a mirror variant of an enzyme - DNA polymeraze - catalyzing the transcription of mirror DNA to mirror RNA also replication of mirror DNA [I141]. What is needed are the DNA strand to be replicated or transcribed, the mirror DNA nucleotides, and short primer strand (see `http://tinyurl.com/j3o8cyx`) since the DNA polymeraze starts to work only if the primer is present. This is like recalling a poem only after hearing the first few words.

The commonly used DNA polymerase containing about 600 amino-adics is too long to be built up as a right-handed version and researchers used a much shorter version: African swine fever virus having only 174 amino-acids. The replication turned out to be very slow. A primer of 12 nucleotides was extended to a strand of 18 nucleotides in about 4 hours: 3/2 nucleotides per hour. The extension to a strand of 56 nucleotides took 36 hours making 44/36= 11/9 nucleotides per hour. DNA and its mirror image co-existed peacefully in a solution. One explanation for the absence of mirror life is that the replication and transcription of mirror form was so slow that it lost the fight for survival. Second explanation is that the emergence of mirror forms of DNA polymerase and other enzymes was less probable.

Can one learn anything about this?

1. Chiral selection is one of the deep mysteries of biology. Amino-acids are left-handed and DNA and RNA double strands form a right-handed screw. One can assign handedness with individual DNA nucleotides and with DNA double strand but web sources speak only about the chirality of double strand. If the chirality of the DNA nucleotides were not fixed, it would have been very probably discovered long time ago as an additional bit doubling the number of DNA letters.

2. What could be the origin of the chirality selection? Second helicity could have been loser in the fight for survival and the above finding supports this: fast ones eat the slow ones like in market economy. There must be however a breaking of mirror symmetry. Weak interactions break of mirror symmetry but the breaking is extremely small because the weak bosons mediating weak interaction are so massive that the length scale in which the breaking of mirror symmetry matters is of order 1/100 times proton size. This breaking is quite too small to

explain chiral selection occurring in nano-scales: there is discrepancy of 8 orders of magnitude. The proposal has been that the breaking of mirror symmetry has been spontaneous and induced by a very small seed. As far as I know, no convincing candidate for the seed has been identified.

According to TGD inspired model chiral selection would be induced from that in dark matter sector identified in terms of phases of ordinary matter with non-standard value of Planck constant $h_{eff}/h = n$ [K29, K30, K31, K32, K70]. In living matter dark matter would reside at magnetic flux tubes and control ordinary matter. TGD predicts standard model couplings, in particular weak parity breaking. For $h_{eff}/h = n$ the scale below which weak bosons behave as massless particles implying large parity breaking is scaled up by n. Large parity breaking for dark matter becomes possible in even biological length scales for large enough h_{eff}.

The crucial finding is that the states of dark proton regarded as part of dark nuclear string can be mapped naturally to DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code can be reproduced naturally [K47]. This suggests that genetic code is realized at the level of dark nuclear physics and induces its chemical variant. More generally, biochemistry would be kind of shadow of dark matter physics. A model for dark proton sequences and their helical pairing is proposed and estimates for the parity conserving and breaking parts of Z^0 interaction potential are deduced.

Dark matter and chirality selection

In TGD framework the hierarchy of Planck constants suggests an explanation for the chirality selection.

1. In TGD Universe the new physics of quantum biology involves magnetic bodies and dark proton sequences as a representation of the genetic code at the level of dark nuclear physics. The crucial observation is that dark proton states provide representations for RNA, DNA, tRNA, and amino-acids [K47, L2] and there is also natural map between DNA and amino-acid type states giving rise to vertebrate genetic code. This looks like a miracle and I find still difficult to believe that it is true. A The extreme slowness of the wrong-handed DNA replication as compared to the ordinary replication means large breaking of parity symmetry. This is possible to understand in terms of weak interactions only if they are dark in DNA length scales so that weak bosons are effectively massless and weak interactions are as strong as electromagnetic interactions.

   This suggests that the replication of DNA and takes place at the level of dark proton sequencies - dark nuclear strings - serving as a dynamical template for the biological replication. Also transcription and translation would be induced by dark processes. Actually all biochemical processes could have as template the dynamics of molecular magnetic bodies and biochemistry would be kind of shadow of dark matter physics.

   If this is the case, then chiral selection would take place the selection at the level of dark nuclear strings and induce that the level of biochemistry. If dark and ordinary chiralities fit together like hand and glove. Dark matter at magnetic bodies could control the behavior of ordinary matter. By parity breaking the dark weak binding energy between members of proton pairs in the dark DNA strand consisting of a pair of helical dark proton strings is higher for the second helical chirality and would favour this chirality. A very naïve thermodynamical estimate is that the ratio of the densities of two chiralities is proportional to the Boltzmann exponent $exp(-\Delta E_B/T)$. The transition to thermodynamical equilibrium can be however very slow so that thermodynamical argument need not make sense.

2. There is experimental support for dark proton sequences. Leif Holmlid and Berhard Kotzias [L28] (see `http://tinyurl.com/hxbvfc7`) have published an article about the superdense phase of hydrogen proposed to make possible to overcome the Coulomb wall making cold fusion impossible in the textbook Universe. In TGD superdense phase has interpretation as dark proton sequences at magnetic flux tubes with the Compton length of dark proton coded by $h_{eff}/h = n_{eff} \simeq 2^{11}$ to electron's Compton length [L16]. Remarkably, it is reported that the superdense hydrogen is super-conductor and super-fluid at room temperatures and even above: this is just what TGD predicts.

The dark protons in TGD inspired quantum biology (see http://tinyurl.com/lwxdl7y) should have much longer Compton length of the order of the distance between nucleotides in DNA sequences in order to serve as templates for chemical DNA. This gives a dark Compton length of order $\simeq 3.3$ Angstroms from the fact that there are 10 codons per 10 nm. This would give $n_{eff,p} \simeq 2^{18}$. The safest manner to estimate the dark binding energy is by scaling the binding energy about $E_B \simeq 7$ MeV per nucleon by $1/n_{eff,p}$ to give $E_{B,d} = E_B/n_{eff,p} = 28$ eV.

3. Further evidence for the importance of dark protons in biology comes from the recent finding of the group led by Thomas Carell related to the understanding the origins of life [I63] (see http://tinyurl.com/z65kpyo). For TGD inspired model see [L25], [K39, K40]. Carell *et al* have identified a mechanism leading to the generation of purines A and G, which besides pyrimidines A,T (U) are the basic building bricks of DNA and RNA. The crucial step is to make the solution involved slightly acidic by adding protons.

   In TGD inspired quantum biology this suggest that the protons in the acidic water are dark and that the attachment of the dark protons to the amines of the amino-pyrimidine transforms them to ordinary protons and makes the amino-pyrimidine non-reactive. There would be however one exception: the amine which reacts further to give purines as a reaction product. In this case the proton would remain dark and the chemical properties of the amine would remain intact. This suggests that DNA nucleotides and DNA strands can attach to dark protons or are accompanied by them.

Model for the replication of DNA

One can consider a detailed model for the replication as induced by the addition of dark protons to dark proton sequence representing dark DNA strand. The added dark protons would be accompanied or attached with the DNA nucleotides as suggested by the work of Carell *et al*.

1. In the replication and transcription of DNA the basic step would be the addition of dark proton to an increasing dark proton sequence. The need for primer means that there must already exist a dark proton sequence. In the presence of prime the attractive dark nuclear binding energy of the added dark proton with the prime would make the dark fusion rate higher. The addition of dark protons could proceed like a dark nuclear chain reaction. It would be made possible by the dark nuclear binding energy per proton scaling like $1/h_{eff,p}$.

   For the ordinary nuclei the binding energy per nucleon would be of the order of 7 MeV (note that charge independence of strong interactions holds in good approximation). The scaling down by $h_{eff}/h = 2^{18}$ would give $E_B \simeq 4$ eV, which corresponds to UV photon energy. Note that bio-photons assumed to correspond dark photons with same energy have energies in visible and UV range.

2. Dark nuclear energy cannot explain parity breaking. The axial part of dark weak energy between dark protons belonging to dark strand and its conjugate and having nuclei acids and its conjugate as a chemical "shadow" must be also involved. Two values of h_{eff} are involved: $h_{eff,p}$ assignable to the flux tubes containing dark protons parallel to DNA strands and $h_{eff,W}$ assignable to the transversal flux tube connecting dark protons associated with different dark strands.

   One of the assumptions of the TGD inspired model of cold fusion [L16, L28] is that the weak scale is scaled up from weak boson Compton length to about atomic length scale. This would require $h_{eff,W}/h = n_{eff,W}$ for weak bosons to be roughly

$$n_{eff,W} \simeq \frac{m_Z}{m_p} \times n_{eff,p} \simeq 91 \times n_{eff,p}$$

   so that one would have $n_{eff,W} \simeq 2^{25}$. If this is the case weak interactions are of essentially same strength as em interaction below the scaled up Compton scale of order 3 Angstroms. This makes it possible to talk about classical Z^0 Coulomb potential and about spin dependent parity breaking Z^0 force. These two interaction energies sum up and this reduces the binding energy per proton in double strand for the other chirality.

3. The parity conserving Z^0 Coulomb interaction energy between two protons at different strands connected by a flux tube is given by the expression

$$\begin{aligned} & V_{PC}(r_{12}) = -kV(r_{12}) \ , \quad V(r_{12}) = \frac{\hbar}{r_{12}} \ , \\ & k = \alpha_Z Q_Z^2(p) \ , \qquad\qquad \alpha_Z = \frac{\alpha}{sin^2(\theta_W)cos^2(\theta_W)} \ , \quad Q_Z(p) = 1/4 - sin^2(\theta_W) \ . \end{aligned} \tag{4.3.2}$$

Here units $\hbar = 1$, $c = 1$ are used. r_{12} refers to the distance between dark protons at magnetic flux tubes assignable to DNA strands. Base pair thickness is about .34 nm and thickness of DNA double strand is about 2 nm. r_{12} could be between these two limits.

4. The spin dependent and parity non-conserving Z^0 interaction potential for Dirac spinors proportional to the gradient of the Z^0 Coulomb potential can be written as

$$V_{PNC} \ = \ \alpha_Z Q_Z^A(p) Q_Z^V(p) \gamma_5 V(r_{12}) \ . \tag{4.3.3}$$

Here $Q_Z^A = I_{3,A}/2 = 1/4$ is the axial weak charge of proton. The vectorial charge of proton is $Q_Z(p) = 1/4 - sin^2(\theta_W) \simeq 0.02$ so that it is much smaller than $Q_Z^A(p)$. Hence the axial force dominates by a factor $10^2/8 \sim 12.5$ for a given relative position. Usually the axial part becomes very small by symmetries as one estimates quantum averages but in the recent situation one cannot expect this since the positions of dark protons are in the first approximation fixed.

5. Using non-relativistic correspondence following from $\gamma_5 = \gamma_0\gamma_1\gamma_2\gamma_3$ and $(\gamma_5)^2 = -1$: this equation holds true also for $(\gamma^0\gamma^k p_k(m)$, and one has

$$\gamma_5 \rightarrow \frac{\overline{\sigma} \cdot p}{m_p} \ .$$

Here $\overline{\sigma}$ denotes Pauli sigma matrices expressible as $\gamma^0\gamma^i$). Using the replacement $p \leftrightarrow i\hbar_{eff,W}\nabla$ one can write V_{PNC} as the sum of the axial energies of the two protons

$$\begin{aligned} V_{s_1,s_2} \ &= \ V_{s_1} + V_{s_2} \ , \\ V_{s_i} \ &= \ \frac{\hbar_{eff,W}}{m_p}\overline{\sigma}_i \cdot \nabla_i V_{PC}(r_{12}) = (-1)^i \frac{k n_{eff,W}\hbar}{m_p}\hbar\frac{\overline{\sigma}_i \cdot \overline{r}_{12}}{r_{12}^2} \ . \ i = 1,2 \ . \end{aligned} \tag{4.3.4}$$

The parity breaking part of Z^0 force is proportional to $n_{eff,W}$ from the expression of momentum operator in terms of gradient operator so that dark matter physics makes itself visible and increases further the magnitude of parity breaking. The potential energy changes sign in reflection $\overline{r}_{12} \rightarrow -\overline{r}_{12}$. This gives

$$\begin{aligned} V_{s_1,s_2} \ &= \ -\frac{\alpha_Z}{4}(\frac{1}{4} - sin^2(\theta_W))\frac{n_{eff,W}\hbar}{m_p r_{12}}\frac{(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\overline{r}_{12}}{r_{12}}\frac{\hbar}{r_{12}} \\ &= \ \frac{1}{4}\frac{1}{(\frac{1}{4} - sin^2(\theta_W))}\frac{n_{eff,W}\hbar}{m_p r_{12}}\frac{(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\overline{r}_{12}}{r_{12}}V_{PC}(r_{12}) \ . \end{aligned} \tag{4.3.5}$$

6. For the vectorial part one has

$$V_{PC} = -\alpha_Z(\frac{1}{4} - sin^2(\theta_W))^2 V(r_{12}) \ . \tag{4.3.6}$$

The order of magnitude is about $V_Z = .16/x$ eV.

7. The condition that r_{12} corresponds to dark Compton length of proton implies in the first approximation $\frac{n_{eff,p}}{m_p r_{12}} = 1$ so that $n_{eff,W}$ proportionality gives factor $m_Z/m_p \simeq 91$. The order of magnitude parity breaking potential is the value potential at distance in the range $r_{12} \in [3.4, 2]$ nm. Let us expres the horizontal distance between the paired dark protons as $r_{12} = x$ Angstroms. This gives for the axial part

$$\begin{aligned} V_{s_1,s_2} &= \frac{1}{4}\frac{1}{(\frac{1}{4} - sin^2(\theta_W))}\frac{m_Z}{m_p}(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\frac{\overline{r}_{12}}{r_{12}}V_{PC}(r_{12}) \\ &\simeq .5\times 10^2 \times 91 \times \frac{V_{PC}(r_{12})}{x} \times (\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\frac{\overline{r}_{12}}{r_{12}} \ . \end{aligned} \tag{4.3.7}$$

The order or magnitude for the axial part is roughly $4550/x$ times larger than for the vectorial part. V_{PNC} is proportional to $1/x^2$ and V_{PC} to $1/x$. The condition that the states are spin eigenstates requires that spin quantization axes must be chosen along the flux tube connecting the dark protons. This is rather natural choice.

This would give for the axial part order of magnitude $V_{PNC} \sim 728/x^2$. For 2 nm distance one would obtain $V_{PNC} \sim 1.82$ eV. For 1 nm distance one would have $x = 10$ and this would give $V_{PNC} \simeq 7.28$ eV. For this value $V_{PC} \simeq 16$ meV, which is of same order of magnitude as thermal energy $kT/2$ at room temperature.

8. The process of adding dark protons to the increasing DNA sequence must be possible irrespectively of the direction of spin. The spin eigenvalue in the direction of the horizontal axis connecting the members of dark proton pair is assumed to be opposite for the members of the dark proton pairs of dark double strand. This assumption comes from the model of the dark genetic code. This demands that V_{NPC} is considerably smaller than strong binding energy E_B. For 1 nm distance one has $V_{PNC} \simeq 7.28$ eV considerably smaller than $E_B \simeq 28$ eV.

9. What is the relation of the fermionic chirality to the geometric chirality? The reflection for dark protons induces the reflection of the entire helix turning also its direction. The reflection permutes the dark protons of each pair since their positions are related by reflection in the plane orthogonal to z-axis $(x_2, y_2) = (-x_1, -y_1)$. One has $(x_1, y_1, z) \leftrightarrow (x_2, y_2, -z)$. A further rotation of π in say (x, z)-plane around say y-axis is symmetry and gives $(x_2, y_2, -z) \rightarrow (-x_2, y_2, z) = (x_1, -y_1, z)$. Hence the net effect is $(x_1, y_1, z) \rightarrow (x_1, -y_1, z)$ and DNA strand with an opposite screw direction is generated.

The model of dark genetic code motivates the assumption that the dark protons of the pair are spin eigenstates for the spin projection along the axis connecting the members of the pair. The direction of the spin quantization axis changes in reflection from that given by (x_1, y_1) to that given by $(x_1, -y_1)$ so that the states are not anymore eigenstates of the spin projection along this axis. Thus the fermionic chirality indeed correlates with the chirality of double strand and the two chiralities are in physically different position.

What happens at the level of classical fields? Kähler magnetic field transforms like angular momentum in reflections and rotations as is easy to see from its expression in terms of vector potential. Hence it does not change its direction in reflection but changes its direction in

the rotation. Hence the magnetic flux along flux tube changes to opposite in the reflection. This also affects the physics and induces effects at the level of dark strong interactions. The magnetic energy is of form $s \cdot B$ and vanishes classically. Quantum mechanically it does not vanish since s is operator and one can wonder what this implies physically.

Differences between standard model and TGD based description

The above estimate relies on standard model, which is quantum field theory in Minkowski space, and one can wonder what new elements TGD brings in. I do not try to estimate the effects in TGD framework but just list the differences.

1. In TGD framework space-time is 4-surface in $M^4 \times CP_2$ and this description must be replaced with a description using 8-D embedding spinors. At space-time level massive M^4 Dirac equation $p_k\gamma^k\Psi = m\Psi$ is replaced by 8-D chiral symmetry implying separate conservation of quark and lepton numbers with the analog of massless Dirac equation for the Kähler-Dirac gamma matrices, which are superpositions of M^4 and CP_2 gamma matrices. K-D gamma matrices are contractions of canonical momentum current densities of Kähler action with the embedding space gamma matrices. If the action is volume term, one obtains induced gamma matrices. The twistorialization of TGD by replacing the embedding space with the product of twistor spaces of M^4 and CP_2 and lifting space-time surfaces to their twistor spaces with induced twistor structure leads to the addition of volume term to Kähler action [K42]. This term corresponds to cosmological constant and is extremely small in the recent cosmology.

2. One can decompose K-D gamma matrices to their M^4 and CP_2 parts: $\Gamma^\alpha = \Gamma^\alpha_{M^4} + \Gamma^\alpha_{CP_2}$ and write the K-D equation as $\Gamma^\alpha_{M^4} D_\alpha \Psi = -\Gamma^\alpha_{CP_2}\Psi$. The presence of $\Gamma^\alpha_{CP_2}$ parts breaks conservation of M^4 chirality and serves as a signal for massivation. This operator is kind of mass operator acting non-trivial in electroweak spin degrees of freedom assignable to CP_2 and the action of its square is analogous to the action of mass squared operator.

   The understanding of particle massivation at this level does not seem however possible and the proper approach relies of p-adic thermodynamics for super-Virasoro representations for which ground states are characterized by the modes of embedding space spinors which are massless in 8-D sense and are eigenstates of M^4 mass squared operator with eigenvalues determined by CP_2 spinor Laplacian [K56]. Its action on M^4 chirality is same as action of mass in massive Dirac equation in M^4.

3. In the case of M^4 Dirac equation the multiplication of massive Dirac equation with γ_5 using anti-commutativity of γ_5 and γ_k gives $\gamma^k p_k \gamma_5 \Psi = -m\gamma_5\Psi$ instead of$p_k\gamma^k\Psi = m\Psi$. TGD framework γ_5 anti-commutes with $\Gamma^\alpha_{M^4}$ but commutes with $\Gamma^\alpha_{CP_2}$ so that also now one has similar equation $\Gamma^\alpha_{M^4} D_\alpha \Psi = +\Gamma^\alpha_{CP_2}\Psi$.

4.4 Did Life Evolve In The Womb Of Mother Gaia?

The idea that Earth interior, even the hot regions at the boundary of core and mantle, could serve as a seat for life, sounds totally outlandish in the standard physics framework. The many-sheeted space-time and hierarchy of Planck constants however allow to consider at least half seriously this idea although I hasten to admit that during these years I have very often had the feeling that this is one of those painfully stubborn fix idees that like to tease imaginative theoretician. This idea has variants characterized by a varying degree of craziness. It is a fact that rocks contain simple life forms down to surprising depths. A crazier idea is that underground lakes could have served as seats for evolving life. The really crazy variant of the idea is that the boundary between mantle and Earth's core as a regions containing strong gradients has been a seat of self organization leading to the emergence of life in some form.

Recently however completely unexpected support for this idea came as I learned that the geological evolution of Earth involves an anomaly. The continents would fit nicely to form a single super continent (Wegener's theory does not predict complete fit) if the radius of Earth would have been at the time of Cambrian explosion by factor of 1/2 smaller than now. The fact that Cambrian explosion is one of the biggies mysteries of biology puts bells ringing. For long time

ago this anomaly has inspired what have been called Expanding Earth Theory but the physical mechanism giving rise to expansion has been lacking.

Quantum TGD provides this mechanism. TGD predicts that cosmic expansion does not take place smoothly but via quantum jumps induces by the growth of the Planck constant by a factor of 2 for space-time sheet considered. This holds true also in planetary scales and TGD variant of Expanding Earth theory predicts relatively fast expansion of Earth's radius with a factor 2. The sudden appearance of completely new life forms in Cambrian explosion could be understood as a burst of various multicellular life forms which have developed in the womb of Mother Gaia sheltered from UV light and meteoric bombardment. What remains open is how deep in Earth's interior life is possible. This of course depends also on the definition of life: probably biological life would not be possible at core mantle boundary but one can consider much more general forms of molecular life.

In the following I will proceed in stepwise manner from not totally crazy (I hope so) to really crazy and discuss first the quantum version of Expanding Earth theory and its possible connection with Cambrian explosion and only after consider the really crazy possibilities.

4.4.1 Quantum Version Of Expanding Earth Theory And Cambrian Explosion

TGD predicts that cosmic expansion at the level of individual astrophysical systems does not take place continuously as in classical gravitation but through discrete quantum phase transitions increasing gravitational Planck constant and thus various quantum length and time scales. The reason would be that stationary quantum states for dark matter in astrophysical length scales cannot expand. One would have the analog of atomic physics in cosmic scales. Increases of $\hbar$ by a power of two are favored in these transitions but also other scalings are possible.

This has quite far reaching implications.

1. These periods have a highly unique description in terms of a critical cosmology for the expanding space-time sheet. The expansion is accelerating. The accelerating cosmic expansion can be assigned to this kind of phase transition in some length scale (TGD Universe is fractal). There is no need to introduce cosmological constant and dark energy would be actually dark matter.

2. The recently observed void which has same size of about 10^8 light years as large voids having galaxies near their boundaries but having an age which is much higher than that of the large voids, would represent one example of jerk-wise expansion.

3. This picture applies also to solar system and planets might be perhaps seen as having once been parts of a more or less connected system, the primordial Sun. The Bohr orbits for inner and outer planets correspond to gravitational Planck constant which is 5 times larger for outer planets. This suggests that the space-time sheet of outer planets has suffered a phase transition increasing the size scale by a factor of 5. Earth can be regarded either as n=1 orbit for Planck constant associated with outer planets or n= 5 orbit for inner planetary system. This might have something to do with the very special position of Earth in planetary system. One could even consider the possibility that both orbits are present as dark matter structures. The phase transition would also explain why n=1 and n=2 Bohr orbits are absent and one only n=3, 4, and 5 are present.

4. Also planets should have experienced this kind of phase transitions increasing the radius: the increase by a factor two would be the simplest situation.

The obvious question - that I did not ask - is whether this kind of phase transition might have occurred for Earth and led from a completely granite covered Earth - Pangeia without seas - to the recent Earth. Neither it did not occur to me to check whether there is any support for a rapid expansion of Earth during some period of its history.

Situation changed when my son visited me and told me about a Youtube video [F54] by Neal Adams, an American comic book and commercial artist who has also produced animations for geologists. We looked the amazing video a couple of times and I looked it again yesterday.

The video is very impressive artwork but in the lack of references skeptic probably cannot avoid the feeling that Neal Adams might use his highly developed animation skills to cheat you. I found also a polemic article [F1] of Adams but again the references were lacking. Perhaps the reason of polemic tone was that the concrete animation models make the expanding Earth hypothesis very convincing but geologists refuse to consider seriously arguments by a layman without a formal academic background.

The claims of Adams

The basic claims of Adams were following.

1. The radius of Earth has increased during last 185 million years (dinosaurs [I11] appeared for about 230 million years ago) by about factor 2. If this is assumed all continents have formed at that time a single super-continent, Pangeia, filling the entire Earth surface rather than only 1/4 of it since the total area would have grown by a factor of 4. The basic argument was that it is very difficult to imagine Earth with 1/4 of surface containing granite and 3/4 covered by basalt. If the initial situation was covering by mere granite -as would look natural- it is very difficult for a believer in thermodynamics to imagine how the granite would have gathered to a single connected continent.

2. Adams claims that Earth has grown by keeping its density constant, rather than expanded, so that the mass of Earth has grown linearly with radius. Gravitational acceleration would have thus doubled and could provide a partial explanation for the disappearance of dinosaurs: it is difficult to cope in evolving environment when you get slower all the time.

3. Most of the sea floor is very young and the areas covered by the youngest basalt are the largest ones. This Adams interprets this by saying that the expansion of Earth is accelerating. The alternative interpretation is that the flow rate of the magma slows down as it recedes from the ridge where it erupts. The upper bound of 185 million years for the age of sea floor requires that the expansion period - if it is already over - lasted about 185 million years after which the flow increasing the area of the sea floor transformed to a convective flow with subduction so that the area is not increasing anymore.

4. The fact that the continents fit together - not only at the Atlantic side - but also at the Pacific side gives strong support for the idea that the entire planet was once covered by the super-continent. After the emergence of subduction theory this evidence as been dismissed.

5. I am not sure whether Adams mentions the following objections [F6]. Subduction only occurs on the other side of the subduction zone so that the other side should show evidence of being much older in the case that oceanic subduction zones are in question. This is definitely not the case. This is explained in plate tectonics as a change of the subduction direction. My explanation would be that by the symmetry of the situation both oceanic plates bend down so that this would represent new type of boundary not assumed in the tectonic plate theory.

6. As a master visualizer Adams notices that Africa and South-America do not actually fit together in absence of expansion unless one assumes that these continents have suffered a deformation. Continents are not easily deformable stuff. The assumption of expansion implies a perfect fit of *all* continents without deformation.

Knowing that the devil is in the details, I must admit that these arguments look rather convincing to me and what I learned from Wikipedia articles supports this picture.

The critic of Adams of the subduction mechanism

The prevailing tectonic plate theory [F27] has been compared to the Copernican revolution in geology. The theory explains the young age of the seafloor in terms of the decomposition of the litosphere to tectonic plates and the convective flow of magma to which oceanic tectonic plates participate. The magma emerges from the crests of the mid ocean ridges representing a boundary of two plates and leads to the expansion of sea floor. The variations of the polarity of Earth's

magnetic field coded in sea floor provide a strong support for the hypothesis that magma emerges from the crests.

The flow back to would take place at so called oceanic trenches [F20] near continents which represent the deepest parts of ocean. This process is known as subduction. In subduction oceanic tectonic plate bends and penetrates below the continental tectonic plate, the material in the oceanic plate gets denser and sinks into the magma. In this manner the oceanic tectonic plate suffers a metamorphosis returning back to the magma: everything which comes from Earth's interior returns back. Subduction mechanism explains elegantly formation of mountains [F21] (orogeny), earth quake zones, and associated zones of volcanic activity [F37] .

Adams is very polemic about the notion of subduction, in particular about the assumption that it generates steady convective cycle. The basic objections of Adams against subduction are following.

1. There are not enough subduction zones to allow a steady situation. According to Adams, the situation resembles that for a flow in a tube which becomes narrower. In a steady situation the flow should accelerate as it approaches subduction zones rather than slow down. Subduction zones should be surrounded by large areas of sea floor with constant age. Just the opposite is suggested by the fact that the youngest portion of sea-floor near the ridges is largest. The presence of zones at which both ocean plates bend down could improve the situation. Also jamming of the flow could occur so that the thickness of oceanic plate increases with the distance from the eruption ridge. Jamming could increase also the density of the oceanic plate and thus the effectiveness of subduction.

2. There is no clear evidence that subduction has occurred at other planets. The usual defense is that the presence of sea is essential for the subduction mechanism.

3. One can also wonder what is the mechanism that led to the formation of single super continent Pangeia covering 1/4 of Earth's surface. How probable the gathering of all separate continents to form single cluster is? The later events would suggest that just the opposite should have occurred from the beginning.

Expanding Earth theories are not new

After I had decided to check the claims of Adams, the first thing that I learned is that Expanding Earth theory [F6], whose existence Adams actually mentions, is by no means new. There are actually many of them.

The general reason why these theories were rejected by the main stream community was the absence of a convincing physical mechanism of expansion or of growth in which the density of Earth remains constant.

1. 1888 Yarkovski postulated some sort of aether absorbed by Earth and transforming to chemical elements (TGD version of aether could be dark matter). 1909 Mantovani postulated thermal expansion but no growth of the Earth's mass.

2. Paul Dirac's idea about changing Planck constant led Pascual Jordan in 1964 to a modification of general relativity predicting slow expansion of planets. The recent measurement of the gravitational constant imply that the upper bound for the relative change of gravitational constant is 10 time too small to produce large enough rate of expansion. Also many other theories have been proposed but they are in general conflict with modern physics.

3. The most modern version of Expanding Earth theory is by Australian geologist Samuel W. Carey. He calculated that in Cambrian period (about 500 million years ago) all continents were stuck together and covered the entire Earth. Deep seas began to evolve then.

Summary of TGD based theory of Expanding Earth

TGD based model differs from the tectonic plate model but allows subduction which cannot imply considerable back-flow of magma. Let us sum up the basic assumptions and implications.

1. The expansion is or was due to a quantum phase transition increasing the value of gravitational Planck constant and forced by the cosmic expansion in the average sense.

2. Tectonic plates do not participate to the expansion and therefore new plate must be formed and the flow of magma from the crests of mid ocean ridges is needed. The decomposition of a single plate covering the entire planet to plates to create the mid ocean ridges is necessary for the generation of new tectonic plate. The decomposition into tectonic plates is thus prediction rather than assumption.

3. The expansion forced the decomposition of Pangeia super-continent covering entire Earth for about 530 million years ago to split into tectonic plates which began to recede as new non-expanding tectonic plate was generated at the ridges creating expanding sea floor. The initiation of the phase transition generated formation of deep seas.

4. The eruption of plasma from the crests of ocean ridges generated oceanic tectonic plates which did not participate to the expansion by density reduction but by growing in size. This led to a reduction of density in the interior of the Earth roughly by a factor 1/8. From the upper bound for the age of the seafloor one can conclude that the period lasted for about 185 million years after which it transformed to convective flow in which the material returned back to the Earth interior. Subduction at continent-ocean floor boundaries and downwards double bending of tectonic plates at the boundaries between two ocean floors were the mechanisms. Thus tectonic plate theory would be more or less the correct description for the recent situation.

5. One can consider the possibility that the subducted tectonic plate does not transform to magma but is fused to the tectonic layer below continent so that it grows to an iceberg like structure. This need not lead to a loss of the successful predictions of plate tectonics explaining the generation of mountains, earthquake zones, zones of volcanic activity, etc...

6. From the video of Adams it becomes clear that the tectonic flow is East-West asymmetric in the sense that the western side is more irregular at large distances from the ocean ridge at the western side. If the magma rotates with slightly lower velocity than the surface of Earth (like liquid in a rotating vessel), the erupting magma would rotate slightly slower than the tectonic plate and asymmetry would be generated.

7. If the planet has not experienced a phase transition increasing the value of Planck constant, there is no need for the decomposition to tectonic plates and one can understand why there is no clear evidence for tectonic plates and subduction in other planets. The conductive flow of magma could occur below this plate and remain invisible.

The biological implications might provide a possibility to test the hypothesis.

1. Great steps of progress in biological evolution are associated with catastrophic geological events generating new evolutionary pressures forcing new solutions to cope in the new situation. Cambrian explosion indeed occurred about 530 years ago (the book "Wonderful Life" of Stephen Gould [I133] explains this revolution in detail) and led to the emergence of multicellular creatures, and generated huge number of new life forms living in seas. Later most of them suffered extinction: large number of phylae and groups emerged which are not present nowadays.

   Thus Cambrian explosion is completely exceptional as compared to all other dramatic events in the evolution in the sense that it created something totally new rather than only making more complex something which already existed. Gould also emphasizes the failure to identify any great change in the environment as a fundamental puzzle of Cambrian explosion. Cambrian explosion is also regarded in many quantum theories of consciousness (including TGD) as a revolution in the evolution of consciousness: for instance, micro-tubuli emerged at this time. The periods of expansion might be necessary for the emergence of multicellular life forms on planets and the fact that they unavoidably occur sooner or later suggests that also life develops unavoidably.

2. TGD predicts a decrease of the surface gravity by a factor 1/4 during this period. The reduction of the surface gravity would have naturally led to the emergence of dinosaurs 230 million years ago as a response coming 45 million years after the accelerated expansion ceased. Other reasons led then to the decline and eventual catastrophic disappearance of the dinosaurs. The reduction of gravity might have had some gradually increasing effects on the shape of organisms also at microscopic level and manifest itself in the evolution of genome during expansion period.

3. A possibly testable prediction following from angular momentum conservation ($\omega R^2 = constant$) is that the duration of day has increased gradually and was four times shorter during the Cambrian era. For instance, genetically coded bio-clocks of simple organisms during the expansion period could have followed the increase of the length of day with certain lag or failed to follow it completely. The simplest known circadian clock is that of the prokaryotic cyanobacteria. Recent research has demonstrated that the circadian clock of Synechococcus elongatus can be reconstituted in vitro with just the three proteins of their central oscillator. This clock has been shown to sustain a 22 hour rhythm over several days upon the addition of ATP: the rhythm is indeed faster than the circadian rhythm. For humans the average innate circadian rhythm is however 24 hours 11 minutes and thus conforms with the fact that human genome has evolved much later than the expansion ceased.

4. Scientists have found a fossil of a sea scorpion with size of 2.5 meters [I52], which has lived for about 10 million years for 400 million years ago in Germany. The gigantic size would conform nicely with the much smaller value of surface gravity at that time. The finding would conform nicely with the much smaller value of surface gravity at that time. Also the emergence of trees could be understood in terms of a gradual growth of the maximum plant size as the surface gravity was reduced. The fact that the oldest known tree fossil is 385 million years old [I112] conforms with this picture.

Did intra-terrestrial life burst to the surface of Earth during Cambrian expansion?

Intra-terrestrial hypothesis is one of the craziest TGD inspired ideas about the evolution of life and it is quite possible that in its strongest form the hypothesis is unrealistic. One can however try to find what one obtains from the combination of the IT hypothesis with the idea of pre-Cambrian granite Earth. Could the harsh pre-Cambrian conditions have allowed only intra-terrestrial multicellular life? Could the Cambrian explosion correspond to the moment of birth for this life in the very concrete sense that the magma flow brought it into the day-light?

1. Gould emphasizes the mysterious fact that very many life forms of Cambrian explosion looked like final products of a long evolutionary process. Could the eruption of magma from the Earth interior have induced a burst of intra-terrestrial life forms to the Earth's surface? This might make sense: the life forms living at the bottom of sea do not need direct solar light so that they could have had intra-terrestrial origin. It is quite possible that Earth's mantle contained low temperature water pockets, where the complex life forms might have evolved in an environment shielded from meteoric bombardment and UV radiation.

2. Sea water is salty. It is often claimed that the average salt concentration inside cell is that of the primordial sea: I do not know whether this claim can be really justified. If the claim is true, the cellular salt concentration should reflect the salt concentration of the water inside the pockets. The water inside water pockets could have been salty due to the diffusion of the salt from ground but need not have been same as that for the ocean water (higher than for cell interior and for obvious reasons). Indeed, the water in the underground reservoirs in arid regions such as Sahara is salty, which is the reason for why agriculture is absent in these regions. Note also that the cells of marine invertebrates are osmoconformers able to cope with the changing salinity of the environment so that the Cambrian revolutionaries could have survived the change in the salt concentration of environment.

3. What applies to Earth should apply also to other similar planets and Mars [L60] is very similar to Earth. The radius is .533 times that for Earth so that after quantum leap doubling the radius and thus Schumann frequency scale (7.8 Hz would be the lowest Schumann frequency)

would be essentially same as for Earth now. Mass is.131 times that for Earth so that surface gravity would be.532 of that for Earth now and would be reduced to.131 meaning quite big dinosaurs! have learned that Mars probably contains large water reservoirs in it's interior and that there is an un-identified source of methane gas usually assigned with the presence of life. Could it be that Mother Mars is pregnant and just waiting for the great quantum leap when it starts to expand and gives rise to a birth of multicellular life forms. Or expressing freely how Bible describes the moment of birth: in the beginning there was only darkness and water and then God saidLet the light come!

To sum up, TGD would provide only the long sought mechanism of expansion and a possible connection with the biological evolution. It would be indeed fascinating if Planck constant changing quantum phase transitions in planetary scale would have profoundly affected the biosphere.

4.4.2 Did Pre-Biotic Life Evolve In Mantle-Core Boundary?

In the sequel this question is taken to mean simple prebiotic life forms preceding the life that possibly developed in underground seas near to the surface of Earth. One can imagine that prebiotic life moved from high temperature environment in the Earth's interior to the underground seas and charged molecules polymerized in this process and generated gel like phase around them.

Some arguments supporting IT life

The following arguments favor IT hypothesis.

1. Life would have originated already in interstellar space via evolution of primitive metabolic cycles involving temporary chemical storage of metabolic energy. The decay of molecules would have been induced by incoming radiation in UV and visible range and fusion would have occurred spontaneously liberating energy quantum. As stars and planetary systems formed these primordial precedessors of life would have naturally ended into the planetary and even interiors and received their metabolic energy from the hot environment.

   The dropping of particles, in particular protons and electrons, to large space-time sheets could have provided fundamental metabolic energy quanta, and the anomalies lines in the IR, visible, and UV radiation from interstellar space indeed contains this kind of lines with energies which can be understood in terms of the spectrum of these quanta [K11].

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

2. Boundary layers are ideal places for self-organization since they contain gradients which give rise to energy currents feeding self-organization. Liquid state is certainly crucial for life since this makes it possible quantum control the atomic space-time sheets very effectively. Ordinary life relies actually on the liquid crystal property of water which suggests that the same is the case quite generally. Thus those parts of the planetary core which correspond to boundary regions between solid and liquid phases and thus analogous to ordered water, could be ideal places for IT life forms to flourish, and it is actually difficult to imagine any other state of matter making possible life able to control the surrounding world effectively.

3. This picture is consistent with and would realize concretely the general vision about magnetosphere as a living system. In Earth's interior the mantle-core and core-inner core boundaries are especially interesting in this respect since these boundaries represent solid liquid boundaries.

4. Mg, Fe, Al, Si, and O are the dominant elements in mantle. Also Ca is present. These are the basic minerals involved with life. Also the minerals believed to be important for the evolution of polymer structures (like kaolinites consisting of Al, Si, and O) could form both at the hot space-time sheets and atomic space-time sheets. Below mantle-core boundary Fe and S are the prevailing elements. Fe-S centers play a key role in high temperature and pressure models for photosynthesis pathways [I54]. The establishment of the photosynthesis has been proposed to occur first in a sulphur containing environment with S replacing O. Inner core contains mainly Fe at hot space-time sheets.

5. A further possibly important aspect is the transparency of the liquid glass state at mantle-core boundary implying that visible light propagates over long distances without absorption. This might be absolutely essential for the possibility of visible photons to propagate through sufficiently long distances. For dark photons situation changes, and the transparency of liquid glass might be due the fact that some fraction of photons propagate as dark photons through it. Hence quartz is transparent in liquid state, and thus an optimal candidate for a medium whose behavior is quantum controlled from larger space-time sheets.

6. Magnetic body means the presence of both magnetic nervous system and the analog of blood circulation which could bring in sufficient amounts of elements needed for the synthesis of bio-polymers. The low concentrations of the elements needed to build up bio-monomers need not be a problem anymore since magnetic Mother Gaia could control them.

Structure of the Earth's interior and IT life

Combining the above described general ideas with the knowledge about Earth interior, one ends up with a more detailed picture.

1. Earth's interior decomposes into a relatively thin crust of thickness 30-60 km; a plastic mantle consisting mainly of Si, O, Mg, Fe, and Al mostly in form of silicates FeO-SiO_2 and MgO-SiO_2; a liquid core containing mainly Fe and S; and the inner core consisting mainly of solid Fe. There are thus two solid-liquid boundary regions. The upper boundary region could contain at least glass in liquid crystal form and the lower boundary region Fe in liquid crystal form.

2. Theoretically, the thickness for the mantle-core layer is expected to be of order few meters. The reflection of tectonic waves from mantle-core boundary has given evidence for a rich structure at this boundary and suggests that this expectation is not quite correct [F55]. Structures of thickness about 150 meters and with of several kilometers and between liquid and solid state have been identified at the top of the liquid core. One explanation is that lighter elements in the core-inner core boundary saturate and condense to solid form and being lighter than iron, raise up and form kind of puddles at the highest points of core.

   A more radical explanation is that these structures relate to a highly developed self-organization patterns which have given rise to some kind of life-forms. In the mantle-core layer the velocity of tectonic waves gets ultra-low. The velocity of sound in solid phase is quite generally higher than in liquid phase: this reflects directly the fact that the approximately harmonic forces between atoms are stronger. If liquid crystal phase is present the velocity in transversal liquid directions should be low. What is fascinating that sooner or later the analysis of reflected tectonic waves could give detailed information about mantle-core boundary.

3. Earth contains a previously unidentified core region with size of 300 km [F38]. Assuming that the magnetic field behaves like a dipole field down to the distances of order 300 km, the electronic cyclotron frequency at this distance is 5 GHz which corresponds to the wave length of about 6 cm, the size scale of BOLs for the dark companion $B_{end} = 2B_E/5$ of B_E. If the magnetization density below this distance is constant (so that the core would be like ordinary magnet), the magnetic field would be constant below this length scale.

Also some other experimental findings support this picture. It has been found that the times for of the compressional waves to travel through Earth in magnetic north-south direction and equatorial direction differ by 2-3 seconds [F50]. This suggests a gigantic crystal structure

with symmetry axis parallel to magnetic field. If the join along boundaries/flux tube condensate associated with atomic space-time sheets is hollow with a hole of radius 300 km, and if only $k = 151$ space-time sheet consisting of cold and magnetized iron is at this space-time sheet one can understand the crystal structure and how Earth's magnetic field results by magnetization. The estimated velocity of propagation for compressional waves in the crystal is about 3 km/s which is rather near to the 5 km/s for steel at room temperature. The appearance of a relatively small hole at the atomic space-time sheet is not so surprising since typically the field equations of TGD imply hole like singularities at given space-time sheet, and the hole could be analogous to black hole like singularity carrying inertial and gravitational masses at its boundary.

The simplest hypothesis is that the magnetic field associated with the plasmoids is the Earth's magnetic field in the core region of Earth. This would mean that some kind of plasmoid like life forms could reside also at the boundary layer associated with the new core. If the $k = 151$ space-time sheet is not ferromagnet above the radius $r = 300$ km, the boundary region could be in spin glass type magnetic phase and the bio-control from magnetic flux tubes would operate on the local direction of magnetization of the magnetized regions in the boundary region.

4.4.3 What Conditions Can One Pose On Life At Mantle-Core Boundary?

In the following some conditions on life at high temperatures at pressures are discussed as a mere intellectual exercise certainly not to meant taken deadly seriously. The speculations rely on the ideas which should be already familiar such as presence of strong gradients driving self-organization as indeed found in mantle-core boundary, magnetic bodies as controllers of biological bodies, dark matter as phases with large value of Planck constant able to form macroscopic quantum phases even at high temperatures, and the notion of universal metabolic currencies. Gel-sol phase transitions are also key element in the model of life. The condition that topological quantum computation like information processing based on braids requires existence of some kind of polymers defining braids and consisting of some basic building blocks stable under the conditions in question. The presence of analogs of lipids and cell membranes might be argued to be also necessary.

Plasmoid life as minimum option

The least non-realistic assumption is that IT life corresponds to plasmoid like life forms having magnetic body containing dark matter with large Planck constant controlling visible matter at high temperatures and in plasma phase. Fractality suggests that the high frequency analog of EEG is present and allows magnetic body to use the visible body as a sensory receptor and motor instrument. Frequencies and the values of Planck constant should be such that the energies of dark photons are above thermal energy. General vision about evolution suggests that the values of Planck constant are not very high so that frequency scale should be rather high.

1. Only biologically important ions and relatively simple molecules are expected to be present. Primitive metabolic cycles based on the fusion and decay of molecules induced by the radiation coming from environment can be considered. Cyclotron Bose-Einstein condensates of ions at magnetic flux tubes correspond to energies above thermal threshold only if the magnetic field is strong enough.

2. At temperature of about 4000 K at mantle core interior hydrogen bonds are still stable and metabolic energy quantum of $E_0 = .5$ eV is near thermal energy. There exists of course other metabolic quanta comings as power of two multiples of this quantum. Hence one can assumes that the dropping of protons and possibly of electrons from larger space-time sheets is responsible for metabolic energy quanta also now. One might argue that the typical p-adic length scale associated with the space-time sheets corresponds to the de-Broglie wave length a $\lambda_{dB} = \sqrt{3}\hbar/\sqrt{2mT}$ associated with electron. For electron this wavelength is around 35 slightly below $L(149) = 50$ A defining the thickness of the lipid layer of ordinary cell membrane. This scale increases with increasing $\hbar$.

3. Dark micro-waves amplified by quartz crystals might be crucial for the metabolism of plasmoid life-forms and replace visible light serving as the "food" of the terrestrial life forms.

Tectonic activity might be as important for these life-forms as solar radiation is for us. The crust and mantle could serve as amplifiers of em waves is a wide wave length range and make possible communications between IT and us.

Could topological quantum computation like activities be considered?

Could even more advanced life forms have evolved in the environment provided by mantle-core boundary? The presence of magnetic body makes possible braidings and simple versions for the mechanisms of memory, of topological quantum computation like information processing, and of catalysis. The presence of braids could be taken almost as a basic prerequisite of life. The presence of polymers of some basic molecules seems necessary if one wants something resembling DNA as TQC.

1. The presence of polymers consisting of some thermally stable basic units is the basic requirement. Hydrocarbons, lipids, amino-acids, and nucleotide polymers are not chemically stable at temperatures considered and mantle contains carbon only in trace amounts. The dominating elements in mantle are O, Si, and Mg whereas C is present only in trace amounts. S is present in core and thus also in mantle-core boundary. P is so called siderophilic element meaning that it tends to avoid Si. It is theorized that during the formation of Earth from magma ocean siderophilic elements including P separated from the mantle and went to core. In [F39] ratio of concentrations of P in core and mantle was estimated to be $D(P) = 30$ but the article does not report the concentration of P on mantle. In [F42] the phosphorus content of upper mantle is reported to be in the range 130-220 ppm which would give 3-7 percent in core. One can also imagine a formation of phosphate deposits in mantle core boundary: in absence of oxygen these kind of deposits are formed at sea floor. This kind of deposits might have formed at the top of the solid structures reported to exist at mantle core boundary [F55]. These structures could themselves have formed as light elements from inner core has gradually diffused to the mantle core boundary and could include phosphate deposits. If so then mantle-core boundary could contain considerable amounts of P and the replacement C, N, O with Si, P, O or Si, P, S might make sense.

2. Water flow is not the only flow which could generate the self-organization patterns defining braidings as the analogs of TQC programs. Since O dominates in mantle water is however the first guess. It is known that lower mantle can contain water at least up to.2 weight per cent [F44]. Water molecules are stable at the temperatures considered. The phase diagram of water [D2] shows that water is in overcritical phase in the temperatures and pressures considered4000 K and 1.4 million atm and at the bottom of the mantle.

3. The replacement of O with S might be considered in the mantle-core boundary since S is present in liquid core. Water would be replaced with hydrogen sulfide H_2S (responsible for the smell of rotten eggs!) if it appears in liquid form H_2S at temperatures and pressures considered. H_2S could be also used as food. H_2S is used by some bacteria living in deep ocean volcanic vents as a nutrient and also in our own gut: chemically this means that H_2S acts as electron donor in primitive photosynthesis like process to give ATP. That sulphur is essential for growth and physical functioning of plants might be due to the fact that it preceded oxygen based life [F2]. For instance, Cys and met containing sulphur are very important amino-acids.

4. The polymers should contain atoms acting as plugs for flux tubes acceptors flux tubes ($O =$ or $S =$) and terminal points of flux tubes identifiable as donors of hydrogen bonds. $S - H$ shows only very weak tendency for hydrogen bonding so that Si, P, O option looks more promising and is of course especially natural if IT life forms are considered. For instance, silicic acids [F30] satisfying the formula $[SiO_x(OH)_{4-2x}]_n$ are candidates for polymers containing both $O =$: s and OH: s. The presence of PO_4 could have made possible the formation simple analogs of nucleotides and AMP, ADP, and ATP molecules. It might be possible to abstract nucleotides with a polymer consisting of four different simple molecules which are phosphorylized and attached to the backbone made of sugars.

5. One can continue the analogy with carbon life even further. The backbone could consist of the variants of riboses with carbon cycles replaced with Si cycles, the variants of aromatic rings with C and N replaced with P, and base pairing between $N-H$ and $O=$ replaced with $P-H$ and $O=$. In the case of amino-acids one can also consider the replacement of $C, N \to Si, P$. It is of course far from obvious that the possibly existing silicon analogs of organic polymers are stable enough against rapid burning to SiO_2 and water. One might hope that the higher mass of Si stabilizes them chemically at temperatures involved. Professional chemist could probably kill this kind of ideas without big effort.

Could one consider analogs of cell membrane and gel phase crucial for cellular life?

1. The first guess would be that gel like phase might have emerged only after these plasmoid like life-forms came in contact with water and induced the generation of structure water in presence of metabolic energy feed. On the other hand, it could well be that structured dater might form around charged polymers also at high temperatures and pressures as in the case of ordinary cell. Also silica (SiO_2) is known to form a gel. Also glass consists of SiO_2: the transparency of glass to visible light might be also relevant. A group of algae polymerize silicic acid to so called biogenic silica used to construct their cell walls.

2. Lipids forming cell membrane would be replaced with structures consisting of hydrosilicons with the silicon analog of carbon residue as its hydrophilic head and silicon analog of the hydrophobic fat forming the tail of the lipid. The formation of these double layers would be an outcome of self-organization. The analogs of phospholipids having PO_4 at their hydrophilic tail would be needed for TQC.

3. Super-conductivity plays an essential role in the TGD based model for cell membrane. Large enough values of Planck constant in principle allow to have super-conductivity at magnetic flux tubes.

4. The requirement that the energy $E = ZeV$ associated with Josephson junctions over the cell membrane like structure is above thermal energy requires very strong electric field over the membrane unless the membrane is thick. In the case of ordinary cell membrane the energy is rather near to thermal energy at room temperature. Now the energy would be roughly ten times higher and correspond to about.5 eV. Whether this kind of strong electric field is realizable is not clear. One might hope that the densities of ions could be high enough in the dense environment.

Do metabolism and photosynthesis possess signatures telling about intra-terrestrial evolution?

Also the intra-terrestrial metabolism should rely on atomic/molecular "Karma's cycles". Assume that the protons and electrons can be modeled as free particles in box. This assumption might not be correct as the model for ATP- ADP involving Coulomb binding energy of proton with negatively charge ATP molecule reducing the size of metabolic energy quantum already demonstrated. In this case the wavelength would be roughly by a factor 1/2 longer than predicted meaning Coulombic binding energy of order.25 eV.

In any case, with this assumption the quanta saturating to $E_{max}(k) = [.5, 1, 2, 4, 8, 16]$ eV and wavelengths $\lambda_{min} = [1240, 620, 310, 155]$ nm could have been important. The maximal quanta $E_0(k)$ correspond to the dropping from space-time sheet labeled by $k = 137 - \Delta k$ (in the case of proton) to a very large space-time sheet. The size of the space-time sheets would be given by $L(k) = r \times 2^{(k-151)/2} \times L(151)$, $L(151) = 10$ nm and $r = \hbar/\hbar_0$ the ratio of the Planck constant in question to its standard value. Actually and entire spectrum of quanta given by the formula $E_n = (1-2^-n)E_0(k)$ saturating to $E_0(k)$ for large values of n. In [K11] the presence of unidentified lines in the spectrum of UV, visible, and IR radiation from interstellar space has been shown to have a satisfactory explanation in terms of universal metabolic energy quanta.

The spectrum of diffuse interstellar medium exhibits three poorly understood structures [I17]: Unidentified Infrared Bands (UIBs), Diffuse Interstellar Bands (DIBs) [I10], and Extended Red Emission (ERE) [I137] allowing an interpretation in terms of dropping of protons or electrons

(or their Cooper pairs) to larger space-time sheets. The model also suggests the interpretation of bio-photons in terms of generalizes EREs.

1. Unidentified infrared bands (UIBs) contain strong bands at $\lambda = 3300, 6200, 11, 300$ nm. Th

2. There are diffuse interstellar bands (DIBs) at wavelengths 578.0 and 579.7 nanometers and also at 628.4, 661.4 and 443.0 nm. The 443.0 nm DIB is particularly broad at about 1.2 nm across - typical intrinsic stellar absorption features are 0.1 nm [I17].

3. The Extended Red Emission (ERE) [I17, I137] is a broad unstructured emission band with width about 80 nm and located between 540 and 900 nm. The large variety of peak wavelength of the band is its characteristic feature. In majority of cases the peak is observed in the range 650-750 nm but also the range 610-750 nm appears. This general vision can be compared with experimental facts.

The generalization ontogeny recapitulates phylogeny principle would suggest that the recent metabolism should have some features serving as telltale signatures of the IT past. The IT past could in turn reflect the primordial evolution in interstellar dust. The signatures of this period would be maxima of the action spectrum for wavelengths which correspond to both the universal metabolic energy quanta and transition energies for transitions of simple molecules present in the molecular dust. Visible and UV range are the most promising regions to consider.

1. There are two wave lengths of maximal effectiveness in the photosynthesis of plants and these correspond to what are called photo-system I and II (see p. 287 of [I48]). Photo-system I is maximally activated at $\lambda = 680$ nm, corresponds to the chlorophyll a, and is not involved with the oxygen evolution. $k = 136$ corresponds to wavelength saturating to $\lambda_{min} = 620$ nm (1 eV). The model of ATP- ADP process suggests that Coulombic binding energy is increases the wavelength.

2. Photo-system II is activated by shorter wave lengths and maximum effectiveness is between 500-600 nm. Photo-system II utilizes second type of chlorophyll (b, c or d) plus some accessory pigments. All photosynthetic cells producing oxygen possess both photo-systems whereas bacteria which do not produce oxygen have only the photo-system I. Hence at least the photo-system I might derive from a very early intra-terrestrial period. The spectrum of metabolic energy quanta for $k = 135$ corresponds to the wave length range [620, 413, 354, .., 310] nm. Coulombic binding energy could increase the wavelength from the 413 nm for $k = 135$ and $n = 2$.

3. The action and absorption spectra of green alga Ulva Taeniata, see p. 284 of [I48], have besides 680 nm maximum also a broad maximum in the range 400-500 nm peaked around 430 nm. The action spectrum has also a shoulder like structure around 600 nm. For $k = 135$ the first peak could correspond to $n = 1$ (620 nm) and second peak $n = 2$ (412 nm).

4. For some bacteria encountered in hot springs [I31] the effective wave length range is in the near infrared range 700-1000 nm rather than in the range of visible frequencies dominating the sunlight. This looks strange since in general the evolution favors maximal metabolic economy. This leads to ask whether these bacteria might be kind of living fossils evolved in an intra-terrestrial environment. This range of wavelength corresponds in a reasonable approximation to that obtained by scaling the wave length range 400-500 nm in previous case and thus to $k = 136$.

5. DNA bases (A, G, T, C) strongly absorb UV light at around 260 nm. For $k = 16$ the nearest metabolic energy quanta correspond to $n = 2$ and $n = 3$ giving wavelengths 310 nm and 207 nm. For proton the p-adic length scale is below atomic size for $\hbar/\hbar_0 \geq 16$.

4.4.4 What About Analogs Of EEG?

It looks strange to mention EEG if one speaks about primordial life forms. These analogs of EEG have of course nothing to do with brains. The prediction is that the fractally scaled counterparts of EEG (in loose sense of course) provide the fundamental communication and control tool for

the magnetic body. This analog of EEG is determined by the cyclotron energy spectrum nE_c of biologically important ions scaling like $\hbar$ and by the characteristic energy $E_J = ZeV$ associated with Josephson junctions assignable to membrane like structures and having no dependence on $\hbar$. The energies nE_c and the differences $nE_c \pm E_J$ define the harmonics of bands and their satellites. alpha band corresponds to E_c and beta and theta bands to differences in the case of ordinary EEG.

Conditions from the thermal stability of the analog of EEG

The analogs of EEG and its scaled up variants are in a fundamental role in the control of biological body by magnetic body and this should hold true also for ITs. According to the model of EEG resulting as a special case of the model for the fractal hierarchy of EEGs and its generalizations [K36], the analog of EEG involves two components.

1. Cyclotron component

The first component corresponds to the harmonics of cyclotron frequencies of biologically important ions: many of them belong to the alpha band in the case of ordinary ions.

Since 10 Hz corresponds to a secondary p-adic time scale assignable to electron defining an inherent time scale of elementary particle in zero energy ontology, one can ask whether this frequency means breakdown of the fractality hypothesis and raises the frequency scale of ordinary EEG in special role. One can also wonder whether 10 Hz frequency could define a universal biorhythm.

Dark ions reside at magnetic flux sheets traversing DNA and cyclotron radiation affects directly DNA. Cyclotron frequencies are associated with motor control affecting directly DNA and inducing gene expression among other things. The models leads naturally to the introduction of the notions of super genome and hyper genome [K36].

2. Josephson junction component

Josephson junctions assumed to be associated with cell membrane define second contribution to EEG as frequencies associated with coherent state of photons emitted by Josephson current. This component is present only if Josephson junctions, naturally assignable with a membrane like structure separating the plasmoid from environment, are present.

The frequencies are expressible as $f_{n,\pm} = nf_c \pm f_J$ and in the case of ordinary EEG alpha band and its harmonics split into counterparts of beta and theta band. alpha band has scaled variant also in more general case and corresponds to ions which define alpha band for ordinary ions.

1. The essential condition is that cyclotron energy scale is above the thermal energy $E_{th} = 2.88T$ ($k_B = 1$ in the units used). This fixes the minimal value of the integer k_d characterizing the level of dark matter hierarchy involved. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. For ordinary EEG frequency of order 1 Hz the minimal value of k_d is roughly $k_d = 44$. DNA cyclotron frequencies assuming that the charge of DNA is solely due to the phosphate groups PO_4^{2-} are around 1 Hz and just above the thermal threshold.

2. Second condition is that Josephson energy determined by the membrane voltage defines Josephson energy which is above thermal energy. This gives $Q_{em}eV \geq 2.88T$ for far from vacuum extremals. For almost vacuum extremals the classical Z^0 field proportional to the classical em field contributes to the coupling and one must replace the charge Q_{em} of charge carrier with effect em charge Q_{eff} [K36]: this increases the scale of Josephson energies roughly by a factor 10. For far from vacuum extremals Josephson energies are near thermal energies whereas for almost vacuum extremals they are in visible and UV region, and one can identify bio-photons and EEG photons as decay products of dark Josephson photons.

3. Superconductivity prevails only below some critical temperature whereas vacuum extremal property is expected to be possible only above some critical temperature. This suggests that cell membrane functions properly only in a narrow temperature range. The range 36-37 C is suggested by the fact that the effects of ELF em fields on vertebrate brain are observed only in this range.

Josephson frequency f_J is inversely proportional to $\hbar$ and would scale in the case of EEG would scale as

$$f_J = \frac{T}{T_{room}} \times f_{J,room} \ ,$$

where $f_{J,room} \simeq 5$ Hz holds true. alpha band and its harmonics and also the widths of theta and beta bands would scale like B. The positions of theta and beta bands would scale like temperature, and one would have the formula

$$f_{n,\pm} = \frac{B}{B_E} n f_c \pm \frac{T}{T_{room}} f_J$$

for the frequencies in the generalized beta and theta bands, when $k_d = 44$ holds true also in the high-T environment.

It is illustrative to consider some examples.

1. *Mantle-core boundary*
   The temperature is $T = 4000$ K $\sim 13 T_{room}$ at the mantle-core boundary. This temperature allows simple ordinary molecules like carbon monoxide and water (due to the high pressure). Thermal energy is still eV and below Josephson energy and super-conductivity is possible only if cyclotron energies are high enough. For 5 Hz cyclotron frequency $r = 47$ gives energy of order eV. One could thus consider the possibility that both the super-conductivity and criticality could be possible in scaled up temperature range.

2. *Sunspots*
   The average temperature of the solar photosphere is about 5800 K whereas the minimum temperature is $T_{min} = 4000$ K and same as the temperature at mantle-core boundary. Inside sunspots the temperature varies in the range 3000-4800 K and sunspots, which are analogous to tornadoes, would be good candidates for the seats of solar life forms. Spectral analysis demonstrates the presence of water inside sunspots [E3]. There is also evidence for a solid calcium ferrite surface at photosphere [E14].

   The value of the sunspot magnetic field is between 1600-2500 Gauss and thus cyclotron frequency is about $3200 - 5000$ times higher than at the surface of Earth. Also in this case $k_d = 44$ level would correspond to thermally stable "EEG" photons with frequencies in the range of ordinary EEG.

What could the analog of EEG for IT look like?

In the following estimates for cyclotron frequencies are for the possibly existing dark companion $B_{end} = 2B_E/5$ of the Earth's magnetic field for which the effects of ELF fields on vertebrate brain provide a direct support.

If the sensory representations of IT life-forms are realized at the personal magnetic canvas and at magnetosphere in the same manner as ours, the cyclotron frequency of the representing ion at distance r_1 is must be same as the cyclotron frequency of the represented ion at distance r_0. Assuming that magnetic field strength scales like $1/r^3$, this gives cyclotron transitions at the distance of about

$$r_1(A) = (A/A_1)^{1/3} \times r_0 \ ,$$

giving

$$y(A, A_1) = (A/A_1)^{1/3} \times x \ .$$

Here $r_0 = xR$ is the radius associated with the life-form, and $r_1 = yR$ is the distance at which the sensory representation is realized. R denotes the radius of Earth and A the mass of the ion at r_0 associated with IT cyclotron transition and A_1 the mass of the ion at r_1 defining the cyclotron transitions associated with the sensory representation.

If the most important frequencies of generalized EEG correspond to cyclotron frequencies, if prebiotic live resides at the mantle-core and core-inner core boundaries, and if the magnetic

field inside Earth behaves as dipole field in a reasonable approximation, one can deduce the EEG frequency range of aliens by scaling the human frequency range by the ratio

$$x^{-3} = (\frac{R}{r})^3 = \left[\frac{f_S(r)}{f_S(R)}\right]^3 \quad ,$$

where r is the distance of the boundary region from the center of the Earth. The constraint that representation is realized in inner magnetosphere gives the bound $y \leq 6$ and the constraint that it is realized in ionosphere gives $y \simeq 1$.

1. Biosphere

In this case the basic equation is obtained by putting $x = 1$ in the general equation so that one has

$$y = (\frac{A}{A_1})^{1/3} \quad .$$

For protonic representations with $A_1 = 1$ possible in entire inner magnetosphere the constraint $y \leq 6$ allows all possible values of A.

2. Mantle-core boundary

For mantle-core boundary the ratio is roughly $x^{-3} = 7.1$ so that the EEG frequency range $1.5 - 90$ Hz scales up to $107 - 639$ Hz. Sensory representations can in this case be realized as ionic transitions in atmosphere. The basic equation is

$$y = (\frac{A}{A_1})^{1/3} x \quad ,$$

where A is the mass number of the ion in mantle-core boundary and A_1 is the mass number of representative ion. For protonic representation one has

$$y = 1.92 A^{1/3} \quad .$$

The condition $y \leq 6$ guarantees that representation is realized in the inner magnetosphere and gives $A \leq 27$. This corresponds in ordinary EEG to frequencies $f \geq 11$ Hz. For $A_1 > 1$ also scaled up variants of alpha and theta frequencies are representable: note however that the densities of these ions are probably much smaller than in ionosphere.

One can consider also ionospheric ion representations satisfying $y \simeq 1$ for mantle-core boundary. Now the mass numbers of the ions involved are related by

$$\frac{A}{A_1} \simeq x^{-3} \simeq 7.1 \quad .$$

The biologically most interesting ions have $A > 7$ and are representable. One manner to realize this sensory representation is using cells or brains of various organisms and one might consider the possibility that we actually are life-forms which have developed as magnetospheric sensory representations of the life-forms at the mantle-core boundary.

3. Core-inner core boundary

For core-inner core boundary the ratio is roughly $x^{-3} = 263$ for $f_S(r) = 50$ Hz and $x^{-3} = 135$ for $f_S(r) = 40$ Hz. In this case only electronic sensory representations are possible and one has

$$y = (\frac{Am_p}{m_e})^{1/3} x \quad ,$$

1. For $x^{-3} = 263$ this gives

$$y \simeq 1.98 \times A^{1/3} \quad .$$

The range $[1, 6]$ for y corresponds to the inner magnetosphere and the upper bound $A \leq 27$ and to scaled up variants of cyclotron frequencies above 11 Hz in ordinary EEG. Only beta and gamma bands would be represented.

2. For $x^{-3} = 135$

$$y \simeq 2.48 \times A^{1/3}$$

The upper bound for A is $A \leq 14$ and to the scaled up variants of cyclotron frequencies above ~ 20 Hz in ordinary EEG.

4. Inner core-most inner core boundary

The boundary of the most inner core of radius 300 km could also be carrier of life-forms, perhaps plasmoid like life-forms. The simplest hypothesis is that the magnetic field associated with the plasmoids is the Earth's magnetic field in the core region of Earth, which would be constant and of order .2 Tesla below this distance if dipole approximation makes sense.

If important "EEG" frequencies correspond to cyclotron frequencies, part of the "EEG" would be scaled up by a factor $2^{169-157} = 2^{12} \simeq 4000$ so that EEG frequency range $.25 - 90$ Hz would be mapped to $1 - 360$ kHz. Ionic cyclotron frequencies would be in the MHz range with proton cyclotron frequency equal to 1.2 MHz. The cavity resonance frequency analogous to the lowest Schumann frequency for a structure with radius 300 km is 159 Hz.

If the sensory representations of IT life-forms possibly existing at at $r_0 = 300$ kilometers are realized as electronic cyclotron transitions one has

$$y \simeq .59 \times A^{1/3} \quad .$$

Ions with $A \geq 6$ would be represented above Earth's surface. All ionic representations would be realized in Earth's interior.

4.5 Model For The Hierarchy Of Josephson Junctions

As far as hierarchy of EEGs and its generalizations is considered the hierarchy of Josephson junctions assignable to cell membrane itself is relevant. Dark matter hierarchy and p-adic fractality allow to imagine a fractal hierarchy of structures analogous to cell membrane with arbitrarily large thickness. One can even imagine scaled up variants of cell membrane with different p-adic length scale and value of Planck constant but possessing same membrane potential as ordinary cell membrane. The generalization of the embedding space helps to understand what is involved and is discussed in Appendix.

4.5.1 The Most Recent Model For The Generation Of Nerve Pulse

For some time ago I learned [J1, J2, J16, J17, J20] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (TQC) [K2] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of TQC. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating soliton solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can

be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that soliton velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as TQC sine also microtubule-cell membrane systems are good candidates for performers of TQC. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane TQC would represent higher level TQC distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several ways. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [L2], [L2] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number obtained by replacing one or more neutral color flux tubes connecting nucleons of neutral atom with a charged one. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

4.5.2 Quantum model for sensory receptor

This original model of nerve pulse and EEG was still based on the implicit assumption that the space-time sheet carrying the Josephson currents is far from vacuum. The model for sensory receptor and sensory qualia however led to a the proposal that the space-time sheet in question is near vacuum extremal [K43, K77]. Near vacuum extremal property does not affect the general structure of the model in an essential manner.

1. The only change [K77, K78] is the replacement of charges ± 1 of ions with effective charges given as

$$Q_{eff} = -\frac{Z-N}{2p} + 2Z + q_{em} \quad . \tag{4.5.1}$$

Z and N denote nuclear charge and neutron number. $p = sin^(\theta_W)$ corresponds to Weinberg angle. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 4.1** gives the values of Josephson energies for some values of resting potential for $p = sin^(\theta_W) = .0295$ reproducing the frequencies of peak sensitivity for photoreceptors. Rather remarkably, they are in IR or visible range.

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 4.1: 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.

2. The energies are in UV and visible range. Hence one can consider also Josephson junctions with considerably lower membrane potentials of order mV are possibly without losing the thermal stability. For instance, one could consider $k = 151, 157, 163, 167$ Josephson junctions with a membrane potential scaling as $1/L(k)$. For $k = 167$ the energies would be scaled down by a factor $2^{-(167-151)/2} = 2^{-8}$ giving for $V_{eff} = .09$ V a photon energy somewhat below the thermal energy at room temperature. On the other hand, the fact that Josephson junctions with a vanishing Z^0 field are at the verge of thermal instability suggests that also they might be present in living matter.

3. From **Table 4.1** one can evaluate the value of Planck constant for a given Josephson frequency for various ions. For $f_J = 5$ Hz giving a first estimate for neuronal Josephson frequency and V=-55 mV corresponding to the critical voltage for the generation of action potential one obtains the values $r = \hbar/\hbar_0 = (1.51, 1.89, 2.11, 1.59) \times 2^{46}$ for $(Na^+, Cl^-, K^+, Ca^{++})$. For V=-70 mV corresponding to the resting potential of neuron and same Josephson frequency one obtains $r = (0.961.201.341.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2. A good mnemonic is that the Josephson energies of biologically important ions vary in an interval, which is in a reasonable approximation half octave ($E_J(K^+)/E_J(Na^+) = 1.3958 \simeq \sqrt{2} \simeq 1.4142$).

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions. **Table 4.1** gives the values of Josephson frequencies of basic biological ions for typical values of the membrane potential.

1. The maximum value of the action potential during nerve pulse is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^{+} Josephson frequency corresponds to 2 eV metabolic energy quantum.

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^{-} corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

4.5.3 The Role Of Josephson Currents

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

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

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

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

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

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

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \quad , \quad \epsilon(u) = -1 \quad , \epsilon(d) = 1 \tag{4.5.2}$$

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses m(u)=2 MeV, m(d)=5 MeV,

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

Table 4.2: Cyclotron frequencies of quarks and electron in magnetic field $B_{end} = .2$ Gauss for standard vacuum with very small Z^0 field and nearly vacuum extremal.

and m(e)=.5 MeV are given by **Table 4.2** for the two options. If one assumes that B_{end} defines the upper bound for field strength then he standard option would require both d quark and electron. Gor $d$quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

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

4.5.4 What Is The Role Of The Magnetic Body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This leaves a huge amount of details open and the almost impossible challenge of theoretician is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

Is magnetic body really needed?

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

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

Is motor action time reversal of sensory perception in zero energy ontology?

One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J12]. Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism

would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

What magnetic body looks like?

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

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

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

3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

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

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

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

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

2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and

change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.

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

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

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

   $$\int BdA = n\hbar$$

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

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

   $$\oint (p - ZeA)dl = n\hbar \ , \tag{4.5.3}$$

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

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

   $$N = \frac{2m}{RZ^2e^2} \tag{4.5.4}$$

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

   $$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} \ . \tag{4.5.5}$$

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

What are the roles of Josephson and cyclotron photons?

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

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

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

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

4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characteristizing the sensory or motor pathway.

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

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

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

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

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

4.5.5 Dark Matter Hierarchies Of Josephson Junctions

The hierarchy of Josephson junctions assignable to cell membrane and characterized by values of Planck constant provides a rather nice model for cell membrane but one can consider also more general dark hierarchies of Josephson junctions. This model conforms with the general vision that living matter processes information by locating it to various pages of the "Big Book".

Maximization of Planck constant in quantum control and communication in living matter

The sectors of the embedding space for which CD and CP_2 are replaced with their n_a- *resp.* n_b-fold coverings define the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter. The reason is that the value of the Planck constant is maximized and given by $r = \hbar/\hbar_0 = n_a n_b$. Also the number of pages with same Planck constant would be finite unlike for the more general option allowing rational values of Planck constant. In particular, infinite number of pages with the standard value of Planck constant would be possible and this might lead to mathematical difficulties.

Experimental constraints allow to consider also the possibility that only covering spaces are possible. One must be however very cautious in making hasty conclusions. If also factor spaces are allowed one can have G_a or G_b as discrete and exact symmetry groups at the level of dark matter and these symmetries would be manifested as approximate symmetries of the visible matter topologically condensed around the dark matter.

1. In M^4 degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the exact G_a-invariance of dark matter quantum states. Molecular rotational symmetries correspond typically to small groups G_a and might relate to this symmetry. Small values of n_a would not affect dramatically the value of Planck constant if n_b is large.

2. $G_a = Z_n$, $n = 5, 6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tetrahedral, octahedral, and icosahedral symmetries appear in living matter.

In the sequel only integer values of Planck constant will be considered. An especially interesting hierarchy corresponds to ruler and compass integers expressible as a product of power of two and distinct Fermat primes (see Appendix). The reason is that these integers correspond to number theoretically very simple quantum phases. This hierarchy includes as a special case powers of two and one can imagined a resonant interaction between p-adic length scale hierarchy and hierarchy of Planck constants.

Dark hierarchy of Josephson junctions with a constant thickness

The model for EEG relies on fractal hierarchy of cell membrane like structures with a fixed thickness and membrane potential. Therefore cell membrane thickness is not scaled by $\hbar$ as one might naïvely expect. Same applies to magnetic flux tubes: this is possible since the condition for the quantization of magnetic flux can be replaced with a more general one if one allows charged currents at the boundaries of flux quanta [K77]. In this model the value of $\hbar$ becomes a measure for the evolutionary level of cell and neurons in hippocampus, associative regions of cortex and their motor counterparts, and frontal lobes are expected to correspond to the largest values of $\hbar$ measuring also the time scale of long term memory and planned action. Note that cell membrane corresponds to twin primes $k = 149$ and $k = 151$ with $k = 151$ defining a Gaussian Mersenne so that it is indeed very special.

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei and also for a collection flux tubes parallel to axons. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons?

The quantum model for qualia [K77] implies that Josephson radiation travels through flux tubes parallel to sensory pathways and there could be also a horizontal organization of the neurons-at least at the level of sensory receptors in the sense that magnetic flux tubes connecting DNA nucleotides to lipids of cell membrane fuse to form longer flux tubes between DNA nucleotides of different cells when sensory receptor is active. Axons could thus be seen as the analogs of text

$(k, k+2)$	$(137, 139)$	$(149, 151)$	$(167, 169 = 13^2)$	$(179, 181)$
$L_e(k)$	.78 A	5 nm	$2.5\mu m$	.32 mm
$(k, k+2)$	$(191, 193)$,	$(197, 199)$		
$L_e(k)$	1 cm	8 cm		

Table 4.3: Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

lines which however can interact with each other. Similar organization would appear at the level of flux sheets traversing through DNA strands.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading" ? One is also forced to ask whether these brain waves are induced by waves propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

An objection against a fractal hierarchy of Josephson junctions with thickness scaling as $\hbar$

One can consider also a hierarchy of Josephson junctions with a scaled up thickness proportional to $\hbar$ instead of constant thickness. If these junctions have same voltage at all levels of the hierarchy a resonant interaction between various levels of the hierarchy would become possible.

One can represent common sense objections against this idea. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like 10^{-7} V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about.3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [F48].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order.08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order 10^{-7} V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

4.5.6 P-Adic Fractal Hierarchy Of Josephson Junctions

p-Adic length scale hypothesis allows to imagine a hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore. Twin primes are especially interesting since they would naturally correspond to pairs of structures analogous to a pair of lipid layers defining cell membrane.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

Also Gaussian Mersennes define highly interesting p-adic length scales and the length scale range between cell membrane thickness and the size of cell contains as many as four Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$. Only the smallest one is associated with a twin prime but p-adic length scale hypothesis allows also non-prime values of k.

The possibility of a p-adic hierarchy of membrane like structures accompanied by Josephson junctions

One can imagine the existence of fractally scaled up variants of cell membrane defining hierarchy of Josephson junctions possibly realized as magnetic flux tubes. The possible existence of this hierarchy is however not relevant for the model of EEG in its recent form.

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 3). Second hierarchy corresponds to dark matter hierarchy for which length scales come as $\sqrt{r}L(k)$), $r = \hbar/\hbar_0$. Later the question which values of r are favored will be discussed.

The size of cell nucleus varies in the range $(L(169) = 5\ \mu m, 2L(169) = 10\ \mu m)$. This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new would emerge at each level.

Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving values of Planck constant. The original hypothesis was that the values of Planck constant comes as $r \equiv \hbar/\hbar_0 = 2^{11k}$ of given p-adic length scale assignable to biological membrane like structure. A possible justification for the hypothesis is that the ratio of electron and proton masses is rather near to 2^{11} and that this number appears in quantum TGD in the role of fundamental constant. This hypothesis is however un-necessarily restrictive and it is better to consider at least the values of r given as products of two ruler and compass integers n_F expressible as a product of distinct Fermat primes and some power of two. The justification comes from the number theoretic vision about evolution and number theoretical simplicity of the phases $q = exp(i2\pi/n_F)$ (Appendix).

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding different values of Planck constant would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to the magnetic body or via the DNA. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

Chapter 5

Evolution in Many-Sheeted Space-Time: Part II

5.1 Introduction

This chapter is the second part of a 2-part chapter devoted to the understanding of evolution in TGD Universe. The introduction to the first part describes the basic ideas and lists the basic questons attacked in these chapters. Here only the topics discussed in this chapter are listed.

5.1.1 Topics Of The Chapter

The topics of the chapter has been restricted to those, which seem to represent the most well-established ideas. The topics of the article have been restricted to those, which seem to represent the most well-established ideas about evolution in TGD Universe. There are many other, more speculative, ideas such as the notion of fractional atom [K37] based on fractalization of electron charge and strong form of the hypothesis that some life forms has evolved in "Mother Gaia's womb", maybe even in the hot environment defined by the boundary of mantle and core.

1. A quantum vision about biological evolution and evolution of brain is discussed on basis of the wisdom gained from the construction of the models of sensory receptor and generalized EEG [K43, K36]. As I started to develop this vision, several obvious questions popped up. The preferred values of (effective) Planck constant are assumed to be integer multiples of ordinary Planck constant: does this integer have preferred values? For eight years later I take the original speculative answer to this question with a grain of salt. Can one distinguish between evolution of biological and magnetic body and identify cultural evolution as evolution of magnetic body? EEG and its variants (and the predicted scaled variants of these) are expected to characterize living organisms, even super organisms like ant nest, bee hive, and bacterial colony: is this really the case? Does bee hive possess a long term memory and what is the role of the queen? One can also ask questions about the evolution of nervous system in the same conceptual framework. Are the magnetic bodies of neurons and larger structures characterized by $\hbar_{eff}$? What about collective and transpersonal levels of consciousness?

   Sheldrake's vision [I125, I126], [J9] about species memory is also highly interesting from TGD point of view but is not considered in the article series about prebiotic evolution. The interested reader can however consult the article at [L5]. The latest view about TGD inspired theory of consciousness justifying Sheldrake's vision in terms of negentropically entangled states defining representations invariant under quantum jump sequence and in this way giving rise to "Akashic records" defining sensory -, memory -, etc. representations can be found at [K23].

   Dark photons characterized by the value of $\hbar_{eff}$ and transforming to ordinary photons with the same energy identified as bio-photons are becoming a central element of TGD inspired quantum biology [K13]: in particular the non-destructive conscious reading of the memories represented in terms of negentropically entangled states by interaction free measurement is

very attractive idea [K23]. The communications by dark photons might have been present already during the prebiotic era before the emergence of biochemical signalling and neural communications. The role of dark photons is not discussed in the vision as it was formulated for more than five years ago.

2. A great vision about biological evolution and evolution of brain is discussed on basis of the wisdom gained from the construction of the models of sensory receptor and generalized EEG.

3. A model for the evolution of the recent genetic code (3-codons) as a fusion of codes for which codons are nucleotides (1-codons) and di-nucleotides (2-codons) is discussed. The symmetries of the genetic code, the observation that tRNA can be seen as a fusion of two hairpin like DNA molecules, and the finding that the first nucleotides of 3-codon code for the reaction path leading from a precursors of the amino-acid to amino-acids for hydrophobic/hydrophilic dichotomy, serve as motivations of the model. 1- and 2-codes corresponding to the two forms of RNA (the exotic $2' - 5'$ RNA and the usual $3' - 5'$ RNA) would have prevailed in RNA world. Amino-acids would have served as catalysts for the copying of RNA on one hand, and RNA molecules would have catalyzed the formation of amino-acids from their precursors on one hand, meaning the presence of a positive feedback loop. In the transition to DNA-amino-acid era RNA began to be translated to amino-acid sequences.

   After writing this section quantum TGD based mathematical models of genetic code prediction correctly the numbers of codons coding for a given amino acid have evolved [L39, L11], and are discussed in [K45] and [L15].

4. The TGD based view about the evolution of genetic code is compared to the views of McFadden [I111] involving the proposal that different DNAs can quantum superpose. In standard ontology this proposal looks strange but in zero energy ontology (ZEO) it can be indeed considered. The TGD based vision about life is also compared with Jeremy England's views [I122]: England's paradoxical observation that entropy growth accompanies evolution finds explanation from the fact that p-adic counterparts of entropies can be negative and have interpretation as measures of cognitive information associated with entanglement.

To sum up, TGD does not yet provide a rather detailed view about prebiotic evolution. The magnetic body of water carrying dark matter and controlling ordinary biomolecules via their dark analogs is very attractive proposal but it is not clear whether it is natural to assume RNA world could have been its follower since both DNA,RNA, aminoacids, and tRNA seem to have dark counterparts.

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` [L10].

5.2 Some aspects of TGD inspired quantum biology

TGD based explanation for the findings relies on the basic notions of TGD inspired quantum biology. The basic notions are magnetic body (MB) and hierarchy of Planck constants $h_{eff} = n \times h_0$ [K29, K30, K31, K32, K70] emerging from the adelic physics as a prediction [L34, L35] but originally proposed on basis of anomalous effects of ELF em fields in living matter. The anatomy of MB has remained unclear hitherto but in this article a detailed model allowing to understand the formula $h_{gr} = h_{eff}$ for gravitational Planck constant and leading to a further formula for h_{gr} relating magnetism and gravitation.

A further central notion is TGD based model for water memory as the ability of the MB of water to control the thickness of its flux tubes to entrain with external frequencies and reproduce them. This is a central element in TGD based view about immune system and homeopathic effects [K47]. Cancer would reduce to a disease of the MB of the living system to high degree determined by the MB of water. Details of the bio-chemistry and even cell membrane dynamics would have surprisingly minor role in the model.

5.2.1 Is the cosmological constant really understood?

The interpretation of the coefficient of the volume term as cosmological constant has been a long-standing interpretational issue and caused many moments of despair during years. The intuitive picture has been that cosmological constant obeys p-adic length scale scale evolution meaning that Λ would behave like $1/L_p^2 = 1/p \simeq 1/2^k$ [K12].

This would solve the problems due to the huge value of Λ predicted in GRT approach: the smoothed out behavior of Λ would be $\Lambda \propto 1/a^2$, a light-cone proper time defining cosmic time, and the recent value of Λ - or rather, its value in length scale corresponding to the size scale of the observed Universe - would be extremely small. In the very early Universe - in very short length scales - Λ would be large.

It has however turned out that I have not really understood how this evolution could emerge! Twistor lift seems to allow only a very slow (logarithmic) p-adic length scale evolution of Λ [L54]. Is there any cure to this problem?

1. Could one consider the *total* action for preferred extremals - at least flux tubes - as proportional to effective cosmological constant Λ_{eff}? Since magnetic energy decreases with the are of string like $1/p \simeq 1/2^k$, where p defines the transversal length scale of the flux tube, one would have effective p-adic coupling constant evolution of Λ_{eff} approaching to Λ, which must be extremely small.

   The corresponding size scale would correspond to the density of the magnetic energy equal to that of dark energy. Flux tubes with quantized flux would have thickness determined by the length scale defined by the density of dark energy: $L \sim \rho_{vac}^{-1/4}$, $\rho_{dark} = \Lambda/8\pi G$. $\rho_{vac} \sim 10^{-47}$ GeV^4 (see `http://tinyurl.com/k4bwlzu`) would give $L \sim 1$ mm, which would could be interpreted as a biological length scale (maybe even neuronal length scale).

2. But can Λ be very small? In the simplest picture based on dimensionally reduced 6-D Kähler action this term is not small in comparison with the Kähler action! If the twistor spheres of M^4 and CP_2 give the same contribution to the induced Kähler form at twistor sphere of X^4, this term has maximal possible value!

   The original discussions in [K93, K12] treated the volume term and Kähler term in the dimensionally reduced action as independent terms and Λ was chosen freely. This is however not the case since the coefficients of both terms are proportional to $1/\alpha_K^2 S$, where S is the area of the twistor sphere which is same for the twistor spaces of M^4 and CP_2 if CP_2 size defines the only fundamental length scale. I did not even recognize this mistake.

The proposed fast p-adic evolution of the cosmological constant would have extremely beautiful consequences. Could the original intuitive picture be wrong, or could the desired p-adic length scale evolution for Λ be possible after all? Could dynamics somehow give it? To see what can happen one must look in more detail the induction of twistor structure.

1. The induction of the twistor structure by dimensional reduction involves the identification of the twistor spheres S^2 of the geometric twistor spaces $T(M^4) = M^4 \times S^2(M^4)$ and of T_{CP_2} having $S^2(CP_2)$ as fiber space. What this means that one can take the coordinates of say $S^2(M^4)$ as coordinates and embedding map maps $S^2(M^4)$ to $S^2(CP_2)$. The twistor spheres $S^2(M^4)$ and $S^2(CP_2)$ have in the minimal scenario same radius $R(CP_2)$ (radius of the geodesic sphere of CP_2. The identification map is unique apart from $SO(3)$ rotation R of either twistor sphere. Could one consider the possibility that R is not trivial and that the induced Kähler forms could almos cancel each other?

2. The induced Kähler form is sum of the Kähler forms induced from $S^2(M^4)$ and $S^2(CP_2)$ and since Kähler forms are same apart from a rotation in the common S^2 coordinates, one has $J_{ind} = J + R(J)$, where R denotes the rotation. The sum is $J_{ind} = 2J$ if the relative rotation is trivial and $J_{ind} = 0$ if R corresponds to a rotation $\Theta \to \Theta + \pi$ changing the sign of $J = sin(\Theta) d\Theta \wedge d\Phi$.

3. Could p-adic length scale evolution for Λ correspond to a sequence of rotations - in the simplest case $\Theta \to \Theta + \Delta_k \Theta$ taking gradually J from $2J$ at very short length scales to $J = 0$

corresponding to $\Delta_\infty\Theta = \pi$ at very long length scales? A suitable spectrum for $\Delta_k(\Theta)$ could reproduce the proposal $\Lambda \propto 2^- k$ for Λ.

4. One can of course ask whether the resulting induced twistor structure is acceptable. Certainly it is not equivalent with the standard twistor structure. In particular, the condition $J^2 = -g$ is lost. In the case of induced Kähler form at X^4 this condition is also lost. For spinor structure the induction guarantees the existence and uniqueness of the spinor structure, and the same applies also to the induced twistor structure being together with the unique properties of twistor spaces of M^4 and CP_2 the key motivation for the notion.

5. Could field equations associated with the dimensional reduction allow p-adic length scale evolution in this sense?

   (a) The sum $J + R(J)$ defining the induced Kähler form in $S^2(X^4)$ is covariantly constant since both terms are covariantly constant by the rotational covariance of J.

   (b) The embeddings of $S^2(X^4)$ as twistor sphere of space-time surface to both spheres are holomorphic since rotations are represented as holomorphic transformations. This in turn implies that the second fundamental form in complex coordinates is a tensor having only components of type $(1,1)$ and $(-1,-1)$ whereas metric and energy momentum tensor have only components of type $(1,-1)$ and $(-1,1)$. Therefore all contractions appearing in field equations vanish identically and $S^2(X^4)$ is minimal surface and Kähler current in $S^2(X^4)$ vanishes since it involves components of the trace of second fundamental form. Field equations are indeed satisfied.

   (c) The solution of field equations becomes a family of space-time surfaces parametrized by the values of the cosmological constant Λ as function of S^2 coordinates satisfying $\Lambda/8\pi G = \rho_{vac} = J \wedge (*J)(S^2)$. In long length scales the variation range of Λ would become arbitrary small.

6. If the minimal surface equations solve separately field equations for the volume term and Kähler action everywhere apart from a discrete set of singular points, the cosmological constant affects the space-time dynamics only at these points. The physical interpretation of these points is as seats of fundamental fermions at partonic 2-surface at the ends of light-like 3-surfaces defining their orbits (induced metric changes signature at these 3-surfaces). Fermion orbits would be boundaries of fermionic string world sheets.

   One would have family of solutions of field equations but particular value of Λ would make itself visible only at the level of elementary fermions by affecting the values of coupling constants. p-Adic coupling constant evolution would be induced by the p-adic coupling constant evolution for the relative rotations R for the two twistor spheres. Therefore twistor lift would not be mere manner to reproduce cosmological term but determine the dynamics at the level of coupling constant evolution.

7. What is nice that also $\Lambda = 0$ option is possible. This would correspond to the variant of TGD involving only Kähler action regarded as TGD before the emergence of twistor lift. Therefore the nice results about cosmology obtained at this limit would not be lost.

5.2.2 The notion of magnetic body

Magnetic flux tubes and field body/magnetic body (MB) are basic notions of TGD implied by the modification of Maxwellian electrodynamics [K74, K53, K88]. Actually a profound generalization of space-time concept is in question. Magnetic flux tubes are in well-defined sense building bricks of space-time - topological field quanta - and lead to the notion of field body/MB as a field identity assignable to any physical system: in Maxwell's theory and ordinary field theory the fields of different systems superpose and one cannot say about magnetic field in given region of space-time that it would belong to some particular system. In TGD only the effects on test particle for induced fields associated with different space-time sheets with overlapping M^4 projections sum.

The hierarchy of Planck constants $h_{eff} = n \times h_0$, where h_0 is the minimum value of Planck constant, is second key notion. h_0 need not correspond to ordinary Planck constant h and both the observations of Randell Mills [L24] and the model for color vision [L43] suggest that one has $h = 6h_0$. The hierarchy of Planck constants labels a hierarchy of phases of ordinary matter behaving as dark matter.

Magnetic flux tubes would connect molecules, cells and even larger units, which would serve as nodes in (tensor-) networks [B9] [L23]. Flux tubes would serve as correlates for quantum entanglement and replace wormholes in ER-EPR correspondence proposed by Leonard Susskind and Juan Maldacena in 2014 (see `http://tinyurl.com/y7za98cn` and `http://tinyurl.com/ydckw5u7`). In biology and neuroscience these networks would be in a central role. For instance, in brain neuron nets would be associated with them and would serve as correlates for mental images [L29, L44]. The dynamics of mental images would correspond to that for the flux tube networks.

5.2.3 Hierarchy of Planck constants, space-time surfaces as covering spaces, and adelic physics

From the beginning it was clear that $h_{eff}/h = n$ corresponds to the number of sheets for a covering space of some kind. First the covering was assigned with the causal diamonds. Later I assigned it with space-time surfaces but the details of the covering remained unclear. The final identification emerged only in the beginning of 2017.

Number theoretical universality and hierarchy of extensions of rationals

Number theoretical universality (NTU) leads to the notion of adelic space-time surface (monadic manifold) involving a discretization in an extension of rationals defining particular level in the hierarchy of adeles defining evolutionary hierarchy. The formulation of this vision is proposed in [L26, L35, L34].

The key constraint is NTU for adelic space-time containing sheets in the real sector and various padic sectors, which are extensions of p-adic number fields induced by an extension of rationals which can contain also powers of a root of e inducing finite-D extension of p-adic numbers (e^p is ordinary p-adic number in Q_p).

One identifies the numbers in the extension of rationals as common for all number fields and demands that embedding space has a discretization in an extension of rationals in the sense that the preferred coordinates of embedding space implied by isometries belong to extension of rationals for the points of number theoretic discretization. This implies that the versions of isometries with group parameters in the extension of rationals act as discrete versions of symmetries. The correspondence between real and p-adic variants of the embedding space is extremely discontinuous for given adelic embedding space (there is hierarchy of them with levels characterized by extensions of rationals). Space-time surfaces typically contain rather small set of points in the extension ($x^n + yn^2 = z^n$ contains no rationals for $n > 2$!). Hence one expects a discretization with a finite cutoff length at space-time level for sufficiently low space-time dimension $D = 4$ could be enough.

After that one assigns in the real sector an open set to each point of discretization and these open sets define a manifold covering. In p-adic sector one can assign 8:th Cartesian power of ordinary p-adic numbers to each point of number theoretic discretization. This gives both discretization and smooth local manifold structure. What is important is that Galois group of the extension acts on these discretizations and one obtains from a given discretization a covering space with the number of sheets equal to a factor of the order of Galois group.

Effective Planck constant as dimension of extension of rationals and number of sheets of space-time surface as covering space

$h_{eff}/h_0 = n$ was identified from the beginning as the number of sheets of poly-sheeted covering assignable to space-time surface. The number n of sheets would naturally a factor of the order of Galois group implying $h_{eff}/h = n$ bound to increase during number theoretic evolution so that the algebraic complexity increases. Note that WCW decomposes into sectors corresponding to the extensions of rationals and the dimension of the extension is bound to increase in the long run by

localizations to various sectors in self measurements [K60]. Dark matter hierarchy represents number theoretical/adelic physics and therefore has now rather rigorous mathematical justification. It is however good to recall that $h_{eff}/h = n$ hypothesis emerged from an experimental anomaly: radiation at ELF frequencies had quantal effects of vertebrate brain impossible in standard quantum theory since the energies $E = hf$ of photons are ridiculously small as compared to thermal energy.

Indeed, since n is positive integer evolution is analogous to a diffusion in half-line and n unavoidably increases in the long run just as the particle diffuses farther away from origin (by looking what gradually happens near paper basket one understands what this means). The increase of n implies the increase of maximal negentropy and thus of negentropy. Negentropy Maximization Principle (NMP) follows from adelic physics alone and there is no need to postulate it separately. Things get better in the long run although we do not live in the best possible world as Leibniz who first proposed the notion of monad proposed!

Formula for the gravitational Planck constant and some background

The formula

$$\hbar_{gr} = \frac{GM_D m}{v_0} \tag{5.2.1}$$

for the gravitational Planck constant was originally introduced by Nottale [E5]. Here v_0 is a parameter with dimensions of velocity: I have considered argument allowing to deduce information about the value of $\beta_0 = v_0/c$ as the ratio of the M^4 size of the system and the size of its magnetic body [L40]. Values of order $\beta_0 \sim 10^{-3}$ are encountered.

Since m disappears from the predictions by Equivalence Principle it is not at all clear what kind limitations one has for m and one can even assume that m corresponds to particle mass without change in predictions. In Nottale's original formula m is mass of planet and M_D the mass of Sun but m could be even mass of elementary particle without change in predictions. The assumption has been $m/M_D << 1$. The replacement of M_D with total mass $M_D + m$ and m by reduced mass $M_D m/(M_D + m)$ does not affect the formula and the asymmetry between m and M_D would become more natural asymmetry between total mass and reduced mass.

For $Mm < v_0 m_{Pl}^2$ one must have $h_{gr} = h$, which suggests that quite generally one must have $m \geq \sqrt{v_0} M_{Pl}$ and $M \geq \sqrt{v_0} M_{Pl}$. The formula is non-relativistic but one can consider a relativistic generalization in which m and M are replaced by energies [K68] .

The formula is expected to hold true at the magnetic flux tubes mediating gravitational interaction. M_D has been interpreted as dark gravitational flux at the gravitational flux tubes with a fixed value of h_{eff} and should be a fraction of the total gravitational flux M. These flux tubes define $n_{gr} = h_{eff}/h_0$-sheeted covering of M^4.

Also a more general formula

$$h_{gr} = h_{eff} \quad , \quad h_{eff} = n_{gr} \times h_0 \quad , \quad h = 6h_0 \quad . \tag{5.2.2}$$

has been assumed. The support for the formula $h = 6h_0$ is discussed in [L24, L43]. The value of h_{gr} can be very large unlike the value of h_{eff} associated with say valence bonds.

One important implication of the formula is that the cyclotron energy spectrum does not depend on the mass of charged particle at all and is therefore universal. The assumption has been that the spectrum is in visible and UV range assignable to bio-photons [K13, K22]. One can however consider also the possibility that also the energies between the thermal energy at physiological temperature and visible photon energies are allowed.

What does one really mean with gravitational Planck constant?

There are important questions related to the QFT-GRT limit of TGD.

1. What does one mean with space-time as covering space?

The central idea is that space-time corresponds to n-fold covering for $h_{eff} = n \times h_0$. It is not however quite clear what this statement does mean.

1. How the many-sheeted space-time corresponds to the space-time of QFT and GRT? QFT-GRT limit of TGD is defined by identifying the gauge potentials as sums of induced gauge potentials over the space-time sheets. Magnetic field is sum over its values for different space-time sheets. For single sheet the field would be extremely small in the present case as will be found.

2. A central notion associated with the hierarchy of effective Planck constants $h_{eff}/h_0 = n$ giving as a special case $\hbar_{gr} = GMm/v_0$ assigned to the flux tubes mediating gravitational interactions. The most general view is that the space-time itself can be regarded as n-sheeted covering space. A more restricted view is that space-time surface can be regarded as n-sheeted covering of M^4. But why not n-sheeted covering of CP_2? And why not having $n = n_1 \times n_2$ such that one has n_1-sheeted covering of CP_2 and n_2-sheeted covering of M^4 as I indeed proposed for more than decade ago [K71] but gave up this notion later and consider only coverings of M^4? There is indeed nothing preventing the more general coverings.

3. $n = n_1 \times n_2$ covering can be illustrated for an electric engineer by considering a coil in very thin 3 dimensional slab having thickness L. The small vertical direction would serve and as analog of CP_2. The remaining 2 large dimensions would serve as analog for M^4. One could try to construct a coil with n loops in the vertical direction direction but for very large n one would encounter problems since loops would overlap because the thickness of the wire would be larger than available room L/n. There would be some maximum value of n, call it n_{max}.

   One could overcome this limit by using the decomposition $n = n_1 \times n_2$ existing if n is prime. In this case one could decompose the coil into n_1 parallel coils in plane having $n_2 \geq n_{max}$ loops in the vertical direction. This provided n_2 is small enough to avoid problems due to finite thickness of the coil. For n prime this does not work but one can of also select n_2 to be maximal and allow the last coil to have less than n_2 loops.

   An interesting possibility is that preferred extremal property implies the decomposition $n_{gr} = n_1 \times n_2$ with nearly maximal value of n_2, which can vary in some limits. Of course, one of the n_2-coverings of M^4 could be in-complete in the case that n_{gr} is prime or not divisible by nearly maximal value of n_2. We do not live in ideal Universe, and one can even imagine that the copies of M^4 covering are not exact copies but that n_2 can vary.

4. In the case of $M^4 \times CP_2$ space-time sheet would replace single loop of the coil, and the procedure would be very similar. A highly interesting question is whether preferred extremal property favours the option in which one has as analog of n_1 coils n_1 full copies of n_2-fold coverings of M^4 at different positions in M^4 and thus defining an n_1 covering of CP_2 in M^4 direction. These positions of copies need not be close to each other but one could still have quantum coherence and this would be essential in TGD inspired quantum biology [L42].

   Number theoretic vision [L35, L34] suggests that the sheets could be related by discrete isometries of CP_2 possibly representing the action of Galois group of the extension of rationals defining the adele and since the group is finite sub-group of CP_2, the number of sheets would be finite.

   The finite sub-groups of $SU(3)$ are analogous to the finite sub-groups of $SU(2)$ and if they action is genuinely 3-D they correspond to the symmetries of Platonic solids (tetrahedron,cube,octahedron, icosahedron, dodecahedron). Otherwise one obtains symmetries of polygons and the order of group can be arbitrary large. Similar phenomenon is expected now. In fact the values of n_2 could be quantized in terms of dimensions of discrete coset spaces associated with discrete sub-groups of $SU(3)$. This would give rise to a large variation of n_2 and could perhaps explain the large variation of G identified as $G = R^2(CP_2)/n_2$ suggested by the fountain effect of superfluidity [L50].

5. There are indeed two kinds of values of n: the small values $n = h_{em}/h_0 = n_{em}$ assigned with flux tubes mediating em interaction and appearing already in condensed matter physics [L31, L43, L24] and large values $n = h_{gr}/h_0 = n_{gr}$ associated with gravitational flux tubes. The small values of n would be naturally associated with coverings of CP_2. The large values $n_{gr} = n_1 \times n_2$ would correspond n_1-fold coverings of CP_2 consisting of complete n_2-fold

coverings of M^4. Note that in this picture one can formally define constants $\hbar(M^4) = n_1\hbar_0$ and $\hbar(CP_2) = n_2\hbar_0$ as proposed in [K71] for more than decade ago.

2. Planck length as CP_2 radius and identification of gravitational constant G

There is also a puzzle related to the identification of gravitational Planck constant. In TGD framework the only theoretically reasonable identification of Planck length is as CP_2 length $R(CP_2)$, which is roughly $10^{3.5}$ times longer than Planck length [L50]. Otherwise one must introduce the usual Planck length as separate fundamental length. The proposal was that gravitational constant would be defined as $G = R^2(CP_2)/\hbar_{gr}$, $\hbar_{gr} \simeq 10^7\hbar$. The G indeed varies in un-expectedly wide limits and the fountain effect of superfluidity suggests that the variation can be surprisingly large.

There are however problems.

1. Arbitrary small values of $G = R^2(CP_2)/\hbar_{gr}$ are possible for the values of $\hbar_{gr}$ appearing in the applications: the values of order $n_{gr} \sim 10^{13}$ are encountered in the biological applications. The value range of G is however experimentally rather limited. Something clearly goes wrong with the proposed formula.

2. Schwartschild radius $r_S = 2GM = 2R^2(CP_2)M/\hbar_{gr}$ would decrease with $\hbar_{gr}$. One would expect just the opposite since fundamental quantal length scales should scale like $\hbar_{gr}$.

3. What about Nottale formula [E5] $\hbar_{gr} = GMm/v_0$? Should one require self-consistency and substitute $G = R^2(CP_2)/\hbar_{gr}$ to it to obtain $\hbar_{gr} = \sqrt{R^2(CP_2)Mm/v_0}$. This formula leads to physically un-acceptable predictions, and I have used in all applications $G = G_N$ corresponding to $n_{gr} \sim 10^7$ as the ratio of squares of CP_2 length and ordinary Planck length.

Could one interpret the almost constancy of G by assuming that it corresponds to $\hbar(CP_2) = n_2\hbar_0$, $n_2 \simeq 10^7$ and nearly maximal except possibly in some special situations? For $n_{gr} = n_1 \times n_2$ the covering corresponding to $\hbar_{gr}$ would be n_1-fold covering of CP_2 formed from n_1 n_2-fold coverings of M^4. For l $n_{gr} = n_1 \times n_2$ the covering would decompose to n_1 disjoint M^4 coverings and this would also guarantee that the definition of r_S remains the standard one since only the number of M^4 coverings increases.

If n_2 corresponds to the order of finite subgroup G of $SU(3)$ or number of elements in a coset space G/H of G (itself sub-group for normal sub-group H), one would have very limited number of values of n_2, and it might be possible to understand the fountain effect of superfluidity [L50] from the symmetries of CP_2, which would take a role similar to the symmetries associated with Platonic solids. In fact, the smaller value of G in fountain effect would suggest that n_2 in this case is larger than for G_N so that n_2 for G_N would not be maximal.

New constraint between h_{gr} and h_{eff}

Cyclotron frequencies and energies in magnetic field B and charged particle with charge Ze and mass m are proportional to the ZeB/m. The energy spectrum of bio-photons would be covered by a spectrum of magnetic field strengths B. A special field strength $B_{end} = 0.2$ Gauss has emerged in biological applications from the beginning and the first guess is that it defines a lower bound for the spectrum of visible photon energies [L41, L38, L53]. One can fix the value of h_{gr} and therefore of GM_D/v_0 if one requires that dark photon frequency of say $f_l = 10$ Hz corresponds to the lower bound $f_h = 400$ THz for visible frequencies as $h_{gr} = f_h/f_l$: in this case would would have $n_{gr} = 4 \times 10^{13}$.

The variation of B means variation of cyclotron frequency and I have proposed that the audible frequencies correspond to a spectrum of B for the flux tubes involved with hearing [K77], and that even 12-note scale represent in terms of rational frequency ratios might have a preferred role [L11, L52].

The formula $h_{gr} = h_{eff}$ is not enough to fix the model completely. A formula fixing the relationship between B and GM_D/v_0 would be needed. This formula should be consistent with $h_{gr} = h_{eff}$. Dimensional analyst would start from the geometry of the situation.

Magnetic flux tubes are characterized by two parameters: length L_c and radius R_B.

1. Length scale naturally corresponds to the cyclotron wave length

$$L_c = \lambda_c = \frac{1}{f_c} = \frac{2\pi m}{ZeB} \ . \tag{5.2.3}$$

L_c is proportional to the mass m of the charged particle so that charge particles with different mass are with different mass flux tubes with different length and therefore different onion-like layers of MB. Charged dark particles are like books about different topics at different shelves so that living matter is extremely well-organized: something totally different from a chaotic soup of charged ions.

2. The radius of the flux tube is obtained from the flux quantization. For ordinary cylindrical flux tube with constant B the condition is $BS = k\hbar$ and for $S = \pi R^2$ the radius would be

$$R_B(h,k) = \sqrt{\frac{k\hbar}{\pi eB}} = \sqrt{\frac{k}{\pi}} L_B \ , \quad L_B = \sqrt{\frac{\hbar}{eB}} \ . \tag{5.2.4}$$

.

For $k = 1$ and for $B = B_{end} = .2$ Gauss one has $R_B(h,1) = 3.3$ μm to be compared with p-adic length scale $L(167) = 2.5$ μm assignable to Gaussian Mersenne $M_{G,167} = (1+i)^{167} - 1$. Magnetic length L_B is in this case $L_B = 5.8$ μm slightly larger than $L(169)$.

3. For $h_{eff} = n \times h_0$, $h = 6h_0$ the formula would generalize to

$$R_B(h_{eff},k) = \sqrt{\frac{k\hbar_{eff}}{\pi eB}} = \sqrt{\frac{n}{6}} R_c(h,k) = \sqrt{\frac{nk}{6}} R_B(h,1) \ . \tag{5.2.5}$$

Note that here n is rather small such as the value of n assignable to valence bonds.

4. The natural guess is that this formula applies at the small part of the MB restricted to the "biological body" of the living system defining that part of system, which corresponds to relatively small values of h_{eff}. The value of h_{eff} would indeed vary, being larger than h for instance for valence bonds [L31]. For dark flux tubes with small value of n the radius would be scaled up by $\sqrt{n}$ such as biological system for fixed value of B. Same happens if the value of flux is scaled by m.

For the simplest flux tubes carrying monopole flux having string world sheet as M^4 projection geodesic sphere as CP_2 projection, the cross section is not circular disk but CP_2 geodesic sphere with radius R. I this case R is fixed. The M^4 projection of these objects is however unstable against thickening and for spherical cross section- think of two disks glued along boundaries but having different CP_2 projections, the area is $4\pi R^2$, where R corresponds to the radius of M^4 projection. Area is reduced by factor 4 from that for non-monopole flux tube and radius is reduced by factor 1/2.

One can guess the additional constraint on h_{gr} without more detailed analysis of what MB really is using dimensional analysis and I will postpone this analysis later.

1. The first natural guess is that one has

$$\frac{h_{gr}}{h_0} = n_{gr} = x\frac{L_c}{R_B(h_{eff},k)} = x(6\pi)^{3/2}\frac{1}{(nk)^{1/2}}\frac{L_B}{l_C(m)} \ ,$$
$$L_B = \sqrt{\frac{\hbar}{eB}} \ , \ l_C(m) = \frac{\hbar}{m} \ . \tag{5.2.6}$$

x is some numerical constant. h_{gr}/h_0 is proportional to the ratio l_B/l_C of the magnetic length and Compton length $l_C = m/\hbar$ of the charged particle.

2. Alternative guess replaces the radius of the magnetic flux tube with the magnetic length L_B.

$$\frac{h_{gr}}{h_0} = n_{gr} = x\frac{L_c}{L_B} == x6^{3/2}\pi\frac{1}{n^{1/2}}\frac{L_B}{L_C(m)} \quad , \tag{5.2.7}$$

This formulas is related by factor $\sqrt{k}pi$ the first formula and has no dependence on h. It is difficult to say anything about exact value of the numerical constant x.

3. h_{gr} is proportional to m so that the formulas are consistent with $h_{gr} = h_{eff}$ formula. Combining these formulas one obtains

$$\frac{GM_D}{h_0 v_0} = \frac{r_S(M_D)}{2} = x2\pi\sqrt{\frac{n}{6Z}}\sqrt{\frac{\hbar}{eB}} \quad . \tag{5.2.8}$$

This formula does not depend on m and gives the value of GM_D/v_0 assignable to the flux tubes carrying magnetic field with strength B and particles with charge Z. One can say that the Schwartschild radius $r_S = 2GM_D$ characterixing M_D is proportional to magnetic length. The first option gives

$$r_S(M_D) = x \times 2 \times 6^{1/2}\pi^{3/2}\frac{1}{(nk)^{1/2}}v_0 l_B \quad . \tag{5.2.9}$$

For Earth Schwartschild radius is $r_{S,E} = 8.87$ mm and if $M_D < M_E$ holds true, one obtains for a given value of v_0 upper bound for the magnetic length and therefore lower bound for B. I have considered in [L40] a model for v_0 and combining this model for this formula, one obtains rather strong constraints on the parameters and also on the minimal value of B. The order of magnitude for v_0 is $v_0 \sim 10^{-3}$.

M_D/v_0 would not depend on the mass of the charged particles at the flux tube (universality) but would depend on their charge Z unless the parameter x has a compensating $Z-$dependence. Therefore electrons and their Cooper pairs would have different value of GMD/v_0. One could perhaps interpret r_S/v_0 as analog of star radius applying to particular dark matter part of Earth. It would be considerably larger than Schwartchild radius.

4. Note that the condition $GM_D m/v_0 = n_{gr}\hbar$ can be written as

$$r_S(M_D) = 2n_{gr}l_C \quad . \tag{5.2.10}$$

Estimate of G/G_N from the delocalization at magnetic flux tubes

The following argument is for a situation in which the mass m corresponds to the mass of ion. By Equivalence Principle m however disappears from the formulas involving gravitational interaction of Earth, and cyclotron frequencies remain invariant for cyclotron BE condensate. Therefore the formulas apply for the BE condensate ions with total mass equal to a multiple of Planck mass $m_P = \hbar_0/R$.

The de-localization length of dark matter wave functions in the gravitational field is much longer than for ordinary value of Planck constant: essentially the height to which particle can rise with given initial velocity V_0 in the gravitational field with gravitational constant G. This would conform with the idea that dark particles are delocalized at the flux tubes in the scale of cyclotron wave-length.

The condition that the height h for the orbit equals to cyclotron wavelength gives an estimate for G_N/G. One can estimate the height $h = R - R_E$ from energy conservation assuming that particle has initial vertical velocity V_0 at the surface of Earth and cyclotron wavelength λ_c:

$$\frac{V_0^2}{2} = \frac{G}{G_N}\left[\frac{GM}{R_E} - \frac{GM}{R}\right] \ ,$$

$$h = \lambda_c = \frac{1}{f_c} = \frac{2\pi m}{neB} \ .$$

One obtains an estimate for G/G_N as

$$\begin{aligned} &\frac{G}{G_N} = V_0^2 \frac{(R_E+h)R_E}{r_S h} \ , \quad R = R_E + h \ , \\ &h = \frac{\lambda_c}{n} = \frac{1}{nf_c} = \frac{2\pi m}{neB} \ . \end{aligned} \tag{5.2.11}$$

This gives

$$\frac{G}{G_N} = nV_0^2 \times \frac{R_E(R_E+\frac{\lambda_c}{n})}{r_S\lambda_c} = nV_0^2 \times \frac{R_E(R_E+\frac{2\pi eB}{neBm})}{r_S} \times \frac{eB}{2\pi m} \ . \tag{5.2.12}$$

The condition that value of G/G_N is constant quantizes the value of V_0. For small value of h one has $V_0^2 n \simeq constant$. For $R_E \sim \lambda_c$ and nV_0^2 is of order unity, the order of magnitude would be $G/G_N \sim R_E/r_S \sim 7 \times 10^8$.

5.2.4 What can one say about the detailed anatomy of the MB?

The details of the anatomy of the MB have remained rather fuzzy hitherto. The following is an attempt to formulate more explicitly and coherently the earlier ideas scattered in books and articles about TGD. There are several empirical facts and theoretical constraints that one can use.

1. There is the notion of dark DNA as dark nuclei consisting of sequences of dark protons. The notion of dark nucleus is central concept in TGD based model of "cold fusion" [L30]. Dark proton sequences are parallel with and in the vicinity of ordinary DNA strands and ordinary codons and dark proton triplets representing them [L20] are paired.

2. Pollack effect [L13] [L13] for water is assumed to generate dark DNA. Part of protons go to the flux tube and negative charge is generated in ordinary matter and ends to negative charge of phosphates associated with the ordinary DNA nucleotides. Ordinary DNA would pair with dark DNA serving as precedessor and controller of ordinary DNA. Also RNA, amino-acids, and tRNA would have dark precedessors and similar pairing would occur.

3. Experiments of Peter Gariaev *et al* - in particular the discovery of phantom DNA [I72] - and of Montagnier [I87] [L3] provide further valuable information.

Consider now what MB could look like.

1. MB has two parts. The small part has size of the physical system consisting of ordinary matter plus parts with relatively small h_{eff} assignable to structures such as valence bonds. The flux tubes of this part of MB connect parts of the system to a network and tensor network is an excellent mathematical model for what is involved. Flux tubes serve as topological correlates for entanglement and even prerequisites for it.

   In living matter one can imagine that the basic units of ordinary matter - say cells - are organized at parallel flux tubes. For $B_{end} = .2$ Gauss, which seems to define an especially important endogenous magnetic field, the radius r_B is of cell size. The value of proton cyclotron frequency is 300 Hz in this case and happens to correspond to the rotation frequency of the "shaft" of the ATPase as power generator.

   60 Hz frequency was found to lead to a transformation of cancer cells to ordinary ones and this suggests that cyclotron frequency for $B = B_{end}/5$ is involved. The flux tubes would

contain 5 cells in their cross section and one can argue that dark proton quantum coherence at gravitational flux tubes with this thickness could give rise coherence in 5-cell length scale and lead to the cure of cancer.

2. The large part of MB - with size of the order Earth radius for $f_c = 60$ Hz corresponds to long flux tubes with large effective Planck constant $h_{gr}/h_0 = n$. Effective value of Planck constant is indeed in question since n_{gr} is the number sheets of the space-time surface as covering space and Planck constant has value h_0 (rather than $h = 6h_0$) at each sheet of the covering. At QFT limit sheets are effectively replaced with single one, and one must allow the "real" Planck constant to have non-standard values.

   What space-time surface as covering does mean has been already discussed, and it seems that the identification as $n = n_1 \times n_2$ covering, where n_1 is the number of sheets as covering of CP_2 realized in the recent case as disjoint flux tubes in M^4 and n_2 is the number of sheets as covering of M^4. Gravitational constant identified as $G = R^2/\hbar_2$ would allow to avoid unphysical predictions since n_2 could be limited to a rather narrow range by symmetry considerations.

   The cyclotron energies are scaled up by $h_{eff}/h_0 = n_{gr}$ and whatever the detailed anatomy of MB is this must be understood. Effectively one has n_{gr} photons with ordinary cyclotron energy and their energies sum up. This can be understood if the flux tubes define n_{gr}-fold coverings of M^4.

3. $h_{gr} = n_{gr}h_0$ correspond to quantum coherence in very long length scales whereas in the scale of organism the value of n is relatively small. The simplest idea is that n_{gr} disjoint flux tubes with small value of n and with given thickness determined by flux quantization coming from the living system combine to form single n_{gr}-sheeted flux tube with length given by $L_c = \lambda_c = 2\pi m/ZeB$ having no dependence on h_{eff}.

   This would be like a large number of cables combining a single cable. The threads of the cable would be now on top of each other in CP_2 direction! A rather exotic space savings! This would combine the sensory information coming from the separate flux tubes to a single super-cable and make the control of the system easy. Central nervous system would have spinal chord as an analogous unit both geometrically and functionally albeit in totally different scale. One of the first proposals was that MB provides an almost topographic representation of the biological body [K54].

   One can estimate the volume of the region with coherence forced by quantum gravitational coherence as $V_{gr} = n_{gr}V(unit)$, where $V(unit)$ is the volume of the basic unit presumably determined by flux tube radius. If $V(unit)$ equals to volume a^3 of cube with side a, V_{gr} corresponds to a cube with side $a_{gr} = n_{gr}^{1/3}a$.

   The assumption that the energies of EEG photons in alpha band with $f = 10$ Hz correspond to ordinary photons at the lower end of the bio-photon spectrum having frequency 400 THz gives n_{gr} as $n_{gr} = 4 \times 10^{13}$. For $n_{gr} = 4 \times 1013$ and $a = 5$ μ m giving lower bound for the volume of neuron one would have $a_{gr} = 0.2$ m, roughly the size scale of brain.

4. The natural interpretation of the super-cables is as gravitational flux tubes. The gravitational flux associated with the ordinary flux tubes would combine to the dark gravitational flux tubes involving n_1 parallel flux tubes in M^4, each of them consisting of n_2 flux tubes on top of each other in CP_2 direction. This combination could take place repeatedly. Could the parameter M_D in $h_{gr} = n_{gr}h_0$ correspond to the portion of the Earth's gravitational flux flowing along these flux tubes? The sum of the masses M_D should over values of field strengths and charged particle masses should give the total mass M_E of Earth if the guess is correct.

   One must of course be extremely cautious in interpretations. For instance, flux tubes carrying Kähler charge the flux tubes should be closed and give rise to a kind of Dirac monopole like structure with return flux. This would mean that gravitational flux returns back, possibly along different space-time sheets. But the flux lines are closed also for the ordinary magnetic fields. Can this really be consistent with the Newtonian view about gravitation in which

gravitational flux flows to infinity? The answer is far from obvious: the many-sheeted space-time in which space-time sheets are glued along the boundaries would that part of the flux can return and part goes to larger space-time sheets and in principle there is no largest space-time sheet so that one would obtain effectively monopoles.

5. An entire fractal hierarchy of magnetic field strengths is predicted. A good guess is that field strengths are given by p-adic length scale hypothesis, that is have scales given by $B(k) \propto 1/L(k)^2$, where $L(k) \propto 2^{k/2}$ is the p-adic length scale assignable to $p \simeq 2^k$. This would mean hierarchy of flux tubes with radii $L(k)$ and at each level the combination to super-cables representing gravitational flux tubes would take place.

   One has $M_D \propto v_0/\sqrt{B} \propto v_0 2^{k/2}$. For a fixed value of v_0, the sum can converge only if the number of p-adic length scales involved is finite. The radius R_E of Earth certainly gives this kind of upper bound and corresponds to a rather modest value of k ($L(151)$ correspond to 10 nm) . Also v_0 can depend on p-adic length scale. The sizes of living organisms give a more stringent upper bound on k.

5.2.5 Water memory and homeopathy

There is a lot of support about the representation of water memory as extremely low frequencies (ELF) of radiation associated with water [I61, I62]. These ELF frequencies can be stored electronically and they produce the same effects as the bio-active chemical, whose presence induced these frequencies in water. At the age of IT the idea about the existence of representations of bio-active molecules as frequency patterns able to induce the biological effects of molecules without the presence of molecules should not raise grave objections. For instance, brain generates this kind of representations by entrainment to external frequencies and water might play a crucial role also here. Few years ago HIV Nobelist Montagnier did experiments giving support for water memory and the procedure involved a part very similar to that used in preparing homeopathic remedies [I87] [L3].

The description of water memory in TGD Universe would look like follows.

1. In TGD framework these frequencies would correspond to cyclotron frequencies assignable to MBs of molecules, and immune system is proposed to have emerged from the ability of water to mimic the MBs of invader molecules and learning to recognize them [K47] by resonant coupling at these frequencies.

   This would take place via entrainment made possible by the variation of the thickness of the flux tube inducing variation of the cyclotron frequency. In entrainment the cyclotron frequency of the flux tube would coincide with the external frequency. MB having flux tubes with modified thickness would be able to produce cyclotron radiation at the these frequencies and couple to the invader molecule resonantly. The coupling would involve also topological part as reconnection of flux tubes with same thickness and carrying same charged particles to make resonance possible.

   One can visualize living systems as systems having magnetic tentacles consisting of U-shaped flux tubes forming thus locally pairs of flux tube tubes and searching for flux similar flux tubes of other systems, in particular bio-active molecules. The recognition of invader molecules is a crucial part of immune systems and this mechanism would be an essential part of immune action besides cyclotron resonance.

2. In TGD universe water is very special substance in that it contains both ordinary water and its dark variant. What makes it dark is that dark magnetic flux tubes representing long hydrogen bonds are present for some portion of water [L51] (see `http://tinyurl.com/y8fvwbp9`): the length of bonds scales as n or perhaps even n^2. The presence of these flux tubes makes any liquid phase a network like structure, and one ends up with a model explaining an anomaly of thermodynamics of liquids at criticality known already in Maxwell's time. This leads to a model explaining the numerous anomalies of water in terms of the dark matter.

   For instance, the dark part of water with non-standard Planck constant transforms to ordinary water in freezing. As a consequence, a large amount of energy is liberated. This explains why water has anomalously large latent heat of fusion. One can also understand

why the volume of water increases in freezing and decreases in heating in the interval 0-4 °C. The anomalies of water are largest at physiological temperature $T_{phys} \sim 37$ °C suggesting that the dark portion of water is largest at T_{phys}. Dark fraction of water would be essential for life.

3. Pollack effect [L13] (see `http://tinyurl.com/oyhstc2`) requiring feed of energy - as IR radiation for instance - generates so called exclusion zones (EZs), which are negatively charged regions. A fraction of protons from water must go somewhere and the TGD inspired proposal [L13] (see `http://tinyurl.com/gwasd8o`) is that the protons transform to dark protons at magnetic flux tubes. The dark variants of particles quite generally have higher energies than ordinary ones and energy feed provides the needed metabolic energy go make the protons dark. In the case of homeopathy and water memory mechanical agitation creates provides the metabolic energy and would generate EZs accompanied by dark proton sequencies at flux tubes [K47].

4. The MB of water would be also a key central part of MB of the living system acting as intentional agent receiving sensory input from biological body and controlling it. Biochemistry would be kind of shadow dynamics. The ions provided by the living system would reside at the flux tubes of MB provided by water and as found the lengths of flux tubes and also the value of $h_{eff} = h_{gr}$ at the would distinguish between different ions. The gravitational flux tubes formed by combination of n_{gr} ordinary flux tubes to n_{gr} flux tubes with the same M^4 projection defining a covering of M^4 would define the large part of MB serving as intentional agent and communications would occur at cyclotron frequencies.

   Cell membranes would produce what I call generalized Josephson radiation, which would couple resonantly to cyclotron Bose-Einstein condensates at the flux tubes. Nerve pulse patterns would induce frequency modulation allowing to code sensory input represented by them and send it to MB which in turn could send control signals through genome [K78, K36, K2, K96].

   MB would be the seat of primary form of genetic code. Dark protons sequences at flux tubes representing genetic code [L20] and the analogs of the other basic biomolecules are realized in water.

5.2.6 What the view about magnetic body could mean at the level of DNA and other basic bio-molecules?

A more precise vision about the anatomy of MB leads to a flux of ideas and questions. Flux tubes from identical basic units (cells, DNA, identical proteins, etc) combine to form single many-sheeted flux tube so that the incoming flux tubes have same M^4 projection being on top of each other in CP_2 direction. This super cable is like umbilical chord! The structures form a Bose-Einstein condensate in abstract topological sense.

This opens fascinating possibilities for understanding of dark DNA.

1. Cells have identical DNAs. Earlier I have assumed that magnetic flux sheets go through DNA in transversal direction and that dark DNA in some sense is sequence of dark proton triplets associated with flux tubes. Furthermore, DNA transcription requires that there are transversal flux tubes emerging from codons or perhaps even from nucleotides as flux tubes inside codon flux tube.

   How to combine these views together with new view about combination of the DNAs flux tube to larger superstructure, one DNA from each cell in structure?

2. For single DNA each codon would correspond to 3-proton units organized linearly into a sequence. Each 3-proton unit must have a flux tube transversal flux to DNA strand and located at 2-D sheet. This brings in mind the structure of spine as anatomical and neurobiological analogy. This suggests that dark DNA codons formed by 3-proton units should be associated with these horizontal flux tubes in 2-D locally planar surface going through DNA.

3. These structures from $n_{gr} = h_{gr}/h_0 = h_{eff}/h_0$ separate cells should combine to single n_{gr}-sheeted gravitational flux tube with sheets on top of each other with same M^4 projection.

This would be dark DNA at the level of MB. It would seem that given codon of each DNA must contribute a dark proton triplet so that there would be n_{gr} dark proton triplets at given flux tube which is however very long. The size scale - that is the length of the flux tube - is that of Earth typically and fixed by the cyclotron wave length λ_c.

This would give a concrete topological meaning to quantum quantum coherence at the level of MB of bio-system. Also a view about how lower level conscious entities integrate to larger ones: one can imagine entire fractal hierarchy of structures integrating to larger structures integrating... In particular, altered states of consciousness could correspond to this kind of temporary integrations to higher level structures. Same should apply to other basic biological structures: cells, proteins, RNA, tRA. Dark realization of the genetic code predicts the dark variants of these biomolecules.

This picture conforms with adelic physics [L34, L35] in which n_{gr} corresponds to the dimension of extension of rationals: the larger the value of n_{gr}, the higher the algebraic complexity and level of conscious intelligence.

4. Where are the dark protons and various dark ions at dark flux tubes? Along entire long flux tubes with length of order cyclotron wavelength for given charged particle? Or inside the organism?

   The model of dark DNA allows only the latter option. They must reside at the short portions of the magnetic flux tubes inside organism. For instance, the dark protons of dark DNA are associated with flux tubes parallel and in immediate vicinity of ordinary DNA strand and codon and dark codon a paired like codon and its conjugate in ordinary DNA.

   What makes these particles dark is that they are controlled by the gravitational flux tube and form a non-local quantum coherent unit containing n_{gr} particles.

This raises a long series of questions and fantastic challenges for visual imagination.

1. How do DNA and its conjugate relate at this level: do DNA and conjugate correspond to single closed long flux tube forming part of the "umbical chord" far from biological body?

2. What replication of DNA could mean topologically at the level of this super-DNA? What about description of transcription and translation at these super-levels. Are the ordinary replication, etc.. induced from this super level as mere shadow processes: this would explain their mysterious coherence?

3. What sexual reproduction and associated recombination of chromosomes could mean at super level? What does the growth of organisms mean at super level? Addition of new sheets to super DNA and its variants so that n_{gr} defined as the number of basic units grows and organism becomes more and more quantum intelligent?

5.3 Great Vision About Biological Evolution And Evolution Of Brain

The following great vision about evolution and is not perhaps strictly about hierarchy of EEGs. The hierarchy of dark matter and EEGs however leads to this vision naturally. The first part of vision relates to biological evolution. Second part is about the evolution of brain. Here the key thread is evolution of two kinds of intelligences, the ordinary fast intelligence evolving via the emergence of fast computation type activities and emotional slow intelligence developing via the emergence of higher levels of dark matter hierarchy. The latter intelligence is what distinguishes us from animals.

5.3.1 Basic Assumptions

The great vision about evolution and brain relies on two several new notions and ideas.

1. Life as something in the intersection of real and p-adic worlds making possible negentropic entanglement- both space-like and time-like. This makes possible to understand what conscious intelligence is and NMP reduces evolution to a generation of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book). DNA as topological quantum computer hypothesis [K2] finds also a justification.

2. The notion of many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) suggesting a universal hierarchy of metabolic energy quanta, and the notion of magnetic body.

3. Communication and control based on Josephson radiation and cyclotron transitions crucial for understanding bio-photons and EEG and its fractal generalization as a key element of bio-communications.

4. Zero energy ontology and the closely related notion of causal diamond (CD) assigning a hierarchy of macroscopic time scales to elementary particles coming as octaves of the basic time scale and justifying p-adic length scale hypothesis. Zero energy energy ontology also justifies the vision about memory and intentional action and the idea that motor action can be seen as time reversal of sensory perception.

5. The hierarchy of Planck constants and the identification of the fundamental evolutionary step as an increase of Planck constant. Evolutionary steps mean migration to the pages of the Big Book labeled by larger values of Planck constant and living system can be regarded as a collection of pages of the Big Book such that a transfer of matter and energy between the pages is taking place all the time. The change of the Planck constant implies either reduction or increase of the quantum scales-this leads to a model for biocatalysis and a model of cognitive representations as scaled down or scaled up "stories" mimicking the real time evolution.

6. A resonant like interaction between hierarchy of Planck constants and p-adic length scale hierarchy favoring the values of Planck constant proportional to powers of two, and idea that weak and color interactions are especially important in the length scales which correspond to Mersenne primes and Gaussian Mersennes. The simplest option is that weak bosons have their standard masses but appear as massless below their Compton length which scales up like $\hbar$ and preferred p-adic length scales correspond to Mersenne primes. Also copies of weak bosons and gluons with ordinary value of Planck constant and reduced mass scale can (and will) be considered.

How to identify the preferred values of Planck constant?

The basic problem is to identify the preferred values of Planck constant and here one can only make theoretical experimentation and all what follows must be taken in this spirit. One can consider assumptions which become increasingly stronger.

1. If only singular coverings of CD and CP_2 are possible Planck constant is a product of integers. Algebraic simplicity of algebraic extensions of rationals favors ruler and compass integers (Appendix).

2. A resonant interaction between the dark length scales and p-adic length scales with ordinary value of Planck constant favors Planck constants coming as powers of two.

3. An even stronger assumption would be that p-adic length scales coming as Mersennes and Gaussian Mersennes are especially interesting.

   (a) If weak bosons can appear with the ordinary value of Planck constant only in the p-adic length scale $k = 89$, one obtains the condition

$$k_d = k - 89 \quad , \quad k \in \{89, 107, 113, 127, 151, 157, 163, 167\} \tag{5.3.1}$$

for the values of of $r = 2^{k_d}$ allowing dark weak bosons in p-adic length scales assignable to Mersennes. These values of k_d assign to electrons and quarks dark p-adic length scales $L(k_{eff}) = \sqrt{r}L(k)$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$. The scales could correspond to size scales of basic units of living systems.

(b) If weak bosons and possibily also gluons with ordinary value of Planck constant are possible in all p-adic length scales $L(k)$, $k \in \{89, 107, 113, 127, 151, 157, 163, 167\}$, one obtains much richer structure. This hierarchy defines defines secondary dark matter hierarchies from the condition that the scaling the p-adic length scale $L(k_1)$ in this set by $\sqrt{r}$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$, gives a p-adic length scale equal to another p-adic length scale $L(k_2)$ in this set. This requires $k_d + k_1 = k_2$ so that the values

$$k_d = k_2 - k_1 \tag{5.3.2}$$

are favored for the scaling of $\hbar$. In this case the hierarchy of dark scales assignable to quarks and leptons is much richer. The tables below demonstrate that electron appears as its dark variant for all Mersennes and also in atomic length scales $k = 137, 139$ so that this option puts electron in a completely unique position.

4. Also other scales are possible. For instance, $r = 2^{47}$ required by 5 Hz Josephson frequency gives dark weak scale which corresponds $k = 136$ as a p-adic scale. The stages of sleep can be understood in terms of scaling of $\hbar$ by factor 2 and 4 so that also the atomic length scale $k = 137$ and the scale $k = 138$ are involved.

Since the experimental input is rather meager, one is forced to do theoretical experimentation with various hypothesis. The quantitative experimental tests are rather primitive but basically quantal.

1. The time scales assignable to CDs of leptons and quarks and their scaled up counterparts for the preferred values of Planck constant should define biologically important time scales. One might even speak about evolutionary level of electron. These time scales could define fundamental biorhythms and also time scales of long term memory and planned action.

2. Josephson frequencies and cyclotron frequencies scaling like $1/\hbar$ (if magnetic field scales down like $1/\hbar$) charactering biologically important ions and elementary particles. In accordance with the quantum criticality of living matter it is assumed that cell membrane corresponds to almost vacuum extremal so that classical Z^0 force is an essential element of the model. Also these frequencies should define fundamental bio-rhythms and characterize the evolutionary level of cell. Experimentally of special importance are the cyclotron frequencies assignable to Ca^{++} ions.

3. The amplitude windows for electric field scaling like $\hbar$ for a particular cyclotron frequency define a basic prediction.

Tables about predicted time and length scales

The following tables summarize various predictions for time scales and length scales. They correspond to the most general assumption that exotic bosons with the ordinary value of Planck constant are possible in all length scales associated with Mersennes and Gaussian Mersennes.

Note that **Table 5.1** includes only the dark length scales associated with $k = 89$ gauge bosons.

Electron and u quark are different

Before continuing an important observation is in order. Electron is exceptional when compared to quarks. It appears as a dark particle in all p-adic length scales defined by biologically important Gaussian Mersennes and also in atomic length scales $k = 137$ and $k = 139$. The reason is trivial:

k_d	p_1	p_2		k_d	p_1	p_2
4	163	167		38	**89**	127
6	107	113		38	113	151
6	151	157		40	127	167
6	157	163		44	107	151
10	157	167		44	113	157
12	151	163		50	107	157
14	113	127		50	113	163
16	151	167		54	113	167
18	**89**	107		56	107	163
20	107	127		60	107	167
24	**89**	113		62	**89**	151
24	127	151		68	**89**	157
30	127	157		74	**89**	163
36	127	163		78	**89**	167

Table 5.1: The integers k_d characterizing the preferred values of $r = \hbar/\hbar_0 = 2^{k_d}$ identified from the condition that the dark variant of p-adic length scale $L(p_1)$ corresponding to some ordinary p-adic length scale defined by Mersenne prime M_p or Gaussian Mersenne $M_{G,p}$, $p \in \{89, 107, 113, 127, 151, 157, 163, 167\}$ corresponds to similar p-adic length scale $L(p_2)$. If one assumes that weak bosons can appear with ordinary value of Planck constant only in the p-adic length scale $k = 89$, only the rows with $p_1 = 89$ of the table are possible: in these cases p_1 is in boldface and the row has double underline. The corresponding values of k_d are in the set $\{18, 24, 38, 62, 68, 74, 78\}$.

by the basic assumptions electron must appear at same length scales as weak bosons above $k = 127$ since it corresponds to Mersenne prime. Also for the less general option (exotic intermediate gauge bosons are possible only as the dark variants of the standard ones) it appears at cell membrane length scale $k = 151$, which is due to the fact that one has $113 - 89 = 151 - 127 = 24$. Also u quark can appear with $k_{eff} = 137, 139, 163, 167$ and also this is an accident. The light invariants of intermediate gauge bosons appearing in long p-adic length scales would naturally correspond to almost vacuum extremals making possible the criticality as the basic aspect of life. One must of course be very cautious about the masses of exotic counterparts of u and d quark: one can also consider the possibility that masses are identical.

5.3.2 Dark Matter Hierarchy And Big Leaps In Evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms wheras in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond

Z, W	d	u	e	k_d
89	120	124	127	**0**
93	124	127	131	4
95	126	129	133	6
99	130	133	137	10
101	132	135	139	12
103	134	137	141	14
105	136	139	143	16
107	138	141	145	**18**
109	140	143	147	20
113	144	147	151	**24**
119	150	153	157	30
125	156	159	163	36
127	158	161	165	**38**
129	160	163	167	40
133	164	167	171	44
139	170	173	177	50
143	174	177	181	54
145	176	179	183	56
149	180	183	187	60
151	182	185	189	**62**
157	188	191	195	**68**
163	194	197	201	**74**
167	198	201	205	**78**

Table 5.2: The dark p-adic length scales $\sqrt{r}L(k) = L(k_{eff})$, $k_{eff} = k + k_d$, of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $r = 2^{k_d}$ of Planck constant defined in **Table 5.1**. The uppermost row gives the integers characterizing the p-adic length scales of the particles for the standard value of Planck constant. k_{eff} characterizes also the CD times scale through the formula $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

k_1	k_M	k_1	k_M	k_1	k_M	k_1	k_M
113	89	113	107	163	127	163	157
127	89	119	107	167	127	169	157
151	89	123	107	133	127	173	157
157	89	113	107	139	127	163	157
163	89	117	107	143	127	167	157
167	89	111	107	133	127	161	157
95	89	175	113	137	127	169	163
109	89	181	113	131	127	183	163
133	89	187	113	225	151	207	163
139	89	191	113	229	151	213	163
145	89	119	113	157	151	219	163
149	89	133	113	171	151	223	163
103	89	157	113	195	151	177	163
127	89	163	113	201	151	201	163
133	89	169	113	207	151	207	163
139	89	173	113	211	151	213	163
143	89	127	113	165	151	217	163
113	89	151	113	189	151	187	163
119	89	157	113	195	151	193	163
125	89	163	113	201	151	199	163
129	89	167	113	205	151	203	163
95	89	137	113	175	151	169	163
101	89	143	113	181	151	175	163
105	89	149	113	187	151	179	163
95	89	153	113	191	151	169	163
99	89	119	113	157	151	173	163
93	89	125	113	163	151	167	163
145	107	129	113	167	151	187	167
169	107	119	113	157	151	211	167
175	107	123	113	161	151	217	167
181	107	117	113	155	151	223	167
185	107	195	127	235	157	227	167
113	107	201	127	163	157	181	167
127	107	205	127	177	157	205	167
151	107	133	127	201	157	211	167
157	107	147	127	207	157	217	167
163	107	171	127	213	157	221	167
167	107	177	127	217	157	191	167
121	107	183	127	171	157	197	167
145	107	187	127	195	157	203	167
151	107	141	127	201	157	207	167
157	107	165	127	207	157	173	167
161	107	171	127	211	157	179	167
131	107	177	127	181	157	183	167
137	107	181	127	187	157	173	167
143	107	151	127	193	157	177	167
147	107	157	127	197	157	171	167

Table 5.3: Table gives all weak boson length scales -both non-dark and dark implied by the assumption that all Mersennes primes and their Gaussian counterparts and their dark counterparts defined $k_d = k_i - k_j$ them are possible.

particle	Z, W	d	u	e
k	89	120	123	127
f(CD)/Hz	2.7488×10^{12}	1280	160	10

Table 5.4: The fundamental frequencies associated with the CDs of intermediate gauge bosons Z, W, d and u quarks, and electron. Note that for intermediate gauge bosons the frequency of CDs corresponds to energy $E = 1.13 \times 10^{-2}$ eV and wavelength $\lambda = 1.01 \times 10^{-4}$ m (size of a large neuron).

Z, W	d	u	e	k_d
3.64e-13	7.81e-04	6.25e-03	1.00e-01	**0**
5.821e-12	1.25e-02	1.00e-01	1.60e+00	4
2.31e-11	5.00e-02	4.00e-01	6.40e+00	6
3.73e-10	8.00e-01	6.40e+00	1.02e+02	10
1.49e-09	3.20e+00	2.56e+01	4.10e+02	12
5.97e-09	1.28e+01	1.02e+02	1.65e+03	14
2.38e-08	5.12e+01	4.10e+02	6.55e+03	16
9.54e-08	2.05e+02	1.64e+03	2.62e+04	**18**
3.81e-07	8.19e+02	6.55e+03	1.05e+05	20
6.10e-06	1.31e+04	1.05e+05	1.68e+06	**24**
3.91e-04	8.39e+05	6.71e+06	1.07e+08	30
2.50e-02	5.37e+07	4.30e+08	6.87e+09	36
1.00e-01	2.15e+08	1.72e+09	2.75e+10	**38**
4.00e-01	8.59e+08	6.87e+09	1.10e+11	40
6.40e+00	1.37e+10	1.10e+11	1.76e+12	44
4.10e+02	8.80e+11	7.04e+12	1.12e+14	50
6.55e+03	1.41e+13	1.13e+14	1.80e+15	54
2.62e+04	5.63e+13	4.50e+14	7.21e+15	56
4.19e+05	9.01e+14	7.21e+15	1.15e+17	60
1.68e+06	3.60e+15	2.88e+16	4.61e+17	**62**
1.07e+08	2.31e+17	1.84e+18	2.95e+19	**64**
6.87e+09	1.48e+19	1.18e+20	1.89e+21	**74**
1.10e+11	2.36e+20	1.89e+21	3.02e+22	**78**

Table 5.5: The $\hbar$-scaled fundamental time scales $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds associated with the CDs of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $\hbar/\hbar_0 = 2^{k_d}$ of Planck constant defined in **Table 5.1**. The scales are expressed in seconds. The uppermost row gives the time scales of CDs for the standard value of Planck constant. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales or corresponding electronic Compton lengths, the number of which is 23, are excellent candidates for the scales of basic building brickes of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from.1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [E1].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the begining, evolution would mean a steady growth of k_d. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \to 107 \to 113 \to 127 \to 151 \to 157 \to 163 \to 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the

lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unknown role in the functioning of living matter.

2. $89 \to 107$ *step with* $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [K96] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [K28, K96] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [K47]. The possible existence of the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \to 113$ *step with* $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order 100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \to 127$ *step with* $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \to 151$ *step with* $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass.25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a precedessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [I22] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [I39] is between 10-300 nm covers the entire range of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest [I21] [I21], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \to 157 \to 163 \to 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between.2 μm ($k = 157$ corresponds to.08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, 457, 997\}$ [A1]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and

above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187, 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From **Table 5.5**one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determines the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20, 2.74, 3.07, 2.31) eV, see Table 1). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the $L_e(k = 163)$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 5.6: The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

(c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

(d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average.8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of.1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in **Table 5.6**. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given

scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [A1]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are (72, 74) ($167 \to (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assignment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about (41.4, 82.8) months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to (54.4, 108.8) years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleotides involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

5.4 A model of Genetic Code as Fusion of Doublet and Singlet Models

I have proposed a model for the evolution of genetic code as a fusion of singlet and doublet codes to triplet code already earlier. The model to be discussed here is obtained from this model by some dramatic simplifications.

The basic questions are following.

1. What were the physical counterparts of the pre-amino-acids and pre-tRNAs for singlet and doublet codes?

2. How the triplet code emerged from the singlet and doublet codes? How the tRNA molecules evolved and how the amino-acids replaced pre-amino-acids?

3. Can one identify singlet and doublet life-forms or at least some precedessors of triplet life forms as existing life-forms?

In an attempt to answer these questions p-adic length scale hypothesis and the vision about the molecular evolution as a sequence of spontaneous symmetry breakings induced by the generation of new space-time sheets serve as valuable guide lines. The following biological input is needed.

1. RNA world [I139] as a model for pre-biotic evolution allows to identify pre-amino-acids as RNA sequences (RNA_1 for short) differing somehow from the ordinary RNA sequences (RNA_2 for short). 1-code was associated with the transformation of $RNA_2 \to RNA_1$ and 2-code in the simplest case with the transcription of RNA_2 to its conjugate.

2. The cross like structure of tRNA molecule identifiable as a composite of its singlet and doublet precedessors allows to read directly the main steps in the evolution of the triplet code as a fusion of singlet and doublet codes and also gives detailed and highly non-trivial information about RNA_1.

3. The reverse transcriptase, appearing in retro-viruses like HIV and acting also as a transcriptase [J3], provides the mechanism transforming RNA sequences to DNA sequences inside pre-nucleus so that DNA→RNA code emerged and also evolved rapidly since reverse transcriptase makes a lot of errors.

4. The basic idea is that the fusion of $tRNA_1$ and $tRNA_2$ to to $tRNA_3$, the recent tRNA, made $RNA_2 \to RNA_1$ and $RNA_2 \to RNA_2$ transformations impossible and the amino-acids originally catalyzing the attachment of RNA_2 doublet in RNA_2 transcription began to be attached to a growing amino-acid sequence and mRNA→ amino-acid part of genetic machinery was established. The emergence of reverse transcriptase brought in DNA. DNA as topological quantum computer idea generalized to RNA context provides tight additional conditions on the course of events: in particular, membrane like structures, most naturally consisting of RNA_1 should have been present already at RNA era.

5. Nanno-bacteria claimed to be even the dark bio-matter are excellent candidates for singlet and doublet life-forms or at least, precedessors of the recent life-forms. There are reasons to believe that RNA era is still continuing inside cell nucleus.

Second group of questions relates to the quantum control of the translation process. There are many questions also now.

1. What makes a codon stopping codon?

2. What is behind the symmetries of the code with respect to the third codon.

3. What is the origin of breaking of the canonical A-T, C-G rules for mRNA-tRNA association?

The model for the transition from RNA era to RNA-amino-acid era allows to answer these questions and te DNA as TQC picture leads to a physical interpretation of these symmetries and their breaking.

5.4.1 RNA World

The hypothesis that pre-biotic life before the emergence of the cell membrane structures was RNA dominated (the notion of RNA world) is based on a strong empirical evidence summarized in detail in [I54]. For instance, only RNA can be generated spontaneously in the absence of cell membrane bounded structures. There is also a lot of support for the ability of RNA to take care of functions like replication, translation, and transfer (see the [I54] and references therein). Ribozymes could even replace enzymes as RNA based catalyzing agents so that even amino-acids might be unnecessary in RNA world and the system could consist of RNA only. This of course does not mean that this system could yet realize genetic code and evolve.

An important implication is that pre-amino-acids might be identifiable as $2', 5'$ RNA, which was produced in the classical experiments of Leslie Orgel at 1980s mimicking primordial ocean. There are however also other candidates and the structure of tRNA more or less fixes identification to a high degree.

Ontogeny recapitulates phylogeny principle suggests that if RNA coded RNA during primordial period, the remnants of these RNAs could still exist and be coded by specific genes. This is indeed the case [I113] (for an article about RNA genes and RNA world see [I134]). RNA genes were discovered already 1990 in the genome of Caenorhabditis elegans, the small nematode worm but it took years to realize that they do not code proteins but small RNA molecules that somehow turn off other genes that play a role in worm development. Later these small RNA coding genes were found in flies, mollusks, fish, and even humans. As many as 200 microRNA genes in C. elegans were known at time of the writing of the article, which would represent about 1 percent of the genes of its genes. There is also evidence that centrosomes possess their own genome based on RNA rather than DNA [I8].

5.4.2 Programming Of Bio-Molecular Self Assembly Pathways From TGD Point Of View

The beautiful results (for a popular summary see [I124]) about programming of bio-molecular self assembly - described above - when combined with the earlier model for the pre-biotic evolution - inspire interesting insights about the role of braiding in translation. The basic observation is that the structure of tRNA- although more complex than that of hairpin- has much common with that of hairpins. Therefore it is interesting to look this structure from the point of view of TGD. For instance, one can find whether the notions of braiding, anomalous em charge and quark color could provide additional insights about the structure and function of tRNA.

The brief summary of the resulting picture is as follows. According to the TGD based model of pre-biotic evolution, 3-code should have resulted as a fusion of 1- and 2- codes to 3-codes involving fusion of $tRNA_1$ and $tRNA_2$ to $tRNA_3 \equiv tRNA$. Second hypothesis is that during RNA era the function of $tRNA_2$ was to generate RNA_2 double helix from single RNA strand and that amino-acids catalyzed this process. The considerations that follow strongly suggest that $tRNA_1$ was involved with a non-deterministic generation of new RNA sequences essential for the evolution. After the establishment of 3-code these two process fused to a deterministic process generating amino-acid sequences. RNA era could still continue inside cell and play an important role in evolution.

There is an interesting work about programming bio-molecular self assembly pathways [I33]. The catalytic self assembly of complexes of nuclei acids is carried out automatically by a program represented implicitly as a mixture of linear DNA strand acting as catalyst and so called hairpin DNA: s containing three nucleation sites a_t, b_t, c_t - so called toeholds.

Key ideas

The basic idea is that a set of bio-molecular reactions can be programmed to occur in a desired order by using a generalization of lock and key mechanism. The simplest self assembly pathway can be specified by a collection of keys and locks. In the beginning there is only one key and the this key fits to only one door, which leads into a room with several doors. The lock eats the key but gives one or more keys. If the room contains several doors to which the keys fits, the reaction corresponds to addition of several branches to the already existing reaction product. By continuing in this manner one eventually ends up to the last room and at the last step the lock gives back the original key so that it can act as a catalyst.

The translation of this idea to a program defining self assembly pathway is following.

1. DNA hairpin define key structural element of the self-assembly program. Hairpin is a single-stranded DNA strand in meta-stable configuration having form A+B+C [I104] such that B forms a loop and C is a palindrome [I28] . The formal expression for palindromy is $C = A_t^*$: this means that C read backwards (C_t) is conjugate A^* of A implying that A and C running in opposite direction can form a double helix (duplex) by hydrogen bonding. As catalytic a^* acting as key forms a double helix with a, the hairpin molecule opens to a linear DNA molecule and energy is liberated. In this process original key is lost but the two other toeholds b_t and c_t contained by the hairpin become available as keys. Each hairpin in the mixture of catalyst and hairpin molecules has its own lock and two keys.

2. The process of opening new doors continues until all hairpin molecules are used. The key given by the last lock must be catalyst strand a^*. The outcome is a molecule consisting of pieces of DNA strands and can possess a very complex topology. For instance, the formation trees and star like structures can be easily programmed.

3. To run this program one needs only an optimal mixture of catalyst molecule and hairpin DNA molecules. In the applications discussed in [I33] hairpins have length of order 10 nm which corresponds to $L_e(151) = \sqrt{5}L(151)$ defining also cell membrane thickness. That $L_e(151)$ corresponds also to the length of 30-nucleotide sequence defining the codon of the code associated with Mersenne prime $M_{61} = 2^{61} - 1$ might not be an accident. The simplest applications are autocatalytic formation of DNA dublex molecules and of branched junctions, nucleated dendritic growth, and autonomous locomotion of a bipedal walker.

The basic idea in the realization of the autonomous motion of bipedal walker is to cheat the walker to follow a track marked by food. The walker literally eats the food and receives in this manner the metabolic energy needed to make the step to the next piece of food. The menu contains two kinds of hairpins (see **Fig. 5.1**): hairpins A attached regularly along the desired path of the walker (second DNA strand) and hairpins B but not attached to the strand. The front leg l of the walker attaches to A and this catalyzes the formation of the duplex $A \cdot B$ as a waste and the liberated metabolic energy allows to make a step in which hind leg becomes the front leg.

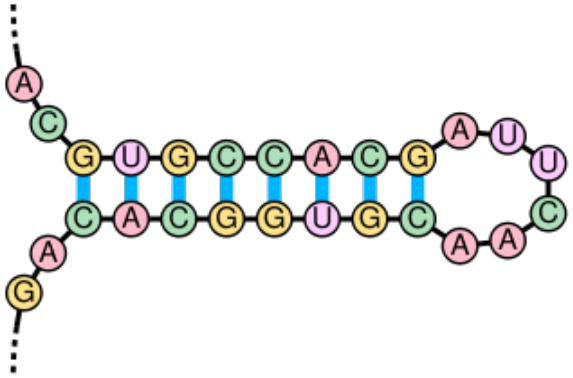

Figure 5.1: The structure of DNA hairpin (stem loop)

TGD view about the situation

The possibility to program the self-assembly relies on the almost deterministic realization of the lock and key mechanism. The presence of braid strands could make this possible.

1. Consider first the hypothesis about the cancelation of anomalous DNA charge. The palindromic character of A means that the neck of the hairpin has vanishing anomalous em charge and also vanishing color charge is possible. Hence palindromes are favored in TGD Universe. The circular piece B is not in general color singlet. It could have braid strands connecting it to it to some other DNA or nuclear membrane but this is not necessary. Same applies to the toehold a_t at the end of the other strand of neck.

2. The attachment of the lock to key could be seen as a process in which a braid consisting of magnetic flux tubes connecting lock and key strands (DNA and its conjugate) is formed spontaneously and followed by a phase transition reducing $\hbar$ contracting the flux tubes and in this manner guiding the key to the lock.

If one assumes that only paired nucleotides of single DNA strand possess braid strands, one must assume the same for mRNA. As a consequence one would loose the nice interpretation for the formation of AAA... tail of mRNA as a way to guarantee integer valuedness and small value (or even vanishing) of the anomalous em charge. If there is braid strands associated with entire mRNA, it could end at the nuclear membrane. In this case the transfer of tRNA to mRNA during translation by a phase transition reducing $\hbar$ of braid strands could be initiated by the fusion of the braid strand ends coming from mRNA codon and from its conjugate codon at tRNA at nuclear membrane.

5.4.3 The Archeology Of TRNA Molecules As A Guideline

The study of the structure of the ordinary tRNA molecule is of considerable help in the attempts to guess what might have been its precedessor.

The structure of the tRNA molecule

The shape of the tRNA molecule [I37] in 2-D representation is that of cruciform.

1. tRNA molecule has a cross like appearance, and decomposes into a body coded by tRNA gene and an acceptor stem which is same for all amino-acids and added separately and can be replaced during the lifetime of the tRNA molecule. Acceptor stem, to which the amino-acid is attached with the mediation of amino-acyl-tRNA synthase, can be said to be a passive component and is same for all tRNAs so that its structure does not determine which amino-acid is attached to it. The stem is not coded by genes and contains 4 nucleotides.

2. tRNA molecule can be seen as single RNA strand just as hairpin. The five stems are double helices analogous to the necks of the hairpin. Strand begins at $5'$ end of the acceptor stem directed upwards. The second strand of acceptor stem continues as a toehold ending to $3'$ end of tRNA. The toehold has at its end ACC to which the amino-acid (rather than conjugate DNA) attaches.

3. tRNA molecule (see **Fig. 5.2**) contains three arms with hairpin structure. A arm containing the anticodon is directed downwards. D and T arms are horizontal and directed to left and right. Between T arm and A arm there is additional variable hairpin like structure but with highly degenerate loop is degenerate. It has emerged during evolution.

4. The structure of tRNA minus anticodon depends on anti-codon which conforms with the fact T and D arms are related to the binding of amino-acid so that their nucleotide composition correlates with that of anticodon.

5. Anticodon arm contains the anticodon of mRNA codon and thus corresponds to RNA. For doublet part of the mRNA codon the correspondence is 1-1 but for the third nucleotide the correspondence is more complex due to wobble base pairing to be discussed below. Wobble base pairing indeed leads to the recent simplified model for the evolution of the triplet code as a fusion of 1-code and 2-code.

Wobble base pairing

The phenomenon of wobble base pairing [I41] is very important. There are only about 40 tRNA molecules instead of 61 which means that one-to-one map between mRNA nucleotides and tRNA conjugate nucleotides is not possible. Crick suggests that so called wobble base pairing resolves the problem. What happens that the first nucleotide of anticodon is either A, G, U, or I(nosine) [I16]. The base-pairings for third nucleotide are $\{A-U, G-C, U-\{A,G\}, I-\{U,A,C\}\}$. The explanation for the non unique base pairing in the case of U is that its geometric configuration is quite not the same as in ordinary RNA strand. I is known to have 3-fold base pairing.

Minimization of the number of tRNAs requiring that only three mRNA codons act as stopping signs predicts that the number of tRNAs is 40.

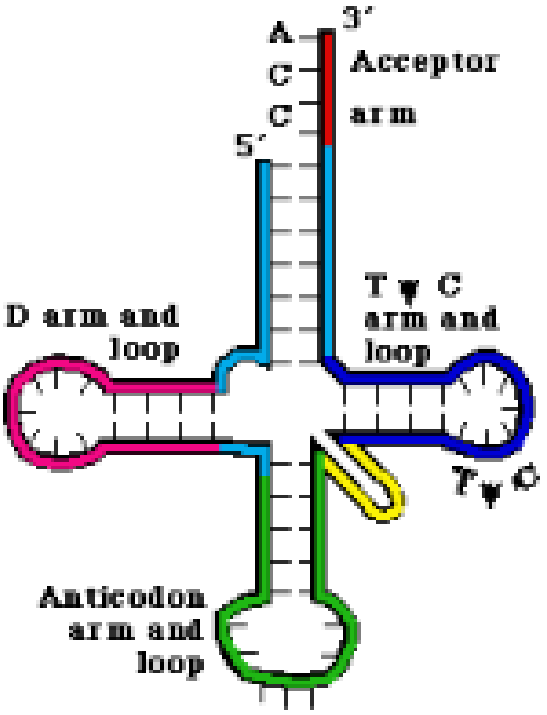

Figure 5.2: The structure of tRNA

1. It is convenient to classify the 4-columns of code table according to whether all four codons code for the same amino-acid ($(T,C,A,G) \to X$, whether 4-column decomposes into two doublets: $[(T,C),(A,G)] \to [X,Y]$, or whether it decomposes to triplet and singlet ($[(T,C,A),G] \to [ile,met]$). There are also the 4-columns containing stop codon: $[(U,C),(A,G)] \to [(tyr,tyr),(stop,stop)]$ and $[(U,C),A,G] \to [(cys,sys),stop,trp]$. Mitochondrial code has full A-G and T-C symmetries whereas for vertebrate nuclear code 3 4-columns break this symmetry.

2. Consider first 4-columns for which the doublet symmetry is broken. $[tyr,tyr,top,stop]$ column must correspond to first tRNA nucleotide which is A or G (tyr). The absence of anti-codons containing U implies stop codon property. For $[cys,sys,stop,trp]$ one must have A, G and C but U is not allowed. ile-met column can correspond to tRNAs with I and C as the first nucleotide.

3. For 4-columns coding for two doublet amino-acids the minimal set of first tRNA codons is $\{A,G,U\}$. For completely symmetric 4-columns the minimal set of tRNA codons is $\{I,U\}$. Thus $\{A,G,U,I\}$ would replace $\{A,G,U,C\}$.

4. There are 9 completely symmetric 4-columns making 18 tRNAs, 5 doublet pairs making 15 tRNAs, ile-met giving 2 tRNAs, and the columns containing stopping codons giving 5 tRNAs. Altogether this gives 18+15+2+5= 40. Also the deviations from the standard code can be understood in terms of the properties of tRNA.

Consider the interpretation of wobble base pairing in TGD framework assuming the braiding picture and the mapping of nucleotides to quarks. The completely symmetric 4-columns correspond to unbroken isospin and matter-antimatter asymmetries. 4-columns decomposing into doublets result from the breaking of matter-antimatter asymmetry at quark level. ile-met column corresponds to the breaking of both symmetries. The base pairings of I obviously break both symmetries.

The non-unique based pairing of U and I means that they cannot correspond to a unique quark or anti-quark in braiding U pairs with both A and G so that the braid strands starting from these RNA nucleotides must both be able to end to tRNA U. Hence tRNA U is not sensitive to

the isospin of the quark. This non-uniqueness could relate to the assumed anomalous geometric character of the binding of U codon to tRNA sequence. The braid strands beginning from U, A, and C must be able to end up to I so that I can discriminate only between $\{U, C, A\}$ and G.

Anomalous em charge and color singletness hypothesis for tRNA

One can test also whether the vanishing of anomalous em charge of tRNA leads to testable predictions. One can also try understand translation process in terms of the braiding dynamics. One must distinguish between the states of tRNA alone and tRNA + amino-acid for which braidings are expected to be different.

Before continuing it must be made clear that braiding hypothesis is far from being precisely formulated. One question is whether the presence of the braiding could distinguish between matter in vivo and vitro. For instance, the condition that anomalous em charge is integer valued or vanishing for DNA hairpins in vivo gives strong condition on the loop of the hairpin but or hairpins in vitro there would be no such conditions. Second point is that amino-acids and I and U in tRNA_1 could carry variable anomalous em charge allowing rather general compensation mechanism.

1. tRNA without amino-acid

1. The minimal assumption is that braiding hypothesis applies only to the stem regions of tRNA in this case. In this case the strands can indeed begin from strand and end up to conjugate strand. The possibility of color singletness and vanishing of total anomalous em charge are automatically satisfied for the stem regions as a whole in absence of non-standard base pairings. In general the acceptor stem contains however $G*U$ base pair which is matter-antimatter asymmetric but breaks isospin symmetry and gives unit anomalous charge for the acceptor stem. Also other stems can contain $G*U$, $U*G$ pairings as also $P*G$ and $L*U$ pairings (P and L denote amino-acids Pro and Leu). The study of concrete examples [I34] shows that single G*U bond is possible so that anomalous em charge can be non-vanishing but integer valued for double strand part of tRNA. Suppose that a given amino-acid can have anomalous of any codon coding for it. If P in $G*P$ pair has the anomalous em charge of the codon CCG, $G*P$ pair has vanishing anomalous em charge. If L corresponds to CUA the value of anomalous em charge is integer.

2. The anomalous em charge in general fails to vanish for the loops of hairpins. For the braids possibly associated with the loops of tRNA the strands can only end up to tRNA itself or nuclear membrane. If there are no braid strands associated with these regions, there is no color or anomalous em charge to be canceled so that the situation trivializes. On the other hand, in the case of tRNA I and U associated with the first nucleotide of the anticodon of tRNA can have a varying value of anomalous em charge. Therefore integer valued em charge and color singletness become possible for tRNA. tRNA can also contain amino-acids. If the amino-acids can carry a varying anomalous em charge with a spectrum corresponding to its values for DNA codons coding it, also they could help to stabilize tRNA by cancelling the anomalous em charge.

2. tRNA plus amino-acid

1. Amino-acyl tRNA synthetase, which is the catalyst inducing the fusion of amino-acid with ACC stem [I38], could have braid strands to both amino-acid and tRNA and have regions with opposite anomalous em charges compensating separately that of amino-acid and of the active part of tRNA. The required correlation of amino-acid with anticodon would suggest that both D and T loops and A-loop are included. The simplest option is however that the anticodon is connected by braid to amino-acid so that braiding would define the genetic code at the fundamental level and the many-to-one character of genetic code would reflect the 1-to-many character of amino-acid-quark triplet correspondence. This hypothesis is easy to kill: for the portion of catalyst attaching to a given portion of DNA strand amino-acids and codons should have opposite anomalous em charges: $Q_a(amino) = -Q_a(codon)$.

2. After the catalysis involving reduction of $\hbar$ amino-acid and tRNA would form a system with a vanishing net anomalous em charge but with a braiding structure more complex than that before the fusion.

3. In the translation process the braiding structure of tRNA- amino-acid system should reorganize: the braid strands connecting anticodon with amino-acid are transformed to braid strands connecting it to mRNA codon with a subsequent reduction of $\hbar$ of braid strands bringing tRNA into the vicinity of mRNA. In the transcription the anticodon-codon braiding would be replaced with amino-acid-mRNA braiding forcing formation of the amino-acid sequence. It will be later found that the simpler option without this step corresponds to the earlier hypothesis according to which amino-acids acted originally as catalysts for the formation of RNA double helix.

4. tRNA is basically coded by genes which suggests that the general symmetries of the genetic code apply to the variants of tRNA associated with same anticodon. Hence the variants should result from each other by isospin splits and modifications such as permutations of subsequent nucleotides and addition of AT and CG pairs not changing overall color and isospin properties. Also anomalous base pairs $X*Y$ can be added provide their net anomalous em charge vanishes.

5. tRNA has a complex tertiary (3-D) structure [I36] involving base pairing of distant nucleotides associated with the roots of the stem regions where tRNA twists sharply. This pairing could involve formation of braid strands connecting the nucleotides involved. The reduction of Planck constant for these strands could be an essential element of the formation of the tertiary structure.

The fossilized components of tRNA as record about the evolution of the recent form of the genetic code

The ordinary tRNA indeed seems to contain in its structure fossilized components providing a record about how the molecular evolution proceeded. tRNA_1 and tRNA_2 correspond naturally to the horizontal and vertical segment in the recent tRNA formed as a fusion of tRNA_1 and tRNA_2 to form a cross like structure (see figure above). Hence tRNA_1 and trNA_2 should represent in their structures the respective genetic codes.

1. tRNA_2 should contain both the conjugate of the coding RNA nucleotide attaching to RNA_2 plus the conjugate of the coded nucleotide to which RNA nucleotide was attached and then transferred to RNA_2 and added to the growing RNA sequence. This means that the structure of tRNA should help to deduce the doublet code experimentally. The pairs formed by the RNA triplet XYZ at the end of the anticodon arm of the ordinary tRNA and the pair formed by the triplet $X'Y'Z'$ and its conjugate on right and left sides of XYZ should provide detailed information about the doublet code. The pairs $XY - X'Y'$ should represent the doublet code apart from possible symmetry breaking effects. These effects might be induced at the level of $X'Y'Z'$-amino-acid correspondence level and thus not visible in the structure of tRNA.

2. The transition to the triplet code added one RNA nucleotide to both the exotic doublet $(XY)_2$ and the doublet $X'Y'$ and its conjugate coded by it. The exotic $2', 5'$ doublet plus the added singlet transformed to ordinary triplet. The simplest assumption is that these RNAs came from D arm and TψC arm. This is possible since all loops are physically near to each other. The structure of D and Tψ loops conforms with the assumption that the precedessor of the first *resp.* second loop has lost the coding *resp.* coded RNA. The structure of these loops forces also to conclude that all tRNA loops have been stem like structures before their deactivation just as the acceptor stem is. Deactivation of RNA_1 translation process must have meant the completion of these stems to loops by addition of a conjugate of the conjugate of the coded RNA.

The components of tRNA as ribozymes which have acted originally as RNA polymerases

The mechanism of ribozyme catalyzed polymerization for both the exotic RNA with mono- *resp.* disphosphate backbones, and their their double strand can be guessed from the fact that the process can be seen as an unfaithful replication. Hence the tRNAs involved would play a role analogous to DNA polymeraze in the polymerization of DNA. The only difference is that, instead of the conjugate of the template strand, a copy of strand is reproduced and the copy can be un-faithful.

DNA replication utilizes the conjugate strand as a template and occurs with the mediation of DNA polymerase enzyme, which brings dXTP, $X = A, T, C, G$ rather than dXMP, to the vicinity of the DNA conjugate strand [I48]. The di-phosphate is cleaved out from dXTP and the liberated energy makes it possible to add the resulting dXMP to the growing DNA strand.

The prediction is that tRNA_1 and tRNA_2 have originally been ribozymes acting as exotic RNA polymerases. In the case of DNA strand dXMP pairs with its conjugate in the template strand by hydrogen bonds and $3', 5'$ bond is formed between monophosphate deoxiribose of previous nucleoside. In the case of exotic RNA strand the XMP associated with the tRNA pairs with its conjugate in the template RNA strand, $2', 5'$ bond with the ribose of the previous RNA unit is formed. tRNA is not so selective as a polymerase as DNA polymerase and this ultimately gives rise to the many-to-one correspondence crucial for the non-triviality of the genetic code.

1. RNA_2 consists of exotic RNA doublets with nucleotides connected by $2', 5'$ monophosphate bonds. tRNA_2 brings $2', 5'$ doublet $\mathrm{XMP}_2 \circ \mathrm{YTP}_2$ to the growing strand and glues it to the $5'$ position of the ribose in the already existing polymer. The YTP suffers the cleavage $\mathrm{YTP}_2 \to \mathrm{YMP}_2$ as in the case of DNA polymerization and the amount of metabolic energy provided by the cleavage is the same. The formation of $\mathrm{XMP}_2 \circ \mathrm{YTP}_2$ proceeds by gluing of XTP_2 to YTP_2 by a similar process so that the net metabolic energy used per nucleotide is essentially the same as in the ordinary DNA polymerization.

2. RNA_1 consists of exotic RNA singlets connected by $2', 5'$ diphosphate bonds. tRNA_1 brings XTP_2 near the growing strand, the cleavage $\mathrm{XTP}_2 \to \mathrm{XDP}_2$ occurs, and XDP_2 is glued to the $5'$ position of the ribose of the previous RNA nucleotide. The amount of metabolic energy provided by the cleavage is roughly one half of that in the case of RNA_2 polymerization, and this might partially explain why diphosphate exotic RNA strands are rare whereas monophosphate exotic DNA strands can be found inside cells. On the other hand, it is $ATP \to ADP$ cleavage, which usually occurs in the ordinary metabolism instead of $ATP \to \mathrm{AMP}$ cleavage: only during a very intense metabolism $ATP \to \mathrm{AMP}$ cleavage occurs. Since ATP metabolism is a functional fossil from a very early period of evolution, one might expect that $ATP \to \mathrm{ADP}$ cleavage has in fact occurred naturally, if not even more naturally, also in the polymerization of $2', 5'$ RNA during (exotic) RNA era.

3. In the case of double exotic RNA strand of ordinary and exotic RNA the precedessor of the recent tRNA formed by $\mathrm{tRNA}_1 + \mathrm{tRNA}_2$ would be a ribozyme bringing energized singlet and doublet RNAs to the double strand acting as a template with tRNA_1 component catalyzing the cleavage of the monophosphate and tRNA_2 component catalyzing the cleavage of the diphosphate.

The crucial and testable prediction is that the ribozymes responsible for the exotic mono- and diphosphate $2', 5'$ RNA polymerization should have a strong resemblance with the two structural components of the recent tRNA. Furthermore, the replication catalyzed by these ribozymes should be unfaithful, perhaps in a way consistent with the genetic code before the breaking of its symmetries. Ribozymes responsible for the ordinary RNA polymerization are known but I am not aware about how much is known about the corresponding ribozymes in the case of $2', 5'$ RNA. The building blocks of recent tRNA would however provide a good starting point for innovative RNA engineers. In any case, the very fact that this form of RNA does not even allow DNA, makes it a more natural candidate for the basic building block of RNA life than $3', 5'$ RNA.

From RNA world to RNA-tRNA world to RNA-DNA-tRNA world to DNA-RNA-protein world: how it went?

I encountered a highly interesting work [I64] (see `http://tinyurl.com/y9ps2efz`) related to the emergence of RNA world and I warmly recommend it to the reader (for a popular article see `http://tinyurl.com/y7m3absu`).

First a summary of basic terms for the possible reader of the article. There are three key enzymes involved in the process which is believed to lead to a formation of longer RNA sequences able to replicate.

1. Ribozyme is a piece of RNA acting as catalyst. In RNA world RNA had to serve also as a catalyst. In DNA world proteins took this task but their production requires DNA and transcription-translation machinery.

2. RNA ligase promotes a fusion of RNA fragments to a longer one in presence of ATP transforming to AMP and diphospate and giving metabolic energy presumably going to the fusion. In TGD fUniverse this would involve generation of an atom (presumably hydrogen) with non-standard value of $h_{eff} = n \times h$ having smaller binding energy scales so that ATP is needed. These dark bonds would be involved with all bio-catalytic processes.

3. RNA polymerase promotes a polymerization of RNA from building bricks. It looks to me like a special kind of ligase adding only single nucleotide to an existing sequence. In TGD Universe $h_{eff} = n \times h$ atoms would be involved as also magnetic flux tubes carrying dark analog of DNA with codons replaced with dark proton triplets.

4. RNA recombinase promotes RNA strands to exchange pieces of same length. Topologically this corresponds to two reconnections occurring at points defining the ends of piece. In TGD Universe these reconnections would occur for magnetic flux tubes containing dark variant of DNA and induce the chemical processes at the level of chemistry.

Self ligation should take place. RNA strands would serve as ligases for the generation of longer RNA strands. The smallest RNA sequences exhibiting self-ligation activity was found to be 40-nucleotide RNA and shorter than expected. It had lowest efficiency but highest functional flexibility to ligate substrates to itself. R18 - established RNA polymerase model - had highest efficiency and highest selectivity. What I can say about the results is that they give support for the notion of RNA world.

The work is related to the vision about RNA world proposed to precede DNA-RNA-protein world. Why I found it so interesting is that it relates to on particular TGD inspired glimpse to what happened in primordial biology.

In TGD Universe it is natural to imagine 3 or even 4 worlds.There are two scenarios: RNA world, RNA-tRNA world, and DNA-RNA-protein world and RNA world, RNA-tRNA world, DNA-RNA-tRNA world and DNA-RNA-tRNA-protein world.

Years ago I developed a rather detailed version of the idea about transition from RNA world to DNA-RNA-protein world [K39, K40] but I did not realize the tRNA-RNA world as intermediate step (see `http://tinyurl.com/y8ho27rq`).

1. RNA world would contain only RNA. Protein enzymes would not be present in RNA world and RNA itself should catalyze the processes needed to for polymerization, replication, and recombination of RNA. Ribozymes are the RNA counterparts of enzymes. In the beginning RNA would itself act as ribozymes catalyzing these processes.

2. One can also try to imagine RNA-tRNA world. The precedessors of tRNA molecules containing just single amino-acid could have catalyzed the fusion of RNA nucleotide to a growing RNA sequence in accordance with the genetic code. The function of tRNA would thus been different: since the roles of RNA codon and amino-acid would have been changed from the usual. Amino-acid sequences would not have been present at this stage since there would be no machinery for their polymerisation.

3. One can consider a transition from this world to DNA-RNA-tRNA world. This would storage of genetic information to DNA from which it would have been transcribed by using polymerase consisting of RNA. This phase would have required the presence of cell membrane like structure since DNA is stabilized inside membranes or at them. Transition to this world should have involved reverse transcription catalyzed by RNA based reverse-transcriptase. Being a big evolutionary step, this transition should involve a phase transition increasing the value of $h_{eff} = n \times h$.

4. My earlier proposal has been that a transition from RNA world to DNA-RNA-protein world took place. The transition could have also taken place from DNA-RNA-tRNA world to world containing also amino-acid sequences and have led to rapid evolution of catalysis based on amino-acid sequences.

   The amino-acid sequences originating from tRNA originally catalyzing RNA replication stole the place of RNA sequences as the end products from RNA replication. The ribosome started to function as a translator of RNA sequences to amino-acid sequences rather than replication of them to RNAs! The roles of protein and RNA changed! Instead of RNA in tRNA the amino-acid in tRNA joined to the sequence! The existing machinery started to produce amino-acid sequences!

   Presumably the modification of ribosome or tRNA involved addition of protein parts to ribosome, which led to a quantum critical situation in which the roles of proteins and RNA polymers could change temporarily. When protein production became possible even temporarily, the produced proteins began to modify ribosome further to become even more favorable for the production of proteins.

   But how to produce the RNA sequences? The RNA replication machinery was stolen in the revolution. DNA had to do that via transcription to mRNA! DNA had to emerge before the revolution or at the same time and make possible the production of RNA via transcription of DNA to mRNA. The most natural options corresponds to "before", that is DNA-RNA-tRNA world. DNA could have emerged during RNA-tRNA era together with reverse transcription of RNA to DNA with RNA sequences defining ribozymes acting as reverse transcriptase. This would have become possible after the emergence of precedessor of cell membrane. After that step DNA sequences and amino-acid sequences would have been able to make the revolution together so that RNA as the master of the world was forced to become a mere servant!

   The really science fictive option would be the identification of the reverse transcription as time reversal of transcription. In zero energy ontology (ZEO) this option can be considered at least at the level of dark DNA and RNA providing the template of dynamics for ordinary matter.

How the copying of RNA strand to its conjugate strand catalysed by amino-acid of tRNA could have transformed to translation of RNA to amino-acid sequence? Something certainly changed.

1. The change must have occurred most naturally to tRNA or - less plausibly - to the precedessor of the ribosome machinery. The change in the chemical structure of tRNA is not a plausible option. Something more than chemistry is required and in TGD Universe dark matter localized at magnetic flux tubes is the natural candidate.

2. Evolution corresponds in TGD Universe gradual increase of $h_{eff} = n \times h$. A dramatic evolutionary step indeed took place. The increase of the value of $h_{eff} = n \times h$ for some structural element of tRNA could have occurred so that the catalysis for amino-acid sequence instead of that for RNA sequence started to occur.

3. The general model for bio-catalysis in TGD Universe involves a contraction of magnetic flux tubes by a reduction of h_{eff} and bringing together the reacting molecules associated with flux tubes: this explains the magic looking ability of biomolecules to find each other in the dense molecular soup. The reduction of h_{eff} for some dark atom(s) of some reacting molecules(s) to a smaller value liberates temporarily energy allowing to kick the reactants over a potential

wall so that the reaction can occur (atomic binding energies scale as $1/h_{eff}^2$). After than the liberated energy is absorbed and ordinary atom transforms back to dark atom.

In the recent case h_{eff} associated with a dark atom (or atoms) of tRNA could have increased so that the binding energy liberated would have increased and allowed to overcome a higher potential wall than before. If the potential wall needed to overcome in the fusion of additional amino-acid to a growing protein is higher than that in the fusion of additional RNA to a growing RNA sequence, this model could work.

4. The activation energy for the addition of amino-acid should be larger than that for RNA nucleotide. A calculated estimate for the activation energy for the addition of amino-acid is 63.2 eV (see `http://tinyurl.com/yab6dmrm`). An estimate for the activation energy for the addition of RNA nucleotide at the temperature range 37-13 C is in the range 35.6 -70.2 eV (see `http://tinyurl.com/y8xwpvvg`). An estimate for the activation energy for the addition of DNA nucleotide is 58.7 eV (see `http://tinyurl.com/yc8nr4kh`) The value in the case RNA would be considerably smaller than that in the case of amino-acids at physiological temperature. For DNA and amino-acid the activation energy would be somewhat smaller than for amino-acid. This is consistent with the proposed scenario. I am not able to decide how reliable these estimates are.

The natural first guess is that the dark atoms are hydrogen atoms. It is however not at all clear whether "ordinary" hydrogen atoms correspond to $n = h_{eff}/h = n = 1$.

1. Randell Mills [D7] has proposed his notion of hydrino atom to explain anomalous energy production and EUV radiation in 10-20 nm range taking place in certain electrolytic system and having no chemical explanation. The proposal of Mills is that hydrogen atom can make in presence of a catalyst a transition to a lower energy state with a reduced size. I have already earlier considered some TGD inspired models for hydrino. The resemblance with the claimed cold fusion suggests that the energy production involved in the two cases might involve the same mechanism.

   I have considered two models for the findings [L24]. The first model is a variant of cold fusion model that might explain the energy production and the observed radiation at EUV energy range. Second model is a variant of hydrino atom assuming that ordinary hydrogen atom corresponds to $h_{eff}/h = n_H > 1$ and that catalyst containing hydrogen atoms with lower value of $n_h < n_H$ could induce a phase transition transforming hydrogen atoms to hydrinos with binding energy spectrum scaled up by scaling factor $(n_H/n_h)^2$ and radii scaled down by $(n_h/n_H)^2$. The findings of Mills favour the value $n_H = 6$.

2. Suppose the transition corresponds to a transition analogous to photon emission so that it occurs between $\Delta J = 1$ transitions of hydrogen atom. There are two simple options: either the direction of electron spin change but orbital angular momentum remains unaffected or the angular momentum of electron changes by $\Delta L = 1$ but spin direction does not change.

   The simplest assumption is that the principal quantum numbers in the initial and final state are $n_i = 1$ and $n_f \geq n_i$. Assume first that initial state with $(n_{Hi}, n_i = 1)$ having $L_i = 0$ and final state with $(n_{Hf}, n_f \geq n_i)$.

3. The energy difference between the initial state with $(n_{Hi}, n_i = 1)$ and final state with (n_{Hf}, n_f). The initial binding energy is the ordinary binding of thought-to-be hydrogen atom in the ground state: $E_i = E_f(n_{Hf}/n_{Hi})^2 \simeq 13.6$ eV. Here E_f denotes the final ground state binding energy. The final state binding energy is $E_{fn_f} = E_f/n_f^2$.

   The liberated energy defining the order of magnitude for the activation energy (thermodynamical quantity) is given by

$$\Delta E = E_{fn_f} - E_i = \frac{E_f}{n_f^2} - E_f(\frac{n_{Hf}}{n_{Hi}})^2 = E_i\left[(\frac{n_{Hi}}{n_{Hf}})^2 n_f^{-2} - 1\right] \quad . \tag{5.4.1}$$

   The condition $\Delta E > 0$ gives

(n_{Hi}, n_i)	(n_{Hf}, n_f)	$\Delta E/eV$
$(3,1)$	$(1,2)$	17.0
$(4,1)$	$(1,2)$	40.8
$(4,1)$	$(2,2)$	0.0
$(5,1)$	$(1,2)$	71.4
$(5,1)$	$(2,2)$	7.7
$(6,1)$	$(1,2)$	109.0
$(6,1)$	$(2,2)$	17.0

Table 5.7: The liberated energy in transition $(n_{Hi}, n_i = 1) \to (n_{Hf}, n_f = 2)$ in some cases.

$$\frac{n_{Hi}}{n_{Hf}} > n_f \quad .$$

For $n_{Hi}/n_{Hf} = n_f$ one has $\Delta E = 0$. For instance, this occurs for $(n_{Hi}, n_{Hf}) \in \{(2,1), (6,3), (6,2)\}$ $\Delta E > 0$ condition gives $n_{Hi} > 2$.

4. Consider first $n_i = n_f = 1$ for which the spin direction of electron changes if the transition is analogous to photon emission. By putting $n_f = 1$ in Eq. 5.4.1 one obtains a formula for the transition energy in this case. For instance, $(n_{Hi}, n_i) = (6,1) \to (n_{Hf}, n_f) = (3,1)$ would correspond to $\Delta E = 40.8$ eV perhaps assignable to RNA polymerization and the transition $(n_{Hi}, n_i) = (7,1) \to (n_{Hf}, n_f) = (3,1)$ to $\Delta E = 60.4$ eV perhaps assignable to amino-acid polymerization and DNA polymerization. Note that $n_H = 6$ is supported by the findings of Mills.

5. Table 5.7 gives the liberated energies ΔE for transitions with $(n_i, n_f) = (1,2)$ in some cases. The transitions $(4,1) \to (1,2)$ resp. $(5,1) \to (1,2)$ might give rise to the activation energies associated with RNA resp. amino-acid polymerization.

6. If ordinary hydrogen atom and atoms in general correspond to $h_{eff}/h = n = 1$, the liberated energies would be below the ground state energy $E_0 = 13.6$ eV of hydrogen atom and considerably below the above estimates. For heavier atoms the binding energy scale would be Z^2-fold and already for carbon with $Z = 6$ by a factor 36 higher. It is difficult to obtain ΔE in the scale suggested by the estimates for the activation energies.

One could try to test whether tRNA could be modified to a state in which RNA is translates to RNA sequences rather than proteins. This would require a reduction of $h_{eff} = n \times h$ for the dark atom in question.

5.4.4 Recent Genetic Code As A Fusion Of Singlet And Doublet Codes?

There are several guidelines helping to answer the question how DNA-amino-acid translation might have emerged from singlet and doublet codes producing only RNA from RNA.

The following vision about evolution leading from RNA era to the recent DNA-RNA-amino-acid era inspired by a combination of RNA world vision [I139] with the detailed study of the structure of tRNA suggesting the presence of 1- and 2-codes during RNA era with the DNA as TQC vision suggesting the presence of cell membrane like structures as a necessary ingredient making possible topological quantum computation like processes already during RNA era. The recent model is considerably simpler than the earlier models [K39, K40].

RNA era and the transition to RNA-amino-acid era

1. Translation of mRNA to amino-acid sequences separates from the transcription of DNA to mRNA. One expects that during RNA two different kinds of RNAs, call them RNA_2 and RNA_1, analogous to mRNA and proteins existed. RNA_2 can be identified as the ordinary $3', 5'$ RNA acting in the role of mRNA. A natural candidate for RNA_1 playing the role of

proteins is $2', 5'$ RNA since it is generated in the experiments of Orgel and appears also in genomes. Of course, also other candidates can be considered and the structure of tRNA gives valuable information about the character of this RNA. The copying of RNA_2 to its conjugate was the counterpart of RNA replication. The transcription of RNA_2 to RNA_1 was the counterpart of translation.

2. The structure of tRNA, call it $tRNA_3$, gives valuable information about the course of events leading to the translation of mRNA to amino-acids. The cross like structure of $tRNA_3$ and the decomposition of RNA triplet appearing in it to 2-codon and 1-codon suggests that it resulted as a fusion of two hairpin like molecules $tRNA_1$ and $tRNA_2$. $tRNA_2$ brought pairs of nucleotides forming the 2-codon part of RNA triplet to the growing RNA_2 sequence during replication and 2-code was simply RNA conjugation. $tRNA_1$ was involved with transcription of RNA_2 to RNA_1 bringing RNA_1 nucleotides one-by own to the growing sequence. In $tRNA_3$ the third nucleotide does not quite correspond to ordinary RNA but to to A, G, U or I(nositol) and is believed to differ geometrically from ordinary nucleotide, and one can assume that these nucleotides were the building blocks of RNA_1 possibly appearing in $2', 5'$ form. The phenomenon of the wobble pairing can be assumed to have been present already during RNA era so that correspondence 1-code was not not 1-to-1 nor deterministic but given by the correspondence $\{U \to A, C \to G, \{A, G\} \to U, \{U, A, C\} \to I\}$ deduced from the number 40 of tRNAs and assigning unique 1-codon to only G could be interpreted as a many-to-one and non-deterministic correspondence generating new RNA sequences from existing ones. If there was RNA_2 sequence coding for $tRNA_1$, this sequence appearing in hairpin structure could have coded the inverse of the translation. As a consequence, the occurrence of transcription and its reversal generated a rapid evolution by creating new kinds of RNA_2 sequences.

3. From the fact that amino-acids are attached to the ACC stem of $tRNA_2$, one can guess that the role of amino-acids during RNA era was to catalyze the replication. If single amino-acid would have catalyzed the attachment of given RNA doublet to the growing sequence, there would be at most 16 amino-acids and genetic coded would not depend at all on the third nucleotide. This is indeed the case for roughly half of the code table (both matter antimatter symmetry and isospin symmetry with respect to third codon). For those mRNA codons for which A, G and T, C correspond to different amino-acids (breaking of matter antimatter asymmetry but isospin symmetry) two amino-acids catalyzed the attachment. Same amino-acid could also catalyzed two different attachments (ser, arg, leu for standard genetic code).

4. The crucial step was the fusion of the 1-code and 2-code to 3-code took place via fusion of $tRNA_1$ and $tRNA_2$ to $tRNA_3$ along their ends containing RNA_1 nucleotide and RNA_2 doublet which thus combined to RNA triplet. Presumably $tRNA_3$ in its original form was translated from a linear mRNA molecule and transformed spontaneously to the cross like shape because of the presence of palindrome structures in both. The original functions of tRNAs were not possible anymore since the triplet was not at the end of the molecule. The catalyzing amino-acid however was at the ACC end of and the function of $tRNA_3$ became to assist the translation of mRNA to amino-acid sequence. For those 3-codons for which single amino-acid catalyzed the fusion of 2-codon, a full matter antimatter and isospin symmetry resulted. For those 3-codons for which two amino-acids catalyzed the fusion, a breaking of matter antimatter symmetry took place in the sense that for given mRNA codon only the $tRNA_3$ corresponding to single amino-acid was stable. Isospin symmetry was broken only weakly or not at all (human mitochondrial code). Thus codons with A, G as third nucleotide almost always coded the first amino-acid and those with T, C as the third nucleotide the second one. Stopping codons resulted when all $tRNA_3$ corresponding to mRNA triplet were unstable. That same RNA can code for both amino-acid and act as a stop codon in certain situations, can be understood if the stability of corresponding $tRNA_3$ depends on the chemical environment.

Symbiosis with membrane bounded structures

In DNA as TQC picture nuclear and cell membranes make possible topological quantum computation. The magnetic flux tubes connecting DNA nucleotides to lipids of the cell membrane could also explain why DNA is stabile inside cell. The emergence of cell membranes consisting of lipids and generated via self-organization rather being coded by genes would have stabilized DNA generated in this manner during DNA-RNA-amino-acid era. Membrane bounded structures emerged when the space-time sheets corresponding to the p-adic length scale $k = 151$ emerged in the condensate.

Topological quantum computation should have taken place already during RNA era. This suggest that the counterpart of the cell membrane was present already at that time. Quite recently it was reported [I88] that DNA duplexes of length 6 to 20 base pairs can join to longer cylinders which in turn form liquid crystals and that the liquid crystal phase separates from the phase formed by single DNA strands. Long strands had been already earlier known to form liquid crystals. This encourages to think that also RNA duplexes are able to self-organize in this manner so that the analog of cell nucleus containing RNA double helices as genetic material could have existed already during RNA era.

The latter option would allow to distinguish between RNA_2 and RNA_1 used as building block of various structures. This suggests that RNA_1, which disappeared in the transition to RNA-amino-acid era, might have formed liquid membranes containing inside then RNA_2 such that RNA_2 nucleotides were connected by magnetic flux tubes to RNA_1 nucleotides. The minimal function of RNA_1 would have been to make possible the buildup of cell membrane. In this case the lengths of RNA_1 needed to be only of order $L_e(151) = 10$ nm. The sequences consisting of 30 RNA_1 base pairs would correspond roughly to the thickness of cell membrane and to the codon of M_{61} code. Lipid layer of thickness 5 nm would correspond to roughly 16 base pairs and to the codon assignable to M_{17}. If magnetic flux tubes indeed stabilize DNA, the presence of RNA_1 membrane might have been enough to stabilize also DNA so that RNA era could have been followed by DNA-RNA era and eventually by DNA-RNA-amino-acid era with RNA_1 membrane being replaced by double lipid layer membrane.

Reverse transcription of RNA to DNA

The basic problem was how to build DNA sequences which would later take the command. If one, in conflict with the Central Dogma, assumes the presence of the precedessor of the so called reverse RNA transcriptase [J3] associated with retro-viruses (in particular HIV virus), one can understand how this step occurred. Reverse RNA transcriptase allowed to transform ordinary RNA sequences to DNA sequences inside newly emerged pre-nuclei. The reverse transcriptase catalyzes also the transcription of DNA back to RNA so that DNA began to produce new RNA.

Reverse transcriptase requires amino-acids sequences. Amino-acids appeared as catalysts in $tRNA_2$ already during RNA era but the spontaneous emergence of reverse transcriptase before RNA$\rightarrow$ amino-acids translation look improbable. After the fusion of $tRNA_1$ and $tRNA_2$ RNA_2 could replicate only if $tRNA_1$, $tRNA_2$ and $tRNA_3$ continued to live in symbiosis for some time. This could have led naturally to the generation of reverse transcriptase and DNA. After that DNA could have taken care of the production of RNA and $tRNA_1$ and $tRNA_2$ might have lost in the fight for molecular survival or at least their importance could have diminished. The emergence of DNA could have been associated with the replacement of RNA_1 membrane with ordinary cell membrane. For instance, it might be that DNA was able to form only magnetic flux tubes only with lipid bilayer membrane.

The reverse transcription is not reliable (one error per about 1000 nucleotides), and this led to a rapid evolution of DNA analogous to that of HIV virus. This meant an escape from the fixed point situation, and a genuine DNA $\rightarrow$ RNA precedessor of the genetic code emerged. Together with the emergence of membrane bounded structures this meant genuine evolution at DNA level. Reverse transcription is possible only for the ordinary RNA and explains why exotic doublet RNA has disappeared from cell.

What were the first self replicators?

The TGD inspired model of pre-biotic evolution suggests a reasonable guess for the first self-replicating molecular entities. Both $tRNA_1$ and $tRNA_2$ molecules must have resulted as more or less copies of corresponding RNA_2 sequences (amino-acid was added after transcription to $tRNA_2$) and the minimal self-reproducing system could have consisted of $tRNA_1$, $tRNA_2$ and corresponding RNA_2 molecules. Since $tRNA_1$ and $tRNA_2$ are hairpins in the usual configuration and the mechanism making possible biochemical reaction series suggests that these hairpin molecules catalyzed the opening of the corresponding RNA_2 pieces and their coding to $tRNA_1$ or $tRNA_2$.

Note that double strands in the sense they occur for DNA are not necessary since the double strand part of hairpin is analogous to DNA double strand and the opening of hairpin structure is analogous to the opening of DNA double strand during transcription and replication. The non-determinism of 1-code could have rapidly led to a genuine evolution and one can also imagine a spontaneous generation of RNA_2 sequences as oligonucleotides consisting of copies of pieces of RNA_2 coding for $tRNA_2$.

Also more general hairpin might be used to construct a self-catalyzing system. Since exotic and normal RNA do not differ too much, a reasonable amount of guess work might allow to identify $tRNA_1$ and $tRNA_2$, and perhaps even create simple pre-biotic life-forms in the laboratory.

5.4.5 Is RNA Era Continuing Inside Cell Nuclei?

The last issue of [I46] contains an article about the discovery that only roughly one half of DNA expresses itself as amino-acid sequences. A detailed summary of the results has been published in Nature [I15]. The Encyclopedia of DNA Elements (ENCODE) project has quantified RNA transcription patterns and found that while the "standard" RNA copy of a gene gets translated into a protein as expected, for each copy of a gene cells also make RNA copies of many other sections of DNA. In particular, intron portions ("junk DNA", the portion of which increases as one climbs up in evolutionary hierarchy) are transcribed to RNA in large amounts. What is also interesting that the RNA fragments correspond to pieces from several genes which raises the question whether there is some fundamental unit smaller than gene.

None of the extra RNA fragments gets translated into proteins, so the race is on to discover just what their function is. TGD proposal is that the RNA gets braided and performs a lot of topological quantum computation [K3]. Topologically quantum computing RNA fits nicely with replicating number theoretic braids associated with light-like orbits of partonic 2-surfaces and with their spatial "printed text" representations as linked and knotted partonic 2-surfaces giving braids. An interesting question is how printing and reading could take place. Is it something comparable to what occurs when we read consciously? Is the biological portion of our conscious life identifiable with this reading process accompanied by copying by cell replication and as secondary printing using amino-acid sequences?

This picture conforms with TGD view about pre-biotic evolution. Plasmoids [I115], which are known to share many basic characteristics assigned with life, came first: high temperatures are not a problem in TGD Universe since given frequency corresponds to energy above thermal energy for large enough value of $\hbar$ [K38]. Plasmoids were followed by RNA, and DNA and amino-acid sequences emerged only after the fusion of 1- and 2-letter codes fusing to the recent 3-letter code. The cross like structure of tRNA molecules carries clear signatures supporting this vision. RNA would be still responsible for roughly half of intracellular life and perhaps for the core of "intelligent life".

I have also proposed that this expression uses memetic code which would correspond to Mersenne $M_{127} = 2^{127} - 1$ with 2^{126} codons whereas ordinary genetic code would correspond to $M_7 = 2^7 - 1$ with 2^6 codons. Memetic codons in DNA representations would consist of sequences of 21 ordinary codons. Also representations in terms of field patterns with duration of.1 seconds (secondary p-adic time scale associated with M_{127} defining a fundamental bio-rhythm) can be considered.

A hypothesis worth of killing would be that the DNA coding for RNA has memetic codons scattered around genome as basic units. It is interesting to see whether the structure of DNA could give any hints that memetic codon appears as a basic unit.

1. In a "relaxed" double-helical segment of DNA, the two strands twist [I35] around the helical

axis once every 10.4 base pairs of sequence. 21 genetic codons correspond 63 base pairs whereas 6 full twists would correspond to 62.4 base pairs.

2. Nucleosomes [I25] are fundamental repeating units in eukaryotic chromatin [I9] possessing what is known as 10 nm beads-on-string structure. They repeat roughly every 200 base pairs: integer number of genetic codons would suggest 201 base pairs. 3 memetic codons makes 189 base pairs. Could this mean that only a fraction $p \sim 12/201$, which happens to be of the same order of magnitude as the portion of introns in human genome, consists of ordinary codons? Inside nucleosomes the distance between neighboring contacts between histone and DNA is about 10 nm, the electron Compton scale $L_e(151)$ associated with the Gaussian Mersenne $(1+i)^{151}-1$ characterizing also cell membrane thickness and the size of nucleosomes. This length corresponds to 10 codons so that there would be two contacts per single memetic codon in a reasonable approximation. In the example of Wikipedia [I25] nucleosome corresponds to about 146=126+20 base pairs: 147 base pairs would make 2 memetic codons and 7 genetic codons. The remaining 54 base pairs between histone units + 3 ordinary codons from histone unit would make single memetic codon. That only single memetic codon is between histone units and part of the memetic codon overlaps with histone containing unit conforms with the finding that chromatin accessibility and histone modification patterns are highly predictive of both the presence and activity of transcription start sites. This would leave 4 genetic codons and 201 base pairs could decompose as memetic codon+2 genetic codons+memetic codon+2 genetic codons. The simplest possibility is however that memetic codons are between histone units and histone units consist of genetic codons. Note that memetic codons could be transcribed without the straightening of histone unit occurring during the transcription leading to protein coding.

5.4.6 Could Nanno-Bacteria Correspond To Predecessors Of TheTriplet Life-Forms?

The experiments of Leslie Orgel (at 1980) imitating the primordial ocean demonstrate the emergence of the exotic RNA for which doublet effectively replaces the triplet. The so called nanno-bacteria represent a mystery at the borderline between living and non-living matter. The web article of Robert L. Folk [I127], who is one of the pioneers in the field besides Y. Morita [I129] and E. O. Kajander [I82], provides a brief summary about nanno-bacteria and contains also references. A priori one cannot exclude the possibility that nanno-bacteria might represent a precedessor of the triplet code, perhaps even singlet or doublet life-form or their symbiosis.

Basic facts about nanno-bacteria

Nanno-bacteria (often called also nanobacteria) are considerably smaller than ordinary bacteria. The sizes of the nanno-bacteria vary from about 20 nm to.2 micro-meters. Thus the smallest nanno-bacteria have size scale not much above $L_e(151)$ so that optical microscope does not allow to study them. Indeed, geologists discovered nanno-bacteria by using scanning electron microscope.

Nanno-bacteria can originate a precipitation in calcite and argonite crystals by providing the seed of the crystal. Nanno-bacteria act also as catalysts by attracting cations to their negatively charged cell walls. They appear as dense clumps in various minerals and rocks such as limestones, dolomites, native sulphur crystals, and metallic sulfide minerals [I127]. Nanno-bacteria produce complex silicates such as clays, where their sizes can be as small as 30 nanometers. They are involved even with the construction of bird's eggs! Nanno-bacteria of size about.1 micro-meters were found in the Martian meteorite ALH84001 [E9], and there is evidence that carbonaceous chondrite meteorite Allende [I127] contains them. According to Folk, the nanno-bacteria might the biological counterpart of the dark matter perhaps dominating over the ordinary bio-matter in the entire universe. An interesting question is how deep in the rock nanno-bacteria based life forms can survive. The hypothesis about intra-terrestrial life suggests that there is no limit here!

Although nanno-bacteria have been demonstrated to replicate [I127], the prevailing belief has been that nanno-bacteria cannot be real life forms since by their small size they cannot contain the usual genetic apparatus. A Finnish biologist Kajander and his collaborators have done a lot of self-funded pioneering work in the study of the nanno-bacteria [I82]. It has not been demonstrated

that nanno-bacteria possess DNA-mRNA-amino-acid translation machinery, the existence of which is often taken almost as a definition for what it is to be a living system (a size larger than.2 micro-meters has been the second prevailing definition of a living system!). This failure could be understood if nanno-bacteria contain only replicating DNA or if only the RNA-to-RNA translation machinery exists possibly accompanied by RNA-DNA transcriptase transforming the code to DNA-RNA code. Due to the hard cell wall of nanno-bacteria, the study of DNA/RNA is very difficult but according to the Kajander's private communication to Folk [I127], the nanno-bacterial DNA exists and consists of very short strands.

Nanno-bacteria as RNA life?

Nanno-bacteria could correspond to some precedessor of the recent genetic code. One can consider several options.

1. Nanno-bacteria represent an RNA life form involving two kinds of RNA sequences and closed inside RNA_1 membrane. This does not require DNA.

2. If the claim of Kajander about about nanno-bacterial DNA is correct, then two options remain.

   i) Nanno-bacteria are able to just replicate DNA and do not possess genetic code. Thus nanno-bacteria would be at a higher level than viruses.

   ii) RNA-DNA reverse transcription is utilized so that nanno-bacteria could realize DNA-RNA code and would probably be at a higher developmental level than RNA life-forms but had not yet realized DNA-amino-acid code. The objection against this is that the reverse transcriptase enzyme probably requires RNA-amino-acid translational machinery.

   One can ask what what RNA life-forms (option 1) would look if they still exist.

1. Singlet RNA would express itself as RNA sequences containing only U (or C) and A (or G) nucleotides. The tRNAs used by these life-forms should appear as fossil remnants in the ordinary tRNA.

2. In the case of a singlet life-form the layer could correspond to the length scale $L_e(2,73)\backslash = "L_e(146)$ and be formed by doublet atomic layer corresponding to the twin pair of p-adic length scales formed by $L_e(16,9)\backslash = "L_e(144)$ and $L_e(2,73)\backslash = "L_e(146)$.

3. In the case of doublet life-forms the length scale $L_e(2,29)\backslash = "L_e(145)$ and the tertiary p-adic length scale $L_e(3,7^2)\backslash = "L_e(147)$ form a twin pair and could define a double-layered structure. The reported hard cell wall could correspond to this double layered structure. A cell wall consisting of minerals (also nanno-bacteria induce also the precipitation of mineral crystals) might however be most appropriate for life-forms living in the pores of rock, and possibly utilizing tectonic energy in some form to satisfy their metabolic needs.

The generation of the triplet code would have been accompanied by the generation of double lipid layers and possibly a transition to water environment. The most natural location for the primitive RNA-RNA translation machinery is at the inner surface of a lipid membrane if present inside nanno-bacteria.

The singlet or doublet RNA life-forms and their fusions could correspond to what I have christened plasmoids. Intelligent looking plasma balls occur repeatedly in UFO reports and they are also reported to occur around crop formations. There is even a report about a plasma ball in the act of constructing the crop formation. The plasmoid like life forms serving as couriers of ITs could be also seen as multi-cellulars consisting of nanno-bacterial cells or, more probably, of their precedessors. The immune response against nanno-bacteria and their precedessors generated during very early evolution would make possible encounters with crops and even humans (abduction experiences) without fatal consequences. The reported immune response against exotic doublet RNA suggests that plasmoids contain exotic doublet RNA. The visible light from plasmoids suggests that the metabolism indeed involves also the hot $k = 131$ space-time sheet so that ITs or IPs might be in question.

Was the encounter of nanno-bacteria and plasmoids the moment of Gaian fertilization?

Earth consists mostly of ancient meteorites known as chondrites. Carbonaceous chondrites are shown to contain not only basic bio-monomers but even nanno-bacteria. The meteoritic material can end up to the interior of Earth along magnetic flux tubes even today. Recall that this mechanism actually explains the magnetized iron from meteors found in crop circles [K33]).

Thus IT life might have developed nanno-bacteria contained by meteorites in the womb of Mother Gaia. The bio-molecules/nanno-bacteria contained by the meteorites from outer space would thus take the role of the sperm as in panspermia theory.

There is a temptation to develop the fertilization metaphor to a more concrete level in order to understand what happened when the symbiosis of pre-nucleus containing DNAandpre-cell containing RNA was established and led to the development of the genetic code and established a genuine evolution.

1. The simple nanno-bacteria in the meteorites having only replicating DNA or perhaps only the ability to produce DNA nucleotides would have been the sperm. Cell nucleus is much smaller than cell and might itself be regarded as having originated from ancient nanno-bacteria. The much more complex pre-cells containing RNA, amino-acids, and reverse transcriptase as well as the potentiality for the realization of the genetic code plus the needed metabolic machinery, were located in the interior of Earth and played the role of the egg. Since the hot $k = 131$ space-time sheets essential for the metabolic machinery were also involved, primitive plasmoid is an excellent candidate for the egg.

2. The encounter of nanno-bacteria and plasmoids led to the fertilization of Mother Gaia. What is fascinating that balls of light reported to appear near the crop circles and reported to even fabricate them migh be there in order to get fertilized by nanno-bacteria contained by meteors! Alternatively, the simultaneous appearance of pre-biotic egg and sperm might be interpreted as a symbolic hint about what happened in the key event of the pre-biotic evolution.

5.5 Comparison Of Mcfadden's Views With TGD

In his book Quantum Evolution [I111] Johnjoe McFadden discusses the deep problems of molecular biology from quantum point of view and develops very interesting ideas about evolution and consciousness. Because of deep insights about what is not understood in biology, this discussion should provide new insights for any quantum consciousness theorist attempting to build a bridge between theory and biological reality. In the sequel McFadden's vision is compared with TGD view and some new ideas inspired by it in TGD framework are proposed.

5.5.1 General Ideas

Before dwelling into concrete examples, it is good to compare McFadden's general starting points with those of TGD.

1. In accordance with most interpretations of quantum mechanics, McFadden assumes that the initial situation involved no de-coherence and that the biological evolution means basically the emergence of de-coherence, essentially the appearance of conscious observers performing quantum measurements.

   In TGD framework the situation is just the opposite: evolution means the emergence of effective macro–temporal quantum coherence meaning that the duration of sharp mental images (sub-selves) increased. During the primordial stage typical lifetime of self was of order 10^4 Planck times and defined minimal de-coherence time. Dark matter hierarchy provides and hierarchy of Planck constants a concrete realization for a hierarchy of moments of consciousness with increasing geometric duration and quantum parallel dissipation which is second new element of TGD picture.

   The number theoretic generalization of Shannon entropy having negative values for rational and even algebraic entanglement is a further mathematical concept. Quantum computers are

basic examples of systems possessing positive number theoretic negentropy, and this certainly conforms with the genuine information content of multi-verse states. It is not clear whether Negentropy Maximization is really consistent with the Second Law of thermodynamics and one must keep mind open for the possibility that Second Law is illusion created by the neglect of dark matter hierarchy meaning at the same time neglect of living life forms.

2. McFadden does not fix his views about quantum measurement theory but assumes that decoherence is an outcome of quantum measurements performed by environment or some subsystem of it. McFadden sees enzymatic action as a basic example of quantum measurement in which an amplification to a macroscopic phenomenon occurs.

   In TGD framework one can imagine two basic elements.

   (a) The emergence of symbolic representations as names of molecules made possible lock and key mechanism and "molecular sex". Once it is possible to name molecules, it becomes possible to regard bio-chemical pathways as analogs of computer programs proceeding rather deterministically. As already found, this idea has very concrete implications for understanding of bio-catalysis.

   (b) The most important bio-molecules could be seen as selves with especially long wake-up periods in a highly negentropic state of macro–temporal quantum coherence, and able to perform intentional actions applying the time mirror mechanism (see **Fig. ??** in the appendix of this book) (`http://tgdtheory.fi/appfigures/.jpg`), which is also The magnetic bodies of bio-structures are at the top of the intentional hierarchy.

3. McFadden sees quantum Zeno effect and its inverse as basic quantum control tools used by enzymes to increase reaction rates or induce mutations. Although the Zeno effect has also TGD counterpart, the intentional action of molecular magnetic bodies based on time mirror mechanism seems a more plausible option. Long ranged dark weak forces, in particular charge entanglement by W MEs, exotic ionization, and the control of the strength of the screening of the classical Z^0 force provides an additional mechanisms of enzyme control explaining chiral selection. Sol-gel transition inducing polymerization and its reverse allows to control the stability of bio-polymers. The leakage of particles between space-time sheets is a further control mechanism and involved with the time mirror mechanism.

4. McFadden assumes that the superpositions of peptide-environment product states involving different peptides with different neutron and proton numbers are possible so that the measurement involves also measurement of proton and neutron numbers. This option looks implausible because it is very difficult to think that states with different fermion numbers, masses, and charges would quantum superpose.

   In fact, it has become clear quite recently that TGD could in well-defined sense allow also quantum superpositions of different DNA molecules. This kind of superpositions are routinely assumed for coherent states of Cooper pairs in super-conductivity although they break conservation of charge, fermion number, and energy. The point is that in zero energy ontology (ZEO) [K25] the total quantum numbers of physical states always vanish and the states decompose into positive energy part such that negative energy part located in its geometry future. Therefore it is possible to have quantum superpositions which in positive energy ontology, which is excellent approximation, would look like quantum superpositions of different DNA molecules. This possibility is not discussed in this chapter but it is needless to say that it could mean a revolution in the understanding of living matter. Even thermodynamics could be interpreted in a completely new manner since thermodynamical states which are "superpositions" of states with different values of conserved charged could have genuine quantal counterparts.

McFadden's view about biochemistry

McFadden represents a very general view about the essentials of bio-chemistry.

1. Protons associated with hydrogen bonds and electronic Cooper pairs serve as basic tools of quantum bio-control.

2. The localization of proton induces what McFadden interprets as a quantum measurement of proton's position.

In TGD framework the mechanism of catalytic action based on the temporary dropping of proton from the H_N-atom associated with catalyst or reactant, replaces this mechanism. Catalytic action could be seen as a short lasting period of "group sex" between catalyst and reacting molecules. Liberation of standard metabolic energy quantum is automatically involved with the process.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

Important problems of quantum biology

The following list provides examples of problems that McFadden wants to understand in terms of quantum physics.

1. The extreme effectiveness of enzyme action.

2. The mechanism of mutations, in particular that of adaptive mutations and multiple mutations.

3. Evolution.
   i) The loss of complexity in computational models of evolution contra the increase of complexity in real evolution.
   ii) The emergence of the first self replicators.
   iii) The evolution of extremely complex reaction pathways, such as the one leading to the buildup of the ATP ase enzyme.

5.5.2 Enzyme Action

Enzymes as quantum mouse traps is the metaphor introduced by McFadden. Typically enzyme catches the reactant molecules to a fixed conformation and fires a proton to the substrate molecule inducing in this manner a re-organization of some chemical bonds. The enzyme gains the lost proton later from a water molecule.

Mouse trap metaphor conforms completely with the TGD described view about catalytic action and also with the idea about enzyme as a quantum critical system.

1. Production of lactic acid from pyruvate

McFadden represents the production of the lactic acid from pyruvate, which is one of the last steps of catabolism, as a typical example of enzyme action. The process involves LDH, lactate dehydrogenase, catalyzing the transformation of the pyruvate to lactic acid, and NADH providing a proton and an electron pair. LDH donates the proton involved with the transformation of C=0 to C-O-H. NADH in turn provides proton and electron pair so that C=O is replaced with H-C-OH. NAD^+ receives proton and a compensating electron pair from water and LDH_- receives a proton from a water molecule.

2. Catabolism of lactose

Second example used my McFadden relates to the catabolism of lactose induced by the enzyme beta galactose. The rate of the process is trillion times higher than one might expect. McFadden proposes that the process involves a localization of proton in certain amino-acid of the beta galactose to a particular hydrogen bond. If the localization occurs to a correct hydrogen bond, the proton is injected to the lactose molecule and induces hydration. The suggestion is that a repeated quantum measurement of proton's position in beta galactose keeps the proton in the correct position so that the decay occurs with a much higher rate than it would occur otherwise.

It is not necessary to repeat how the catalysis could be understood in TGD framework. The decay of the lactose involves hydrolysis in which lactose molecule receives water H_N-O-H molecule from the environment and the loss of proton de-stabilizes the negatively charged molecule.

Hydrolysis could involve local gel-sol type transition transforming ordered water to ordinary water, which is able to provide the needed water molecule. The gel-sol transition could closely correlate with the non-standard localization of the proton inside enzyme. The process could involve an intentional action of a magnetic body of some system involved and thus negative energy topological light rays and charge entanglement by W MEs.

5.5.3 Quantum Evolution

McFadden considers evolution from a quantum point of view. After the criticism of the RNA world paradigm McFadden poses several questions. How complexity could have emerged during the evolution? What was the first self-replicator? How the complex metabolic pathways could have evolved? What might be the quantum mechanisms of adapted and multiple mutations?

How evolution can create complexity?

McFadden pays attention to the fact that in the computational models of evolution final states tend to be less complex than the initial ones. This can be seen as a consequence of dissipation which leads to asymptotic self-organization patterns which are very simple. This is just the opposite of what is observed in Nature (note however the fact that the rapid extinction of new species after Cambrian explosion might be interpreted in terms of a loss of complexity).

In TGD framework the ability of living systems to circumvent the loss of complexity is due the facts that TGD Universe is quantum critical and p-adic cognition implies p-adic evolution predicting the emergence of systems characterized by increasing values of the p-adic prime and the integer characterizing the levels of dark matter hierarchy serving as their "intelligence quotients".

At the molecular level TGD allows to resolve this puzzle elegantly. During the pre-biotic exotic RNA period the precedessor of the genetic code is realized as many-to-one replication of exotic RNAs meaning a loss of information. This occurred for both singlet and doublet exotic RNA and for their composite forming a double helix with the size of the singlet helix being scaled up by a factor two. This however led to a dead alley involving only the RNAs representing the maximal invariant set of the RNA→RNA mapping as an asymptotic state. Final state was indeed simpler than the initial state.

At some stage the product code transformed to a code coding for RNA triplets, and amino-acids which originally catalyzed the mapping of RNA to RNA, took the role of the coded molecules. RNAs were mapped to DNAs by reverse transcriptase and the high error rate of the reverse transcription implied a rapid mutational rate. The many-to-one character of RNA→RNA replication implying the dead alley thus transformed from a curse to a blessing since it represented implicitly the protein-DNA genetic code.

Criticism of RNA world

McFadden represents severe critics against RNA world paradigm which is the dominating vision about pre-biotic evolution [I110]. The basic objections are following.

1. In water environment bio-polymers become un-stable against de-polymerization by hydration. This makes the idea of primordial sea implausible. The presence of the ordered water could resolve this problem even in the standard physics based models. In many-sheeted space-time the hypothesis that pre-biotic evolution occurred intra-terrestrially in the womb of the magnetic Mother Gaia makes sense and could resolve basic objections against the notion primordial sea.

2. Enzymatic action requires chiral selection. In TGD framework this can be interpreted as a strong indication for the necessity of the classical long ranged weak forces in the enzymatic control (say charge entanglement by W MEs).

3. McFadden lists several reasons for why RNA is implausible as a pre-biotic chemical. RNA consists of three components: RNA base, ribose, and phosphate. RNA bases and phosphate have been generated in the experiments trying to simulate pre-biotic evolution but the spontaneous emergence of ribose looks implausible. The problem is that a plethora of other sugars are produced.

   Some property of ribose should distinguish it from the other sugars. In TGD framework one might argue that for the ribose self "wake-up" periods or even periods of macro-temporal quantum coherence meaning sharp and non-entropic mental images are longer than for the other sugars. Quite generally, important bio-molecules could be identified as maximally autonomous systems able to "stay awake" and realize intentions.

   A more concrete explanation is based on stability.

   i) Both RNA, DNA and amino-acids are negatively charged and thus inherently unstable. The assignment of "names" to generalized hydrogen bonds represented by quark and antiquark at the ends of the magnetic flux tube to the basic building bricks of these polymers could make them stable and lead automatically to highly selective catalytic actions.

   ii) Suppose that the OH groups associated with the sugars have tendency to form a hydrogen bond with water molecules leading to ionization of the water molecule and liberation of proton dropping to a larger space-time sheet so that the polymer generates negative charge. If the number of O-H groups is too large the resulting negative charge can de-stabilize polymers formed by ribose, phosphate, and RNA nucleotides. Note that also the formation of double strand a liberates one proton per hydrogen bond which has a further de-stabilizing effect. This could explain why RNA with 4 O-H groups forms only short double strands whereas DNA having only 3 O-H groups forms very long double strands.

4. One can also wonder why just phosphate, ribose and RNA bases find each other and why the large number of other combinations are not realized. The naming based on flux tubes would restrict dramatically the possible combinations able to form spatially and temporally coherent systems bound together by flux tubes and automatically lead to a final state in which molecules having no braids with environment disappear from the system. Phosphate, ribose and RNA base could also find each other by tuning to common wave length by sending negative energy MEs entangling them with each other.

5. The presence of RNA bases, phosphate and ribose is not enough. McFadden finds it difficult to understand why only RNA molecules amongst many other reaction products of its three basic components are selected. In laboratory the activation of the RNA base allows to select RNA as a dominant reaction product. One possibility is that the liberation of activation energy helps to overcome the potential wall hindering the formation of RNA. This is could also due to the fact that the bound states of the activated RNA base with other two components are short-lived or decay to RNA in accordance with the idea RNA selves have especially long wake-up periods and is winner in the fight for survival. Magnetic body could be able to intentionally activate the RNA bases using universal metabolism present even without ATP ase machinery.

6. In the laboratory isolation, purification, and channeling of the reactants to the reaction volume are crucial parts of the process producing RNA and ribozymes, and almost-self-replicators. In the conventional chemistry framework it is very difficult to imagine how these processes could have occurred during pre-biotic evolution.

   The notion of magnetic body might come in rescue. Magnetic flux quanta could make possible highly controlled reaction network. A possible concrete toy model goes as follows. Suppose that quantum-classical correspondence holds true in the sense that the shape of the magnetic flux tube containing charged particles reacts to the presence of the charged particles so that it can be regarded as a classical orbit of a charged particle in the average magnetic field inducing Lorentz force. This makes sense only if a given magnetic flux tube contains particles with a fixed charge-to-mass ratio, and means that magnetic body indeed isolates and purifies the reactants to the magnetic flux tubes and allows them to react at the nodes of the magnetic web.

Evolution of metabolism

McFadden describes basic aspects of catabolism in an enjoyable manner. Catabolism can be seen as a process in which electrons from the orbitals of complex bio-molecules (in particular glucose) are gradually transferred to the orbitals of oxygen atoms. This process releases energy used as a metabolic energy in the form of ATP molecules.

In the standard chemistry framework the mechanisms behind $ADP \to ATP$ transformation seem miracle like. It is not easy to understand how an evolution based on mere chance and necessity could have led to the recent form of this machinery: intermediate steps seem to be simply absent. For instance, according to McFadden the reaction pathways generating the ATP ase enzyme catalyzing the generation of ATP involves 13 steps and all these steps are necessary. The probability that this pathway could have been generated by a random change is infinitesimally small and comparable to that for a monkey playing with a typewriter to compose Shakespeare's sonnets by accident.

1. Universal metabolic currencies

In TGD framework the predicted universal metabolic currencies remove partially the veil of mysteries surrounding the evolution of metabolism.

The dropping of a proton from atomic space-time sheet to a larger one generates a universal metabolic energy quantum. Thus metabolism would have been present already before the chemical storage of the metabolic energy. At the pre-biotic period the generation of negative energy topological light rays with photon energy $\sim .5$ eV could have induced the dropping of protons and remote utilization of the liberated energy. Indeed, the model for intra-terrestrial life led to the hypothesis that the infrared radiation corresponding to a temperature of about 4000 K near the mantle-core boundary could have provided the energy quanta of about.4 eV driving protons back to the atomic space-time sheets. The evolution of photosynthesis led later to the chemical storage of the metabolic energy.

The mitochondrial battery is kept at the potential of.15 eV by the metabolic energy feed. This process involves oxidation process in which electrons from the orbitals of molecules like glucose end down to the orbitals of oxygen atoms. The electron pairs are provided by NADH molecules in mitochondrial metabolism occurring in the water filled space between mitochondrial membranes. The energy liberated in this manner drives protons from the interior of the mitochondria to the space between the membranes. NAD^+ ion then receives the compensating electronic Cooper pair from water later.

The molecular battery provides the energy to generate ATP molecules serving as universal energy currencies. Three protons leaking back along the channel inside ATP ase molecule, which is analogous to the wire connecting the plus and minus poles of a battery, gain a net energy of $3 \times .15 = .45$ eV. This energy they donate to a proton, which uses it to get back to the atomic space-time sheet of the ATP molecule.

2. Does metabolism generate cell level qualia?

In a philosophical mood one could wonder the purpose of the endless ATP Karma's cycle: why not just the primitive metabolism involving only.5 eV photons? A partial explanation is the possibility to store metabolic energy chemically so that system becomes less dependent on environment. A connection with the TGD based model of sensory receptor as a quantum capacitor suggests a deeper interpretation. The dielectric breakdown of the quantum capacitor gives rise to qualia which correspond to the increments of the total quantum numbers at either electrode when the dielectric breakdown occurs. ATPase could be seen as generating local di-electrical breakdown inducing primitive protonic qualia as a side product.

3. Molecular intentionality

The basic challenge of the bio-chemistry based approach to evolution is to understand how simple reaction steps coherently integrate to long multi-step reaction pathways. The assumption of molecular intentionality simplifies dramatically this task. Indeed, the best manner to understand and plan a complex electronic instrument is to know its purpose. The manual provides explanation of the purpose and magnetic body serves as the manual of the bio-logical body. For instance, it is much easier to understand how the reaction pathway leading to ATP ase has developed if one

knows that the function of this pathway is to liberate universal metabolic energy quanta from mitochondrial battery besides possibly producing protonic qualia.

The fact the number of steps is 13 suggests 13-adicity and it would be interesting to see whether various reaction pathways tend to have a prime number of steps. It deserves to be noticed that $k = 169 = 13^2$ defines the p-adic prime associated with the magnetic flux tubes of the Earth's magnetic field and its possible dark companion $B_{end} = 2B_E/5$, and that the micro-tubular surface defines naturally cognitive code with $k = 13^2$ bits consisting of 13 13-bit sequences defined by tubuline conformations for a full 2π twist around micro-tubule.

Biological evolution could be seen as being induced by the evolution of cognition and of intentional actions. By the properties of the p-adic topology it proceeds from long time and length scales to shorter ones (p-adically short corresponds to something long in the real sense since rational space-time points are common to real and p-adic sectors of the embedding space). This would suggest that the evolution of bio-logical functions is induced by the evolution of the intentional actions of the magnetic bodies, which were initially like rough sketches and gradually became more and more refined. Also motor skills develop in the same manner.

4. The emergence of molecular pathways

The emergence of names attached to molecules makes possible generation of computer program like dynamics in which programs call corresponds to association of molecules with names conjugate to some name of catalyst molecule to clusters so that catalytic action leading to a particular final state becomes possible.

The names of molecules could dictate the dynamics to a high degree. Situation could be like in the human society: knowing that person carries the label "physics teacher" allows to make amazingly precise long term predictions about the daily behavior of the person whereas the knowledge of all imaginable chemical and physical data about the person would not allow to predict anything interesting about the activities of the person in time scales longer than few seconds.

Quantum mechanism of mutations

McFadden suggests the reduction of the superposition of normal and enol configurations of T nucleotide to a tautomeric enol configuration as a quantum mechanism of mutation. The position measurement of the proton can locate it to the second nitrogenic hydrogen bond and thus transform T nucleotide to the isomeric but short-lived enol configuration having only two hydrogen bonds connecting it to the complementary base. In the enol state DNA replication assigns G instead of A with T.

Zeno effect could allow to effectively freeze T to this configuration and thus increase the rate of mutations. The same mechanism could work also at the level DNA→ mRNA transcription and protein translation and assign lys instead of glu to the enol configuration.

The mechanism poses an additional condition to the proposal that DNA nucleotides correspond to quarks and antiquarks. The question is what determines which quark or antiquark corresponds to a given nucleotide and the mechanism of mutation based on disappearance of hydrogen bond suggests that the number of hydrogen bonds (2 or 3) determines this so that one would have correlation with with the weak isospin of quark (u or d) and number of hydrogen bonds (3 or 2).

1. Adaptive mutations of E. coli

In adaptive mutations the bacterium E. coli unable to catabolize lactose to get metabolic energy develops a mutation allowing it to generate beta galactose inducing the decay of the lactose. This mutation occurs with a probability which is higher than predicted by randomness. McFadden poses the question how the information about the presence of the lactose is communicated from the environment to the DNA level.

If life would be mere quantum chemistry, the only possibility would be that the information transfer sequence DNA→mRNA→ proteins of Central Dogma is somehow reversed. What McFadden suggests is DNA-mRNA-betagalactoce-lactose entanglement such that DNA appears as a superposition of ordinary and enol configurations. Lactose would take the role of quantum measurer of the proton's position inside T nucleotide, and Zeno effect would increase the rate of the mutation.

In TGD Universe the bacterial magnetic body receives information about the presence of lactose and its intention to "eat" lactose is transformed to a desire represented by a negative energy ME entangling directly with DNA. The intention of the magnetic body of E. coli would be to push the DNA to enol configuration by kicking the proton to the abnormal position. Negative W ME could induce long lasting entanglement with normal and enol configurations of T nucleotide so that the enol configuration would appear with a higher probability than in the absence of quantum entanglement and mutated DNA results more often in the replication. The alternative option is that magnetic body induces the gel-sol transition inducing mutation in the manner already described.

Quite generally, feeding of dark protons to atomic space-time sheets and gel-sol transition would serve as switches used by the cellular magnetic body to realize its desires. This mechanism could be seen as a refined form of remote metabolism providing metabolic energy for the starving bacterium.

2. Multiple mutations of TB bacteria

TB (tubercle bacillus) bacteria are able to develop a simultaneous resistance against several drugs [I111]. This occurs for bacteria which have only brief growth periods followed by long dormant periods. McFadden interprets dormant periods in terms of entanglement with the environment. When this period ends even multiple mutations could result in the quantum measurement at DNA level.

In the TGD framework the magnetic body of TB population would receive information about the fates of various members of the population in the multi-drug environment and would have a strong desire to develop multi-drug resistance. The long dormant periods of bacteria allowing them to survive bring in mind the sleeping periods of higher life forms, and suggests the entanglement of the bacteria with the other members of the population, also those living in the geometric past and already deceased as victims of the drugs. This kind of entanglement would allow the magnetic body to manipulate the genomes of the still-living bacteria so that they have better changes to survive in the multi-drug environment. McFadden does not discuss whether the simple mechanism of mutations working in the case of E. coli might be enough in the case of TB bacteria.

Note that the notion of hyper-genome allows to understand bacterial colonies as systems analogous to multi-cellulars controlled by genes expressed collectively.

3. Mutations and intronic DNA

The TGD based view about pre-biotic evolution allows to imagine more effective mechanisms of mutations replacing the simple mechanism utilized by E. coli and working in case of eukaryotes.

In the TGD Universe reverse transcriptase plays a key role in the pre-biotic evolution as a generator of the genetic variation. The variation is due to the high error rate of the reverse transcription. For instance, the amazing ability of the HIV virus (retro-virus) to adapt is based on the reverse transcription of HIV RNA to DNA. It would be strange if this ability would have been lost during the sub-sequent evolution. Perhaps fragments of DNA are transformed to mRNA also during dormant, "inwards directed" periods. mRNA fragments are however not translated to proteins now but transformed back to DNA fragments by reverse transcriptase replacing the previous DNA fragment in DNA with a new one. This mechanism might work at least in case of eukaryotes having cell nucleus and mean that mRNA is not transferred outside the nucleus. The replacement of DNA fragment need not occur immediately. mRNA fragments would thus act like retro-viruses to produce the needed genetic variation. In this framework ordinary retro-viruses such as HIV might be seen as kind of fallen angels.

This kind of activity in which collective selves of populations modify the genomes of their members might be present in all eukaryotes during sleeping (or more generally, dormant) periods. The generation of mutations might be one of the fundamental purposes of sleep and explain why sleep is so important for healing.

This mechanism of mutations might be still too primitive for eukaryotes. In TGD framework the intronic portion of DNA expresses itself as temporal field patterns using p-adic cognitive codes, in particular memetic code. Introns play the role of the computer software whereas genes take the role of the hardware. In this picture introns would be naturally involved with the control of the adaptive mutations of higher organisms. In the modern home computers hardware is becoming more and more dynamical, and computer metaphor suggest that the passive DNA could contain

segments representing kind of computer store containing variants of various genes taken in use if required. Transposons might represent these new pieces of the hardware.

This replacement need not involve the removal of the old gene fragment and could be only functional. Computer metaphor inspires the idea that the intronic portion of DNA represents a given gene as a dynamical list of addresses, kind of links or program calls, specifying which portions of DNA contribute to the gene, and that this list characterizes how the splicing of mRNA occurs. Therefore the mutation could occur at the intronic software level as a mere updating of the list representing the gene.

The challenge is to understand how this addressing might be realized physically. For instance, addressing might involve simply common fragments of DNA in meme and corresponding portions of gene serving as addresses making possible a "tuning to a common wave length". Alternatively, magnetic flux tubes might serve as space-time correlates of the links. They could be generated intentionally as wormhole magnetic fields consisting of pairs of positive and negative energy magnetic flux tubes parallel to DNA strand. The generation of wormhole magnetic fields identified as the basic motor activity of the magnetic body could also explain the appearance and disappearance of EEG bands. By the p-adic fractality similar mechanism could be at work also in DNA length scale.

4. Could zero energy ontology be relevant for living matter?

Zero energy ontology [K64] emerged originally from the observation that Robertson-Walker cosmologies correspond in TGD framework to vacuum extremals for which all conserved classical charges vanish (the non-conserved gravitational mass density does is non-vanishing). The construction of S-matrix led to a precise formulation of zero energy ontology.

Zero energy ontology states that physical states have vanishing net quantum numbers and consist of positive energy states at boundaries of future directed light-cones in the geometric past ("not so big bang") and negative energy states at the boundaries of past directed light cones in the geometric future ("not so big crunch") assignable to arguments of N-point function.

Due to the fact that conformal weights are complex it is possible to distinguish between positive energy particles propagating to the geometric future and negative energy particle propagating to geometric past. Phase conjugate laser photons contra ordinary laser photons represent basic empirical example about this distinction.

In the construction of S-matrix identified as entanglement coefficients between these tow kinds of states (this notion makes sense for hyper-finite factors of type II_1 since trace of unit matrix is now equal to unit) these states represent incoming and outgoing states of particle reaction so that measurement of reaction rates is basically quantum measurement in which time-like entanglement is reduced instead of space-like entanglement [K25].

A rather strong argument in favor of zero energy ontology comes from superconductivity [K18]. The models super-conductivity utilize formally the notion of coherent state of Cooper pairs involving quantum superposition of arbitrary numbers of Cooper pairs. This is in conflict with various conservation laws in standard ontology but in zero ontology it is quite possible to consider quantum superposition of zero energy states with various values of quantum numbers for positive energy states.

This opens the gates for rather fascinating speculations. Time-like charge entanglement would allow to imagine a time-like variant of the capacitor model of sensory receptor. For instance, sensory qualia could result in the reduction of coherent state of Cooper pairs to a state with a well defined charge.

Also different DNA sequences with different masses and charges might appear in quantum superpositions for time like entanglement and this might be relevant for evolution of genetic code. In particular, the model of McFadden for mutations might generalize dramatically. As a matter fact, the proposed identification of S-matrix (or rather its generalization M-matrix which need not be unitary) as time-like entanglement coefficients assumes the presence of all pairs of initial and final states appearing in the S-matrix in the superposition so that this possibility could be seen as a prediction.

5.6 Jeremy England's Vision About Life And Evolution

I had an intensive discussion with my son-in-law Mikko about the work of Jeremy England [I122] (`http://tinyurl.com/o64rd7o`). The article of the link is probably the most aggressive hyping I have ever seen but this should not lead to think that a mere hype is in question. There is also another, not so heavily hyped popular article at `http://tinyurl.com/m8s2jqt`. The material at the homepageof england lab (`http://tinyurl.com/ycdrdazq`) gives a good view about the work of England for those who cannot tolerate hyping.

England's work is indeed very interesting also from TGD point of view although it is based on standard physics.

In the sequel I will summarize this approach and compare it with TGD vision. The generalization of the thermodynamical approach to TGD framework leads to surprising new insights about the thermodynamical conditions making life and consciousness possible. The new elements relate to zero energy ontology (ZEO), hierarchy of Planck constants labelling levels in a hierarchy dark matters assignable with quantum criticality, the role of macroscopic quantum coherence associated with gravitation, and strong form of holography. The TGD counterparts of Hawking temperature and Hagedorn temperature seem to be crucial for life and correspond to physiological temperature scales. Near Hawking temperature the special features of ZEO become manifest meaning that time reversals of "selves" (mental images) are generated with a considerable rate in heat bath and long term memory and planned action become possible.

5.6.1 Basic Ideas Of England's Theory

I try first to summarize England's vision.

1. Non-equilibrium thermodynamics (NET) is the starting point. NET has been for decades the theoretical framework underlying the attempts to understand living matter using the principles of self-organization theory. Living matter is never an isolated system: dissipation would take it to a totally dead state in this case - nothing would move. Water in the pond when there is no wind, is a good example.

   Self-organization requires an external energy feed - gravitational potential energy liberated in water flow in river or electric power feed to the hot plate below a teapot. This energy feed drives the system to a non-stationary state far from a thermal equilibrium state. Dissipation polishes out all details and leads to an asymptotic spatio-temporal self-organization patterns. The flow in a river and convection in the heated teapot. With high enough energy feed chaos emerges: water fall or boiling of tea pot.

2. The basic hypothesis of England is that evolution means increase in the ability to dissipate. This looks intuitively rather obvious. The evolving system tends to get to a resonance with the energy feed by oscillating with the same frequency so that energy feed becomes maximal and therefore also dissipation. The basic rule is simple: choose the easy option, ride on the wave rather than fighting against it! For instance, the emergence of photosynthesis means that the systems we call plants become very effective in absorbing the energy of sunlight. In this framework essentially all systems are alive to some degree.

   Dissipation means generation of entropy. Evolution of life and conscious intelligence would mean maximal effectivenes in the art of producing disorder. Now I am perhaps exaggerating. One should speak about "system's maximal ability to transfer entropy out of it": life is not possible without paper baskets. One could argue that the development of civilization durig last decades demonstrates convincingly that evolution indeed generates systems generating disorder with a maximal rate.

   One could argue that the definition is too negative. Living matter is conscious and there is genuine conscious information present. The fact is that evolution involves a continual increase of conscious information: the exponential explosion of science is the best proof for this. England's vision says nothing about it. Something is missing.

   It is however quite possible to imagine that the principle of maximal entropy generation is true and that the increase of the ability to produce entropy is implied by some deeper principle

allowing to speak about living matter as something tending to increase conscious information resources. To formulate this idea one needs a theory of consciousness, thermodynamics is not enough.

3. England has a further idea. The evolution life is not climbing to Mount Everest but coming down from it. Life emerges spontaneously. This is definitely in conflict with the standard wisdom, in particular with the thermodynamical belief on thermal death of the Universe as all gradients disappear. Darwinian evolution would be a special case of a more general phenomenon, which could be called dissipation driven adaptation (DDA). I made a head-on-collision with this principle in totally different framework by starting from quantum criticality of TGD: if took time to fully realize that indeed: evolution could be seen as a sequence of phase transitions breaking in which certain infinite-dimensional symmetry was spontaneously broken to become just the same symmetry but in longer scale!

   Standard thermodynamics predicts the heat death of the Universe as all gradients gradually disappear. This prediction is problematic for England's argument suggesting that differentiation occurs instead of homogenization. Here the standard view about space-time might be quite too simplistic to overcome the objection. In TGD many-sheeted space-time comes in rescue.

   Here is an example about England's argumentation. It seems intuitively clear that replication increases entropy (it is not however clear whether just the splitting into pieces is even more effective manner to increase entropy!). This would suggest that DDA forces the emergence of replication. Very effective dissipators able to replicate, would increase the total effectiveness in dissipation and be the winners. The proposal to be tested is that bacterial mutations , which are best replicators are also best dissipators.

5.6.2 What Is Missing From England's Theory?

What is missing from England's theory? The answer is same as the answer to the question what is missing from standard physics.

1. What is conscious observer - self?

   Observer, which remains outsider to the physical world in the recent day physics - both classical and quantum. Hence one does not have a theory of consciousness and cannot speak about conscious information. Thermodynamics gives only the notion of entropy as a measure for the ignorance.

   Therefore there is a long list of questions that England's theory does not address. What are the physical correlates of attention, sensory perception, cognition, emotions relating closely to information, etc.? Is there some variational principle behing concious existence, and does it imply evolution? Could second law and DDA be seen as consequences of this variational principle?

   England does not say much about quantum theory since he talks only about thermodynamics but his hypothesis is consistent with quantum theory. The restriction to thermodynamics allows only statistical description and notions like macroscopic quantum coherence are left outside.

2. What is life?

   Again one has a long list of questions.

   What it is to be alive? What distinguishes between living and inanimate systems. What it is to die? How general phenomenon evolution is: does it apply to all matter? Also notions like self-preservation and death are present only implicitly in an example about a population of wine glasses whose members might gradually evolve to survive in an environment populated by opera sopranos.

   One can make also other kinds of questions. What really happens in replication? What is behind genetic code? Etc...

England is a spiritual person and has made clear that the gulf between science and spirituality is something which bothers him . England even has the courage to use the word "God". Therefore it sounds somewhat paradoxical that England avoids using the concepts related to consciousness and life. This is however the only option if one does not want to lose academic respectability.

5.6.3 How Does England's Theory Relate To TGD?

It is interesting to see whether England's vision is consistent with TGD inspired theory of consciousness, which can be also seen as a generalization of quantum measurement theory achieved by bringing the observer part of the quantum physical world. In TGD framework several new principles are introduced and they relate to the new physics implied by the new view about space-time.

1. The new physics involves a generalization of quantum theory by introducing a hierarchy of Planck constants $h_{eff} = n \times h$ with various quantal length and time scales are proportional to h_{eff}. h_{eff} hierarchy predicts a hierarchy of quantum coherent systems with increasing size scale and time span of memory and planned action. h_{eff} defining a kind of intelligence quotient labels the levels of a hierarchy of conscious entities.

   h_{eff} hierachy labels actually a fractal hierarchy of quantum criticalities: a convenient analogy is a ball at a top of ball at the top..... The quantum phase transitions inreasing h_{eff} occur spontaneously: this is the TGD counterpart for the spontaneous evolution in England's theory. Dark matter is what makes system alive and intelligent and thermodynamical approach can describe only what we see at the level of visible matter.

2. Second key notion is zero energy ontology (ZEO). Physical states are replaced by events, one might say. Event is a pair of states: initial state and final state. In ZEO these states correspond to states with opposite total conserved quantum numbers: positive and negative energy states. This guarantees that ZEO based quantum theory is consistent with the fundamental conservation laws and laws of physics as we understand them although it allows non-determinism and free will. Positive and negative energy states are localized at opposite boundaries of a causal diamond (CD). Penrose diagram - diamond symbol - is a good visualization and enough for getting the idea.

   State function CDreduction (SFR) is what happens in quantum measurement. The first SFR leads to a state which is one in a set of states determined once measurement is characterized. One can only predict the probabilities of various outcomes. Repeated quantum measurements leave the state as such. This is Zeno effect - watched kettle does not boil.

   In ZEO something new emerges. The SFR can be performed at *either* boundary of CD. SFR can occur several times at the same boundary so that the state at it does not change. The state at the opposite boundary however changes - one can speak of the analog of unitary time evolution - and the second boundary also moves farther away. CD therefore increases and the temporal distance between its tips does so also.

   The interpretation is as follows. The sequence of reductions at fixed bounary corresponds to a conscious entity, self. Self experiences the sequence of state function reductions as a flow of time. Sensory experience and thoughts, emotions, etc.. induced by it come from the moving boundary of CD. The constant unchanging part of self which meditators try to experience corresponds to the static boundary - the kettle that does not boil.

   Self dies in the *first* reduction to the opposite boundary of CD. Self however re-incarnates. The boundaries of self change their roles and the geometric time identified as distance between the tips of CD increases now in opposite direction. Time-reversed self is generated.

3. Negentropy Maximization Principle (NMP) stating roughly that the information content of consciousness is maximal. Weak form of NMP states that self has free will and can choose also non-maximal negentropy gain. The basic principle of ethics would be "Increase negentropy". p-Adic mathematics is needed to construct a measure for conscious information and the notion of negentropic entanglement (NE) emerges naturally as algebraic entanglement.

The negentropy to which NMP refers is *not* the negative of thermodynamical entropy describing lack of information of outsider about state of system. This negentropy characterizes the conscious information assignable to negentropic entanglement (NE) characterized by algebraic entanglement coefficients with measure identified as a number theoretic variant of Shannon entropy. Hence NMP is consistent with the second law implied by the mere non-determinism of SFR.

NMP demands that self during sequence of reductions at the same boundary generates maximum negentropy gain at the changing CD boundary. If self fails, it dies and re-incarnates (in a reduction to the opposite CD boundary more negentropy is generated). Selves do not want to die and usually they do not believe on re-incarnation, and therefore do their best to avoid what they see as a mere death. This is the origin of self-preservation. Self must collect negentropy somehow: gathering negentropic sub-selves (mental images) is a way to achieve this. Plants achieve this by photosynthesis, which means generation of negentropy and storage of it to various biomolecules. Animals are not so saintly and simply eat plants and even other animals. We are negentropy thieves all.

Re-incarnation also means increase of h_{eff} and getting to higher level in hierarchy and occurs unavoidably. As in England's theory, evolution occurs spontaneously: it is not climbing to Mount Everest but just dropping down.

4. England says "Some things we consider inanimate actually may already be 'alive'." This conforms with TGD view. Even elementary particles could have self: it is however not clear whether their SFR sequences contain more that one reduction to a fixed boundary - necessary for having a sense about the flow of time. Elementary particles would even cognize: in adelic physics every system has both real and p-adic space-time surfaces as its correlates. It can even happen that system has only p-adic space-time correlates but not the real one: this kind of systems would be only imaginations of real system! This is one of the most fascinating implications of strong form of holography which follows from strong form of General Coordinate Invariance forced by the new view about space-time.

   Clearly the notion of evolution generalizes from biological context to entire physics in TGD. One can speak about p-adic evolution and evolution as increase of h_{eff}. The most abstract formulation is number theoretical: evolution corresponds to the increase of the complexity of extension of rationals to which the parameters characterizing space-time surfaces belong to.

5. Does DDA emerge in TGD framework? NMP demands a lot of SFRs - also at the level of visible matter. The non-determimism of SFR alone means a loss of knowledge about the state of system and an increase of thermodynamical entropy so that living systems would generate entropy very effectively also in TGD Universe at the level of visible matter. If one believes that second law and NET imply DDA as England argues, then also TGD implies it at the level of visible matter. For dark matter the situation is different, since the outcome of SFR is not not random anymore. Seen from TGD perspective England's vision misses what is essential for life - the generation of phases of matter identifiable as the mysterious dark matter.

6. England talks about God. In a theory of consciousness predicting infinite self hierarchy, it is easy to assign the attribute "divine" to the levels of consciousness above given level of hierarchy. Personally I have nothing against calling the Entire Universe "God".

   One could give NMP the role of God. For strong form of NMP SFR would be almost deterministic except for ordinary matter for which entanglement is not algebraic and is therefore entropic: the universe would the best possible one in dark sectors and the worst one in the visible matter sector - Heaven and Hell! Weak form of NMP makes possible even more effective generation of negentropy than its strong form but allows self to make also stupid things and even SFRs with a vanishing negentropy gain: the outcome is state with no entanglement (system is in very literal sense alone in this state). The world in dark matter sectors is not anymore the best possible one but can become better and does so in statistical sense.

7. Replication is a crucial aspect of being alive. England argues that DDA allows to understand its emergence but does not tell about its mechanism. In TGD framework replication can be understood as an analog of particle decay - say photon emission by electron. This requires however a new notion: magnetic body. In Maxwell's theory one cannot assign any field identity to a physical system but TGD view about space-time forces to assign to a given system its field/magnetic body. The replication occurs primarily at the level of magnetic body carrying dark matter as large h_{eff} phases. Magnetic body replicates and ordinary visible matter self-organizates around the resulting copies of it. The dynamics of dark matter would induce also DNA replication, transcription and mRNA translation, and there are some indications that it is indeed "dark DNA" (dark proton sequences having DNA, RNA, amino-acids, and tRNA as biochemical counterparts), which determines what happens in transcription.

5.6.4 Could One Apply The Thermodynamical Approach Of England In TGD Framework?

It turns out possible to gain amazing additional insights about TGD inspired view of life and consciousness by generalizing England's approach [I122]. Several puzzling coincidences find an explanation in the thermodynamical framework and the vision about solar system as a living quantum coherent entity gains additional support.

1. The situation considered in England's approach is a system - say biomolecule - in heat bath so that energy is not conserved due the transfer of energy between reactants and heat bath.

2. The basic equation is equilibrium condition for the reaction $i \to f$ and its time reversal $f^* \to i^*$. The initial and final state can be almost anything allowing thermodynamical treatment: states of biomolecule or even gene and its mutation. The ratio of the rates for the reaction and its time reversal is given by the ratio of the Boltzmann weights in thermal equilibrium:

$$\begin{aligned} \frac{R(i \to f)}{R(f^* \to i^*)} &= R \ , \\ R &= e^{-\frac{E_i - E_f}{T}} \ . \end{aligned} \tag{5.6.1}$$

   E_i and E_f denote the energies of initial and final state. This formula is claimed to hold true even in non-equilibrium thermodynamics. It is important that the ratio of the rates does not depend at all on various coupling constant parameters. The equilibrium condition must be modified if initial and final states are fermions but it is assumed that states can be described as bosons. Note that in heat bath even fermion number need not be conserved.

3. If the energy eigenstates are degenerate, the ratio R of Boltzman factors must be modified to include the ratio of state degeneracies

$$R \to \frac{D(E_i)}{D(E_f)} \times e^{-\frac{E_i - E_f}{T}} \ . \tag{5.6.2}$$

   This generalization is essential in the sequel.

   One can imagine two possible reasons for the presence of exponentially large factors compensating Boltzmann weights $D(E_i)$. The first reason is that for $h_{eff} = n \times h$ the presence of n-fold degeneracy due to the n-fold covering of space-time surface reducing to 1-fold covering at its ends at the ends of CD is essential. Second possible reason is that the basic object are magnetic flux tubes modellable as strings with exponentially increasing density of states. These mechanisms could quite well be one and same.

Consider now the basic idea inspired by this formula in TGD framework.

1. Since magnetic flux tubes are key entities in TGD inspired quantum biology, stringy dynamics suggests itself strongly. The situation thus differs dramatically from the standard biochemical situation because of the presence of dark matter at magnetic flux tubes to which one can assign fermion carrying strings connecting partonic 2-surfaces defining correlates for particles in very general sense.

2. The key aspect of stringy dynamics is Hagedorn temperature [B6, B12] (`http://tinyurl.com/yamnafy6`). Slightly below Hagedorn temperature the density of states factor, which increases exponentially, compensates for the Boltzmann factor. Hagedorn temperature is given by

$$T_{Hag} = \frac{\sqrt{6}}{2\pi}\frac{1}{\alpha'} \quad , \tag{5.6.3}$$

   where α' is string tension. In superstring models the value of string tension is huge but in TGD framework the situation is different. As a matter fact, the temperature can be rather small and even in the range of physiological temperatures.

3. What makes T_{Hag} so special is that in the equilibrium condition reaction and its reversal can have nearly the same rates. This could have profound consequences for life and even more - make it possible.

   In ZEO based quantum measurement theory and theory of consciousness time reversal indeed plays key role: self dies in state function reduction to the opposite boundary of CD and experiences re-incarnation as a time-reversed self. This process is essential element of memory, intentional action, and also remote metabolism, which all rely on negative energy signals travelling to geometric past assignable to time reversed sub-selves (mental images). The above formula suggests that intelligent life emerges near T_{Hag}, where the time reversed selves are generated with high rate so that system remembers and pre-cognizes geometric future as it sleeps so that memory planned action are possible.

4. String tension cannot be determined by Planck length as in string models if it is to be important in biology. This is indeed the case in TGD based quantum gravity. The gravitational interaction between partonic 2-surfaces is mediated by fermionic strings connecting them. If string tension were determined by Planck length, only gravitational bound states of size of order Planck length would be possible. The solution of the problem is that the string tension for gravitational flux tubes behaves like $1/h_{eff}^2$.

   In TGD framework string tension can be identified as an effective parameter in the expression of Kähler action as stringy action for preferred extremal strongly suggested by strong form of holography (SH) allowing the description of the situation in terms of fermionic strings and partonic 2-surfaces or in terms of interiors of space-time surfaces and Kähler action. $1/h_{eff}^2$ dependence can be derived from strong form of holography [K29, K30, K31, K32] assuming electric-magnetic duality for Kähler form, and using the fact that the monopoles associated with the ends have same magnetic and electric charges.

5. The discussion of the analog of Hawking radiation in TGD framework [K29, K30, K31, K32], [L19] led to an amazing prediction: the TGD counterpart of Hawking temperature turns out to be in the case of proton very near to the physiological temperature if the big mass is solar mass. This suggests that the entire solar system should be regarded as quantum coherent living system. This is also suggested by the general vision about EEG [K36]. Could Hawking temperature be near to the Hagedorn temperature but below it?

One can make this vision more detailed.

1. In ZEO the notion of heat bath requires that one considers reactants as subsystems. The basic mathematical entity is the density matrix obtained by tracing over entanglement with environment. The assumption that dark matter is in thermal equilibrium with ordinary matter can be made but is not absolutely crucial. The reactions transforming visible photons to dark photons should take care of the equilibrium. One could even assume that the description applies even in case of the negentropic entanglement since thermodynamical entropy is different from entanglement entropy negative for negentropic entanglement.

2. In TGD inspired quantum biology one identifies the gravitational Planck constant introduced by Nottale with $h_{eff} = n \times h$ [K29, K30, K31, K32, K86, K68]. The idea is simple: as the strength of gravitational interaction becomes so strong that perturbation series fails to converge, a phase transition increasing the Planck constant takes place. $\hbar_{gr} = GMm/v_0 = \hbar_{eff} = n \times \hbar$ implies that $v_0/c < 1$ becomes the parameter defining the perturbative expansion. h_{gr} is assigned with the flux tubes mediating gravitational interaction and one can say that gravitons propagate along them.

   Note that this assumption makes sense for any interaction - say in the case of Coulomb interaction in heavy atoms: this assumption is indeed made in the model of leptohadrons [K95] predicting particles colored excitations of leptons lighter the weak bosons: this leads to a contradiction with the decay widths of weak bosons unless the colored leptons are dark. They would be generated in the heavy ion collisions when the situation is critical for overcoming the Coulomb wall.

   The cyclotron energy spectrum of dark particles at magnetic flux tubes is proportional to h_{gr}/m does not depend on particle mass being thus universal. In living matter cyclotron energies are assumed to be in the energy range of bio-photons and thus includes visible and UV energies and this gives a constraint on h_{gr} if one makes reasonable assumption about strengths of the magnetic fields at the flux tubes [K13]. Bio-photons are assumed to be produced in the transformation of dark photons to ordinary photons. Also (gravitational) Compton length is independent on particle mass being equal to $L_{gr} = GM/v_0$: this is crucial for macrosopic quantum coherence at gravitational flux tubes.

3. The basic idea is that Hawking radiation in TGD sense is associated with all magnetic flux tubes mediating gravitational interaction between large mass M, say Sun, and small mass m of say elementary particle. How large m can be, must be left open. This leads to a generalization of Hawking temperature [L19] assumed to make sense for all astrophysical objects at the flux tubes connecting them to external masses:

$$T_{GR} = \hbar \frac{GM}{r_S^2 2\pi} = \frac{\hbar}{8\pi GM} \quad . \tag{5.6.4}$$

   For Sun with Schwartschild radius $r_S = 2GM = 3$ km one has $T_{GR} = 3.2 \times 10^{-11}$ eV.

   Planck constant is replaced with $\hbar_{gr} = GMm/v_0 = \hbar_{eff} = n \times \hbar$ in the defining formula for Hawking temperature. Since Hawking temperature is proportional to the surface gravity of blackhole, one must replace surface gravity with that at the surface of the astrophysical object with mass M so that radius $r_S = 2GM$ of the blackhole is replaced with the actual radius R of the astrophysical object in question. This gives

$$T_{Haw} = \frac{m}{8\pi v_0} (\frac{R_S}{R})^2 \quad . \tag{5.6.5}$$

   The amazing outcome is that for proton the estimate for the resulting temperature for M the solar mass, is 300 K (27 C), somewhat below the room temperature crucial for life!

   Could Hagedorn temperature correspond to the highest temperature in which life is possible - something like 313 K (40 C)? Could it be that the critical range of temperatures for

life is defined by the interval $[T_{Haw}, T_{Hag}]$? This would require that T_{Haw} is somewhat smaller T_{Hag}. Note that Hawking temperature contains the velocity parameter v_0 as a control parameter so that Hawking temperature could be controllable. Of course, also $T_{Haw} = T_{Hag}$ can be considered. In this case the temperature of environment would be different from that of dark matter at flux tubes.

4. The condition $T_{Haw} \leq T_{Hag}$ allows to pose an upper bound on the value of the effective string tension

$$\frac{1}{\sqrt{\alpha'}} \geq \frac{m}{4\sqrt{6}v_0}\frac{R_S}{R} \quad . \tag{5.6.6}$$

Chapter 6

More Precise TGD View about Quantum Biology and Prebiotic Evolution

6.1 Introduction

This work is an attempt to clarify the relation of the basic notions of TGD and TGD inspired biology - in particular the vision about prebiotic evolution - to chemistry and to the standard views about prebiotic evolution. There are frustratingly many different approaches and I have been working hardly to see whether TGD could allow to identify the common denominator of these approaches.

1. The works of Fröhlich [I106] and Del Giudice [I59] [D11] have served as a theoretical background in many attempts to develop quantum view about biology and consciousness. The first key idea is that weak em fields with frequencies, which correspond to energies much below the thermal energy in ordinary quantum theory, induce coherence/synchrony - maybe even quantum coherence - and that metabolic energy can be stored into Bose-Einstein condensate type states (`https://www.youtube.com/watch?v=RjF1_eDEsqc`). For instance, the work of Blackman [J8] and others in turn suggests that cyclotron frequencies in magnetic field of .2 Gauss have effects on vertebrate brain.

   Living systems are full of electrets and dipoles and charge separation in water environment is key aspect of living matter. Fröhlich sees electric dipoles and dipole oscillations as something fundamental. Also microtubule based view about consciousness relies on the ideas of Fröhlich. Del Giudice introduces the notion of coherence regions with size of about 1 micron as regions of water. Pollack [L13] has discovered exclusion zones (EZs) as a characteristic of what he calls fourth phase of water. Charge separation occurs in EZs created in presence of gel: EZ is negatively charged and obeys $H_{3/2}$ stoichiometry instead of the usual. Part of protons goes outside EZ. Water clathrates (`https://en.wikipedia.org/wiki/Clathrate_hydrate`) have size scales in the same range as EZs and could be precursors of EZs.

   Questions: What does the coherence/synchrony forced by oscillating external emf really mean? Does it really create Bose-Einstein condensates for oscillatory modes coupled with it? How coherence regions and EZs emerge? Frequency clearly matters as in quantum theory but the photon energies are typically far below thermal energy: how can external emfs with extremely low frequencies have quantal effects?

2. The experimental work carried out to understand prebiotic evolution has led to various insights but no unified view exists. Urey and Miller [I20] found that amino-acids emerge from simpler building blocks in an environment believed to mimic the boundary region between water, dry land, and atmosphere. The recipe for the prebiotic soup was simple: take simplest biomolecules such as NH_3, CH_4, water, lightnings to feed energy (they might have also some other functions), and assume reducing atmosphere. By adding some further simple

ingredients also adenine essential for metabolism, was generated in this kind of environment. It has however become clear that the atmosphere very probably was not reducing.

Question: Is it possible to imagine any counterpart for the reducing atmosphere?

3. There is also a vision that clays represented prebiotic life. Clays form complex chemical and geometric structures consisting of layers microscopically, and also replicate by simply splitting to two. One can even speculate about a simple precedessor of genetic code. Perhaps chemical life evolved in symbiosis with clays.

   Phyllosilicates (`https://en.wikipedia.org/wiki/Category:Phyllosilicates`) - in particular kaolinite and montmorillonite - are most studied clays. There is large variant of them containing basic biologically important ions in their lattice structure. Montmorillonites adsorb amino-acids and RNA nucleotides and promote polymerization of oligomers of RNA although the lengths of the resulting oligomers are considerably shorter than required by RNA world. DNA is not obtained since it is highly unstable in ordinary water. Even vesicles formed by double lipid layers are formed and could serve as precedessors of cells. But something is clearly missing.

   Questions: What is needed to get longer RNA strands and perhaps even DNA? How could one obtain prebiotic genetic code? What kind of environment could contain the biologically important atoms/ions in particular phosphate ion?

4. One can try to combine the experimental vision with the theoretical visions of Fröhlich and Del Giudice and with the experimental discoveries of Blackman and Pollack. This leads to ask whether the layers phyllosilicate structures could generated frequencies which promote coherence (maybe even quantum coherence) in living matter. It is now known (as I learned from Hans Geesink) that phyllosilicates have positive effects on health. Maps are constructed for their frequency spectrum and it is even found that they can serve as kind of frequency storage - this is analogous to water memory [K47]. Even cyclotron frequencies assignable to .2 Gauss magnetic field have been identified, and there is evidence that the powers of 3 and 2 about these frequencies are also biologically important. Quite generally, the THz/microwave region for which energies are below thermal energy (kT paradox) seems to be of special importance.

   Questions: Could basic biomolecules and surfaces of phyllosilicate layers in interaction with water have been precedessors of the recent chemical life? Water clathrates can contain various elements and probably also phyllosilicate crystals: could their transformation to EZs be an essential step in prebiotic evolution?

TGD suggests an answer to the questions posed above.

1. In TGD Universe dark matter corresponds to ordinary matter with large value $h_{eff} = n \times h$ of effective Planck constant. The oscillating classical em fields are classical correlates for dark photons. This solves the kT paradox. The forced oscillations are induced by absorption of these quanta: macroscopic quantum coherence forces the coherence of ordinary biomatter.

   The additional assumption $h_{eff} = h_{gr} = GMm/v_0$ [K70, K86] (to be explained in more detail later) implies universal energy spectrum for dark cyclotron photons and their transforms to ordinary photons can be identified as bio-photons [K13] in energy range containing visible and UV frequencies. Generalized Josephson radiation from membrane proteins acting as generalized Josephson junctions has also a branch for which energy spectrum is universal but frequencies depend on h_{eff}. These two dark photon species are used by magnetic body to control, coordinate, and communicate with ordinary matter in living systems.

2. In TGD framework one can do without coherence regions (one could perhaps identify them as special cases of Pollacks EZs), which can be much larger. The basic observation is that for a pair of hydrogen bonded water molecules the reaction $2H_2O \rightarrow H_3O_2^- +$ dark proton require UV photon with energy of O-H bond of about 5.15 eV. Water clathrates (`https://en.wikipedia.org/wiki/Clathrate_hydrate`), whose importance Hans Geesink emphasizes [L18], are good candidates for the precursors of EZs since they have size scale in the same range as EZs and contain hydrogen bonded water. Quantum criticality suggests

that this process should occur spontaneously as a chain reaction. This is achieved in the same way as in nuclear fusion if the dark protons at the flux tube fuse to nuclear strings giving rise to dark nuclei.

If dark nuclear binding energy transforms as Coulomb energy under scalings of h_{eff} inducing similar scaling of the size of the system, the nuclear energy scale of MeV scales down to 1-10 eV - depending on the value of h_{eff}. An attractive guess is that the energy range of bio-photons corresponds to that for dark nuclear binding and excitation energies. Their spontaneous transformation to ordinary nuclei would liberate energy could at least partially explain the evidence for bio-transmutations. Also the relation to cold fusion is interesting.

Dark nuclear binding energy is liberated as dark photons decaying into bunches of ordinary photons inducing further reactions $2H_2O \rightarrow H_3O_2^- +$ dark proton also other kind of dark ionizations. The size of EZs varies from about 1 micron to 100 microns. Suppose that the size scale of EZ corresponds to the wavelength of dark photon with energy of order dark nuclear binding, and that h_{eff} is such that the nuclear binding energy corresponds to the lower end about 1 eV in the range of bio-photon energies. If so then h_{eff}/h varies in the range $1 - 100$. This would be the total number of dark photons resulting in the decay to ordinary photons.

In this process ordinary protons transform dark protons at magnetic flux tubes outside EZ. Dark ionization differs from ordinary ionization only in that the proton is dark. The difference between dark and ordinary ionization would define the borderline between ordinary and bio-chemistry (or dark chemistry). Chemical quantum criticality is possible also for other cations and also anions and all biologically important ions can appear as dark ions.

3. Dark proton states correspond to states of DNA, RNA, amino-acids and tRNA and therefore provide a fundamental representation of genetic code. The dark ionization of -O-H:s of any linear molecular structure generates dark proton sequence. In particular, the -O-H in phosphate of DNA nucleotide can become O^- plus dark proton, so that one has pairing or DNA with dark proton sequence carrying the genetic information. This splitting can occur also for amino-acids containing -O-H as standard part and also for ATP. Dark ionization can also occur for -O-H:s at of phyllosilicates layers and at their 1-D boundaries. Depending on the correlation between dark proton states and phyllosilicate units one could have an analog of genetic code. One can also imagine formation of DNA, RNA, etc... as their inorganic forms "steal" dark proton sequence from phyllosilicate: dark proton sequence would serve as a template. This would make possible very effective generation of complex biopolymers.

4. As Geesink emphasizes [L18], clays are good candidates for the key structures in prebiotic evolution since they can replicate. One can even speculate with an analog of genetic code. Phyllosilicates containing -O-H groups are especially interesting: they can adsorb basic biomolecules and induce their polymerization to oligomers. They also induce a formation of vesicles formed from lipid bilayer and serving as a candidate for a precedessor of cell. DNA is the problem and has led to a scenario known as RNA world. Phyllosilicates are also known to generate radiation with positive health effects.

   The natural and testable hypothesis is that the presence of EZs allows to circumvent the difficulties of the standard RNA world scenario and also generate DNA and biologically active phosphates containing the mysterious phosphate bond as ionized dark proton. The dark magnetic flux tubes and UV photon energy needed to generate EZs could be provided by gel in Pollacks's experiments and by electric discharges in Urey-Miller experiment. Also dark photons from the formation of dark nuclei decaying to bunches of bio-photons provide this energy.

   Water clathrates serving as precursors of EZs can contain atoms and perhaps even micrometer sized phyllosilicate crystals, which could catalyze the formation of biomolecules at their surfaces as a dark nuclear fusion chain reaction. Clathrate could also develop phospholipid bilayer around it - kind of primitive cell membrane. A possible objection is that Pollack observed that EZs repel impurities from their interior. What "inpurity" exactly means is of course a crucial question.

5. Prebiotic life could have evolved in underground oceans - even below the Earth's crust. The metabolic energy feed could have come as dark photons from the core, whose temperature is rather near to that of solar radiation. Also dark photons from solar radiation could have contributed. EZs could have been generated by dark UV quanta accompanying lightnings. Dark photons would propagate along dark magnetic flux tubes through the crust and transform to bio-photons in underground oceans (this is not the only possibility).

   Geesink [L18]mentions that FIR and THz/microwave radiation is accompanies the clathrate aerosols in atmosphere, which suggests the importance of atmosphere. If EZs generated by solar radiation from clathrates are present, this radiation could be dark and have energies above thermal energy and propagate along dark magnetic flux tubes. EZs could also transform ordinary solar radiation to dark radiation so that the radiation from atmosphere could enter underground oceans as dark radiation.

   In Cambrian explosion the radius of Earth was doubled (in TGD Universe cosmic expansion occurs in rapid jerks at the level of astrophysical objects in given scale) the underground life was burst to the surface of Earth [L46].

Possible technological implications of this picture - if true - are quite impressive. Cold biofusion could make possible artificial generation of technologically important elements and the mechanism generating EZs could make possible creation of artificial intelligent life forms involving silicates and water.

6.2 Background

Recently I have had very interesting discussions with Hans Geesink (`http://tinyurl.com/ya73ydrq`) and have also received a lot of highly interesting material from Hans, in particular his book "Proposal for a quantum field theory about coherence concerning non ionizing radiation" [L18], which can be found from his blog (`http://tinyurl.com/yd4cqpgn`). His views have much in common with my own vision and differences are especially useful since they force to direct attention to ideas that I have not directed enough attention.

6.2.1 About Experimental Work Of Hans Geesink

I was contacted by Hans Geesink, who works in BioTech Silicates, which tries to develop technology intended to reduce negative health effects caused by man-made non-thermal non-ionizing radiation involving typically frequencies from ELF (EEG region) to far infrared region. These effects are caused by EMFs from antennae, mobile phones, and power cables. Perception tests are carried out to see the possible effects on well-being.

Using the words of Geesink:

We have measured more precisely the resonances of the phyllosilicate minerals (used to compensate negative biological effects caused by 'non thermal non ionizing radiation'; having multiple stacked sheets; each platelet 1 nanometer thick, and in stacks of micrometers, and total lengths' of more than earth diameter, able to be organized as a metamaterial, nearly all types of ions incorporated in and between the platelets and we measured: quantized light, IR and FIR spectra properly ordered in powers of 2, and ratios of 1:2, 2:3, and adding multiple frequencies of 2 and 3.

The general vision is that weak external em fields oscillating at frequencies utilized by biosystems to coordinate their behavior by inducing coherent oscillations make possible coherence and perhaps even quantum coherence. The man-made emfs tend to destroy this coherence and weak emfs would restore the coherence if the frequencies are correct. Phyllosilicates seem to provide the materials producing the correct frequencies.

6.2.2 Some Theoretical Ideas

In his articles Geesink has done hard work in building a unified view about the enormous literature related to the biosystems and quantum coherence. Geesink sees the role of classical oscillating em fields central in biology. These fields somehow give rise to the coherent behavior of biomatter and perhaps even quantum coherence. Fröhlich is one of the pioneers, who thought that electric dipoles

and dipole oscillations could be central in living matter and give rise to analogs of Bose-Einstein condensates. A further important notion would be that of coherence region developed by Del Giudice as a quantum field theoretical (QFT) concept important for understanding of quantum biology. Unfortunately, this notion is not established experimentally unlike the exclusion zones (EZs) discovered by Pollack. In the following I try to relate these ideas to TGD framework.

Fröhlich's ideas

Fröhlich [I106] (see `http://tinyurl.com/yas9sv49`) proposes the importance of liquid crystals (`http://tinyurl.com/mcqtmd8`) and electric dipoles in biology. Cell membrane is only one example of liquid crystal and electret important in biology. Already Becker [J7] demonstrated that electric potentials serve as correlates of consciousness. Fröhlich suggests the importance of the longitudinal em modes assignable to dipole oscillations and metabolic energy storage as analogs Bose Einstein condensates (`http://tinyurl.com/y7utzsv8`). For instance, the tubulins inside microtubules are electric dipoles and Hameroff was the first researcher to propose that they might be important for consciousness. I have myself developed this idea from TGD perspective in a model of anesthetes based on electric fields associated with microtubules and give rise also to Becker's DC currents as supra-currents inside microtubules [K78].

One can imagine that dipole oscillations are quantized just like sound waves. Mathematically this is not a problem. The simplest situation corresponds to electrons oscillating in unisono with respect to the ionic lattice and accompanied by an electric field varying in a periodic manner. These oscillations can propagate and define longitudinal electric waves analogous to longitudinal sound waves.

Personally I am a little bit skeptic about quantizing the plasma oscillations but I might be wrong - also acoustic oscillations are quantized. The point is that the density of electrons appears in the formulas for frequencies, which suggests that a phenomenological description is in question. But the density of particles appears also in the frequency for sound waves and we talk fluently about phonons!

I would propose that both phonons and plasma waves have a genuine quantum description at deeper level. In TGD this deeper level would correspond to strings connecting points of partonic 2-surfaces serving as carriers of fermion number. The oscillations of strings would be fundamental besides the oscillations of their ends. Even elementary particles would consist of pairs of wormhole contacts in turn consisting of two partonic 2-surfaces at parallel space-time sheets and connected by strings and string oscillations would represent the fundamental phonons. Phonons would be 2-particle phenomenon and photons single particle phenomenon. This two-particle aspect is missing from QFT description. In string model description only the string aspect is present. In TGD both are involved and this is crucial for obtaining macroscopic gravitationally bound states: in TGD framework string model is doomed to be only a model of gravitation in Planck length scale.

Fröhlich uses the phrase "Governed by negentropy". The notion of negentropy has somewhat fuzzy content in standard physics framework.

1. Fantappie [J22] introduced the notion of syntropy, which in zero energy ontology (ZEO) can be regarded as entropy but with different arrow of time. Spontaneous self assembly would be a process, which would be decay in the reversed direction of time and obey time reversed second law.

2. I have talked about Negentropy Maximization Principle and number theoretic negentropy [K60, K98]. NMP defines the basic variational principle behind state function reduction central for both TGD and TGD inspired theory of consciousness.

   Number theoretical entropy is a variant of Shannon entropy for which the probabilities appearing as arguments of logarithms are replaced with their p-adic norms: this requires that probabilities are rational or at least algebraic numbers. If the entanglement probabilities do not belong to the algebraic extension of rationals used, the entanglement is rather stable since it requires a phase transition to large algebraic extension.

   he final states of state function reduction can have non-vanishing rational entanglement probabilities with projector as a density matrix: this corresponds to entanglement matrix proportional to unitary matrix. The number theoretic entanglement entropy is negative for

these states and one can say that entanglement carries information. NMP is not in conflict with second law: the thermodynamical ensemble entropy characterizes the average particle of ensemble and entanglement entropy characterizes pair of systems. Second law would however hold true only when restricted to the visible sector with standard value of Planck constant.

3. The most powerful implications of NMP in Zero Energy Ontology (ZEO) are precise identification of self as the sequence of state function reductions at a fixed boundary of causal diamond (CD). This leads to the understanding of metabolism and homeostasis as the attempt of conscious entities (selves) to survive: the "death" of self occurs in the first state function reduction to the opposite boundary of CD and actually means re-incarnation in geometric past as far as sensory input is considered. Selves do not however know about this(!) and fight for survival trying to gather negentropy associated with sub-selves to satisfy the needs of NMP. Metabolism is at deeper level gathering of negentropy resources as negentropic entanglement and nutrients are carriers of the negentropic entanglement. This picture is a powerful guideline in attempts to understand how the prebiotic life was initiated.

Forced coherence, coherence regions, and exclusion zones (EZs)

The notion of forced coherence is crucial idea behind the development of devices allowing to reduce the negative health effects caused by man-made non-thermal non-ionizing radiation. Coherent em fields at various frequencies are assumed to play a key role in bio-coordination and artificially generated emfs interfere with this coordination causing negative health effects.

The use of phyllosilicate based devices is argued to help to re-establish the coordination if the generate radiation at frequencies important for maintaining biological coherence via external weak synchronizing signal (for illustration of synchrony see `http://tinyurl.com/nu7cchs`). If phyllosilicates indeed achieve they might have played important role in prebiotic evolution.

Del Giudice [D11] [I59] has introduced the notion of coherence region. These regions would have size of order 1 micrometer and would be characterized by both acoustic and plasma oscillations induced by the synchronizing external fields. Velocity of propagation is dramatically reduced.

I have considered a model of coherence regions as a phase of water in which certain fraction of -O-H bonds of water molecules are excited to high energy state with energy abound 4.8 eV and near the bond breaking energy about 5.15-5.3 eV so that only metabolic energy quantum of about in the range .05-.3 eV is needed to break these bonds. Note that $.05 \times Z$ eV corresponds to the minimal energy assignable to protein Josephhson junctions of neural membrane and that .3 eV is slightly below the nominal value of metabolic energy quantum with nominal value of .5 eV. This would give rise to the formation of fourth phase of water discovered by Pollack [L13]. It however turns out that one can do without coherences regions in TGD framework.

The Exclusion Zones (EZs) of Pollack are generated in water bounded by gel in presence of irradiation by visible light. They have sizes up to 100 micrometers - the size of large neuron - are a fundamental concept in TGD inspired attempts to understand living matter. EZs have high electron density and obey the stoichiometry $H_{3/2}O$. Part of protons must go outside the EZ and TGD inspired proposal is that they go to dark protons at magnetic flux tubes.

Electrons inside EZ have large Fermi energy above thermal energy - maybe even of order 1 eV as in condensed matter - and could be key players in TGD based mechanism of bio-superconductivity. The electrons would be transferred to magnetic flux tubes as dark electrons at quantum criticality. EZs would accompany all bio-active molecules in particular DNA, which has charge -e per nucleotide associated with the phosphate. Also microtubules possess GTP molecules with same charge. The basic problem is to understand how the EZs and coherence regions or clathrates as their possible precursors can be created.

Quantum criticality is a key notion of quantum TGD and TGD inspired biology but has been discussed also by other scientists. For instance, Stuart Kauffman has developed this notion [I131] (`http://tinyurl.com/y74r8gwp`). There are of course many views about quantum criticality: the characteristic difference between TGD inspired proposal [K29, K30, K31, K32] and other proposals is that quantum theory is generalized by introducing the hierarchy of Planck constants $h_{eff} = n \times h$ labeling a fractal hierarchy of isomorphic sub-algebras of so called super-symplectic algebra having the structure of conformal algebra.

Water clathrates

Geesink emphasizes [L18] the importance of water clathrates or clathrate hydrates (http://tinyurl.com/y97q54bp) - crystalline water based solids resembling ices and consist of hydrogen bonded water. Clathrates contain also guest molecules such as small non-polar molecules (typically gas molecules) and polar molecules with large hydrophobic moieties (parts) trapped inside "cages" of hydrogen bonded frozen water molecules. Methane is one gas trapped in deposits of methane clathrate. Clathrates appear also at outer planets, moons, and trans-Neptunian objects.

The size scale range for clathrates varies from 1-100 micros and is same as for EZs of Pollack and the natural identification would be as precursors of EZs. This makes clathrates ideal prebiotic structures inside which molecular life could have evolved.

Geesink notices also the importance of atmospheric aerosol of water clathrates as emitters of radiation in FIR and THz/microwave region inducing coherence and transition betweens protein conformations and Rydberg states (http://tinyurl.com/y8s8bolj). Rydberg states themselves could be excited by UV radiation. The absorption of solar light could transform also atmospheric clathrates to EZs.

6.3 Basic TGD Based Vision About Quantum Biology

From TGD point of view the findings discussed by Geesink in his article [L18] are highly interesting for several reasons. Geesink underlines the importance of external classical fields as inducers of coherence which differs from ordinary coherence in that there is external energy feed as in self-organizing systems, and also the importance of coherence regions of size about 1 micrometer. This raises questions.

1. Is the coherence really quantal or is it the external classical fields classical correlates for quantum coherence? Can one really speak about Bose-Einstein condensates of longitudinal oscillations of electric or is a more fundamental quantum description needed?

2. Do the coherence regions of del Giudice exist except as theoretical entities? What is their origin in TGD Universe if they exist? Could the EZs of Pollack- , which certainly exist - involve the fusion of coherence regions accompanied by a phase transition to $H_{1.5}O$ stoichiometry generating charge separation. Or could one do without coherence regions as separate entities and perhaps identify them with EZs? Or could water clathrates replace them as precursors of EZs? Note that theoretically the size of coherence regions would be about 1 micrometers whereas the sizes of EZs vary up to 200 micrometers. The clathrate option looks to me highly attractive.

3. Another option is based on the hypothesis that dark proton sequences are dark nuclei and their binding energy scales like $1/L$, L the size scale of dark nucleus measured in nanoneters. If so, the binding energy of dark nuclei per dark proton would be in UV range. The process could proceed spontaneously as dark fusion. Dark proton sequences would be formed and emit UV photons with energy near 5 eV, which in turn would excite O-H near to the criticality so that a radiation with energy of energy near metabolic energy quantum can generate the dark proton and hydrogen bonded $H_3O_2^-$. Metabolic energy could induce this process.

4. Geesink reports that the phyllosilicate minerals created in the interaction of water with silicate minerals and possessing characteristic -O-H groups have positive health effects and can be used to reduce the negative effects caused by man-made non-ionizing radiation. When doped with biologically important ions they produce specific biological effects characterizing the ion and also the cyclotron frequencies assigned to .2 Gauss magnetic field by Blackman are detected.

   This leads to a series of questions.

   (a) Could the physics of phyllosilicate-water system involve EZs and possibly also coherence regions in a key role? -O-H groups and their ionized variants $-O^-$ are a common denominator of both water, biologically active phosphate and there of DNA and RNA nucleotides as well as phospholipids containing phosphate, of amino-acids, etc...

Could the transformation of -O-H to -O^- plus dark proton be the fundamental reaction generating dark protons. Note that this transformation would be dark counterpart for what what happens as acid gives up proton. For instance, a fraction of water molecules characterized by pH decomposes to OH^- and H_3O^+ ions. In presence of EZ this process would produce dark H^+ rather than H_3O^+ ions.

This generalizes to other cations and also to anions. The distinction between dark anion/cation (usually proton/electron) is the boundary between non-organic chemistry and bio-chemistry.

(b) Phyllosilicates involve all biologically important ions: did their dark variants emerge already in the prebiotic phase in the interaction of water with phyllosilicate? What is this interaction? Could the process -O-H to -O^- also phyllosilicates in interaction with fourth phase of water and transform also the biologically important ions to their dark counterparts and at the same time ionize the mineral surface?

5. What makes possible coherent generation and liberation of metabolic energy? Is this a quantum coherent process or chain reaction as the model for the generation of EZ suggests or are both options realized?

6. Quantum criticality and dark variants of biologically important ions. What is the mechanism giving rise to the pairing of the biopolymers with their dark analogs at magnetic flux tubes? How dark ions such as K^+,Na^+, Ca^{++}, Cl^- are generated? Could the interaction of water with EZs provide a prebiotic mechanism for the generation of these dark ions?

7. Cell membranes consisting of double lipid layers are in TGD Universe Josephson junctions and Josephson currents between them generate Josephson radiation with energy, which is just above the thermal energy and have frequency proportional to $1/h_{eff}$ and thus give rise to classical counterpart of THz radiation known to be important in the interaction of phyllosilicates with living matter. It is known that vesicles consisting of lipid bilayers are formed in water-montmorillonite system. Could the precedessor of cell emerge in water-phyllosilicate interaction?

   Phyllosilicates appear in bi- and triple-layered structures and are semiconductors. Could they act - perhaps in presence of EZs - as high temperature superconductors in the sense that their resistance would be associated only with the ends of the "wires" (the resistance would be thus independent of length)? Could a charge separation develop in the presence of EZs so that there would be potential difference through the layered structure? Could the layers form Josephson junctions generating radiation with energy above thermal energy and frequency determined by the value of h_{eff}? The lattice spacing for layered structures is of order 1 Angstrom so that one expects Josephson energy ZeV to have order of magnitude of 10^2 eV.

8. Doped phyllosilicates are also catalysts and could have served as prebiotic bio-catalysts. A highly attractive idea is that both prebiotic molecules, atoms of various elements, and phyllosilicate crystals were trapped inside water clathrates so that all important building bricks of bio-molecules would have been automatically inside EZs after their birth.

6.3.1 How Could External Fields Induce Coherence?

By general arguments (Planck constant istoo small) the coherence induced by classical fields in visible matter is like forcing soldiers to march in the same pace and should not be regarded as a genuine quantum coherence. Quantum coherence would be at deeper level and allows to understand why the external classical field is coherent in long scales. In TGD Universe resonance frequencies of EEG etc... perform this task in brain functioning and dark EEG photons are behind EEG mediating sensory information to magnetic body and control commands back to biological body [K36]. (Quantum) criticality is the key notion: at (quantum) criticality large h_{eff} dark matter phases can appear. In applications one should try to identify quantum critical aspects of systems considered.

In TGD framework dark cyclotron photons having oscillating fields as classical correlates and with energy $E = h_{eff} \times f$ above thermal threshold would be inducers of coherence. This picture solves the kT paradox, which originally led to $h_{eff} = n \times h$ hypothesis, which can be now deduced from the number theoretic vision about TGD [K98]. Dark cyclotron photons could transform to ordinary photons in energy conserving manner and have biophotons as their decay products with energies in visible and UV range. $h_{eff} = h_{gr}$ hypothesis [K70] implies that dark cyclotron photons and therefore also bio-photons have universal spectrum reflecting the spectrum of magnetic field strengths.

The model for cell membrane as generalized Josephson junction can act also as an ordinary Josephson junction and thus allows also a piece of spectrum with Josephson photon energy coming as multiples of $E = ZeV$, V resting potential, where Z is the charge of the superconducting charge carrier. Just in the vicinity of thermal threshold for $Z = 2$ (Cooper pairs or Ca^{+2}, Mg^{+2}). Dark Josephson radiation with energies near thermal energy and with frequency inversely proportional to $1/h_{eff}$ so that arbitrary low frequencies would be obtained. These dark photons have always same energy irrespective of the value of h_{eff}.

THz/microwave frequency range is considerably below the thermal threshold for the ordinary value of Planck constant and dark Josephson photons with appropriate value of Planck constant could be transformed to these photons. The simplest transformation is the decay of the $n = h_{eff}/h$ sheeted space-time surface to n sheets each carrying ordinary THz photon. Also energy conserving decay to single photon can occur. The values of Planck constant would not be very large for THz range if Josephson photons are in question. The dark THz/microwave photons emitted by say EZs generated from atmospheric water clathrates by solar radiation could propagate through the crust along magnetic flux tubes to the underground oceans.

The basic mechanism in the interaction of dark matter with visible matter would be phase transition transforming dark photon to ordinary photon(s) in energy conserving manner. All particles can be in dark phase and this makes possible super-conductivity and superfluidity.

6.3.2 Coherence Regions And EZs

The proposal of del Giudice is that what he calls coherence regions/domains play a central role in biology and are induced by oscillating external fields by forcing units of visible matter to march in the same rhythm. In TGD framework one must take a skeptic attitude towards the existence of coherence regions postulated by del Giudice. To my best knowledge there is no direct experimental support for coherence regions and they might be identifiable as special cases of EZs.

1. EZs of Pollack are an experimental fact and are generated in presence of gel phase and incoming radiation. The open question is whether gel phase also serves as an energy source or does it have some kind of control function feeding in information. It might well be that coherence regions of del Giudice are not needed and the water clathrates serve as natural precursors of EZs. The transition *hydrogen bonded* $2H_2O \to H_3O_2^-$ + *dark proton* could be induced by UV light as breaking of -O-H bond.

   EZs carry negative electronic charge and part of protons would become dark and would be transferred to the dark magnetic flux tubes. Dark protons form sequences, which could be seen as scaled up variants of atomic nuclei in the first approximation. The states of dark proton in the model that I have proposed are in one-one correspondence with DNA, RNA, amino-acids, and 40 tRNA states [K47]. The coherence regions could be created by UV light splitting -O-H bonds and possibly also other kinds of bonds to the verge of phase transition. Later various options for the energetics of coherence regions are discussed.

   The simplest assumption is that nuclear binding energy transforms as Coulomb potential in the scaling of $h \to h_{eff}$ scaling also the system size. If so, the dark nuclear energy spectrum could be that for bio-photons and basic bio-molecules. The transformations of dark nuclei to ordinary nuclei could take place and would provide new source of nuclear power and ability to artificially generate elements: there is indeed evidence for biofusion [C3, C7].

2. If the coherence regions of del Giudice exists they must relate closely with EZs. The simplest TGD inspired analog would be as micron sized regions as regions near criticality of a phase transition of water to fourth phase of Pollack. The simplest guess is that Josephson energy

quantum for cell membrane (above $.05 \times Z$ eV) or energy quantum somewhat below metabolic energy quantum $\sim .5$ eV is needed to transform H_2O stoichiometry to $H_{1.5}O$ so that EZ would be obtained. Hence the Josephson radiation from membrane protein Josephson junctions could have a role in the control of EZs. On the other hand, the hydrogen bonds EZs with high enough bond energy would be stable against absorption of Josephson radiation and metabolic energy quanta.

The proposal is that fourth phase of water realizes genetic code at the level of dark nuclear physics and ordinary biomatter has condensed around the dark matter. DNA, etc. are paired to the dark proton sequences representing their dark variants and transcription and translation occurs at the dark level primarily and ordinary biomatter makes this visible. The recent finding that so called knocked out genes are transcribed correctly [I94] (`http://tinyurl.com/y9849jkz`) supports this view [K70].

6.3.3 Quantum Criticality Bio-Chemically

Quantum criticality [K29, K30, K31, K32] has become key concept of quantum TGD and TGD inspired biology. Quantum criticality allows to understandard the hierarchy of Planck constants and also its relationship to p-adic length scale hypothesis, whose origin reduces to number theoretic vision about TGD [K98]. 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}.

1. 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.

2. 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?

3. 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?

4. What could be the fundamental mechanism liberating metabolic energy coherently? This question will be discussed later.

The role of fourth phase of water

Pollack's EZs [L13] and fourth phase of water should be in key role.

1. EZs are generated under conditions equivalent with those prevailing in Pollack's experiments (water bounded by gel plus irradiation). Charge separation occurs: EZ is negatively charged and dark protons reside at magnetic flux tubes. This process could occur also for systems in contact with water such as phyllosilicates. Cations (in particular protons) or anions at these surfaces could be transferred to magnetic flux tubes. Dark proton sequences could realize the genetic code.

2. -O-H bond near quantum criticality would become -O^- in the formation of EZs - most naturally from water clathrates since also EZs have crystal structure. Actually much more general process can be considered: also the -O-H bonds associated with say phyllosilicates in contact with EZ could suffer the same fate. O^- appears in the phosphates associated with XTPs of DNA n and RNA nucleotides, phospholipids, and with GTPs of microtubules. Are all these O^-:s accompanied by dark proton in some spin state at parallel magnetic flux tube. In the case of DNA there should be a correlation between the code letter A, T, C, G and dark proton state. Could the 3-electron state possibly assignable to the codon be same as 3-quark state of corresponding dark proton? In particular DNA as topological quantum computer could involve pairing of dark protons associated with DNA and with phospholipids by flux tubes which can become braided.

3. -O-H bonds associated with O=C-O-H is the basic building brick of amino-acid and could make it acid that is able to donate H^+ received by water molecule becoming H_3O^+. Could amino-acid become biologically active as -O-H becomes -O^- plus dark proton at flux tube possibly defining dark proton sequences dark variant of amino-acid as dark proton sequences? Another possibility is that he phosphorylation of amino-acids brings associates dark protons with amino-acids and can even generate dark nuclei. There should be a correlation with spin state of dark proton and amino-acid side-chain if genetic code is realized.

4. There is no need to restrict this mechanism to -O-H$\rightarrow O^-$. Any chemical bond could be kicked near to criticality either by the combination of dark and p-adic phase transitions liberating zero point kinetic energy or by dark photons absorbed in the time reversal of Bose-Einstein condensation. This would allow generation of dark variants of biologically important ions by EZs associated with phyllosilicates.

One could test this vision empirically by looking whether EZs induce generation of DNA sequences or at least dehydration of DNA and checking whether EZs could stabilize DNA against hydrolysis. Also the interaction between EZs and phyllosilicates could be studied.

Simplest model for the formation of fourth phase of water

The basic ideas about quantum criticality apply to the formation of EZs and possibly existing coherence regions serving as their precedessors. The simplest model for the formation of EZs discussed in the following does not require coherence regions at all and could occur spontaneously as a chain reaction. This is what Occam's razor suggests.

The simplest option does not require pre-existing coherence regions. The basic idea is simple: radiation at visible light induces the transition $2H_2O \rightarrow H_3O_2^- +$ dark proton where water molecules are hydrogen bonded. If dark protons at magnetic flux tubes fuse to form dark nuclei, they liberate dark gamma rays. If they decay to ordinary photons with correct energy they induces further transitions which ca decay to ordinary photons. If their energies are correct they induce further transitions $2H_2O \rightarrow H_3O_2^- +$ dark proton and EZ is generated as a nuclear chain reaction.

1. $H_{3/2}O$ is stoichiometric shorthand for hydrogen bonded $H_3O_2^-$ molecule forming a loosely bound lattice structure with lattice binding energy small compared to the molecular bond energies. A pair of hydrogen bonded water molecules forming H_2O–H-O-H structure ("–" denotes for hydrogen bond) could suffer dark ionization by giving up dark proton so that $H_3O_2^-$ molecule is formed. The dark proton would be transferred to the dark magnetic flux tube. The bond energy of O-H bond is 5.15 eV (`http://tinyurl.com/yccmm7mm`) is in the first approximation the net energy needed to transform $2H_2O$ to $H_3O_2^- +$ dark proton directly. This corresponds to UV energy. This is of course extremely rough estimate.

2. The objection is that the large negative electronic charge gives the system very large Coulomb energy so that it explodes. A possible manner to circumvent the problem is that dark protons fuse to dark nuclear strings and liberate nuclear binding energy, which compensates the Coulombic energy and stabilizes the system. Dark nuclear fusion would liberate dark gamma rays decaying into ordinary photons. If the photons have energies in the range of visible and UV photons they could generate more $H_3O_2^-$ molecules and the generation of EZ could proceed as a chain reaction. Hence dark phase of protons would be generated spontaneously in accordance with NMP and the resulting phase would be stable. These photons can also induce dark ionization of other biologically important ions appearing as anions or cations.

   Dark proton sequences could also transform more complex nuclei containing dark neutrons and in TGD framework also exotic nuclei with charged bonds between nucleons are possible. The transformation of dark nuclei to ordinary ones would provide a new mechanism of nuclear fusion producing various elements outside solar core. There is indeed evidence for bio-transmutations [C3, C7]. I have discussed this possibility as a possible explanation of Lithium anomaly [L2]. One can even ask whether the prebiotic life could have generated some of the needed atomic nuclei artificially!

3. Gel phase in Pollack's experiments could provide the dark magnetic flux tubes for protons. In experiments of Urey and Miller electric discharges accompanied by magnetic flux tubes would do the same rather than providing metabolic energy as one might also imagine. This could be tested by replacing electric discharges with gel in the analogs of Urey-Miller experiments. Lightnings would have the same role in the evolution of prebiotic life. Dark flux tubes might have been associated with the magnetic fields of Earth. The endogenous magnetic field from the experiments of Blackman [J8] has value $2B_E/5$, $B_E = .5$ Gauss is the magnetic field of Earth.

Second option is that coherence regions of del Giudice are created first. A subset of -O-H bonds is first transformed near criticality by UV light with energies around 4.8 eV as coherence regions are formed. After that metabolic energy quantum kicks the molecules over the threshold for the formation of H_3O_2 and liberates about 2 eV per bond. The burst of these ~ 2 eV photons should have been detected so that this option is not plausible. There is also the problem due to the fact that two many O-Hs could be taken to the criticalityandboth -O-H bonds of given water molecule could be taken to criticality.

Could dark proton sequences at flux tubes form dark nuclei?

In TGD framework nuclei correspond to nuclear strings [**?**]onsisting of strings formed from dark protons and neutrons. Neutrons and protons could even form their own dark strings. Therefore dark proton sequences could but need not to fuse to dark nuclear strings with some nuclear binding energy and liberate the nuclear binding energy in the process.

Suppose that the fusion can occur so that a dark proton created in dark ionization is bound to an already existing dark proton sequence representing dark nuclear string at magnetic flux tube. By a naïve extrapolation the binding energy would be same as in ordinary nuclear physics and would be measured in MeV range assignable to gamma rays. This estimate is probably wrong. As already explained, the nuclear binding energy could more naturally behave as $1/h_{eff}$ - like Coulomb energy- and nuclear excitation energy spectrum would be naturally in bio-photon energy range. The situation could become analogous to nuclear fusion liberating large amounts of energy. This would conform with NMP and with the idea that formation of large h_{eff} phases occurs spontaneously.

In the case of linear structures containing -O-H sequences with small enough distance dark nuclear fusion can be imagined. Could the fusion occur at phyllosilicate surfaces and generate dark analogs of DNA codons as highly stable structures? Could the fusion occur as a chain reaction liberating large amounts of energy at biophoton energies and lead to a formation of dark proton sequences with some maximum length dictated by Coulomb repulsion?

Could DNA nucleotides associate with these dark codons? If O^- associated with phosphates inside cell nucleus can can combine with ordinary protons the hydrolysis of DNA can occur inside nucleus. The pairing of DNA and dark proton sequence by connecting magnetic flux tubes could prevent hydrolysis.

One prediction would be that the negative charge of DNA (one units per single nucleotide) is screened by dark proton sequences in vivo in the scale of the system formed by DNA and dark proton sequence. Usually it is believed to be screened by Na^+ counter ions. If the distance between DNA and dark proton sequences is large enough, a local screening by Na^+ counter ions can indeed occur. What happens inside cell nucleus is far from clear to me.

Could dark nuclei collapse to ordinary nuclei?

One can also wonder whether the phase transition $h_{eff} \to h$ could produce ordinary nuclei and liberate energy in nuclear energy range. Could living matter be at criticality against nuclear explosion? The occurrence of bio-transmutations has been indeed claimed [**?**] This possibility would mean a way to generate both nuclear energy and generate artificially those elements, which are depleted.

The observation that the isotope ratios reported to appear in the cold fusion experiment of Andrea Rossi are the natural ones (`http://tinyurl.com/yd8wka4w`) has been used to claim that the E Cat reactor developed by Rossi [**?**]s fraud. Lithium anomaly however forces to ask how large fraction of ordinary matter emerged via dark fusion in interstellar space, and how large fraction was generated in the stellar cores. Could even the fusion in stellar cores have occurred as dark fusion at magnetic flux tubes followed by a phase transition to ordinary matter?

One can argue that since the increase of h_{eff} and generation of negentropic entanglement (NE) occurs spontaneously, the fusion to ordinary nuclei must be a rare process. NMP suggests strongly that the existing NE must be transferred from the dark nucleus - magnetic flux tube - shortening to ordinary nuclear string in $h_{eff} \to h$. If this NE is associated with the transversal flux tubes connecting dark protons of the nuclear string with other similar system, the transfer could take place by reconnection of flux tubes with those of second analogous system (the model for DNA as TQC assumes that flux tubes connect dark protons assignable to DNA codons and lipids of nuclear/cell membrane [K2]). The transfer of single transversal flux tube connecting A and B to that connecting C and D would require two reconnections: AB+ CD$\to$ AC+ BD $\to$ AB+CD. CD would have no NE in the initial situation and would have that of AB in the final situation whereas AB would have no NE. The probability that all flux tubes are doubly reconnected within a reasonable time span is expected to be small and only light nuclei might be generated. The occurrence of biofusion however suggest that this objection might be circumvented in some quantum critical situations.

Decay of very energetic dark photons to low energy photons

It is known that X and gamma rays accompany lightnings (`http://tinyurl.com/cr5e6tz`). This is impossible in standard physics since X and gamma rays should be absorbed in atmosphere. I have proposed that this radiation as also the radiation at lower energies propagates along magnetic flux tubes as dark photons.

Suppose that dark proton sequences indeed fuse to dark nuclei and liberate large amount of energy in the process as dark analogs of gamma rays but possibly much lower energy in the energy range of dark bio-photons and possessing much longer wave-length than usually. These dark photons can decay to ordinary photons and an interesting possibility is that this range includes visible photons (bio-photon energy range is a good in lack-of-anything-better-guess).

Could this decay promote the visible light promoting the generation of EZ? If this were the case the formation of living matter could take place as a chain reaction as NMP encourages to think. Similar chain reaction could have taken place also in prebiotic circumstances, where lightnings could have provided the initiating photons and perhaps also dark photons in dark nuclear binding energy range decaying to visible photons initiating the process. Same could have happened in Urey-Miller experiments.

Anomalies possibly related to EZs

There are several anomalies which might allow explanation in terms of EZs.

1. Tesla studied what happens in di-electric breakdown and was perhaps the first experimentalist to discover dark matter. Critical phenomenon is in question and could in TGD Universe

be accompanied by the formation of dark matter - perhaps even dark nuclear matter accompanied by liberation of energy. Also dark radiation with wavelengths proportional to h_{eff} making possible long range communications and energy transfer could be involved [K7]. The most fascinating phenomenon reported by Tesla was charge separation in length scales much longer than one might have expected and could directly reflect the generation of dark charged particles.

2. The article of Kanarev and Mizuno [D13] reports findings supporting the occurrence of cold fusion in NaOH and KOH hydrolysis. The situation is different from standard cold fusion, where heavy water D_2O is used instead of H_2O. I have considered this finding in [L2]. Obviously the mechanism generating dark proton sequences as dark nuclear fusion could explain the findings of Kanarev and Mizuno.

3. The irradiation of salt water with microwaves induces the "burning" of water with a visible flame [D1]. The phenomenon is believed to involve the breaking of salt water into oxygen, hydrogen and salt. If EZ is formed this could mean formation of H-O-H–$OH_2 \rightarrow H_3O_2^-$ + dark proton. Nuclear fusion need not be initiated since polymer structures are absent. The burning process could be induced by microwaves accompanied by dark photons having energy in the energy range of UV photons and transforming to UV photons.

4. Free energy anomalies are not taken seriously by the main stream since they are not consistent with energy conservation in standard physics framework. I have proposed they they could be understood in terms of generation of dark proton sequences and cold fusion liberating energy [K84].

   The so called Brown's gas [H2] (might be same as fourth phase of water) produced from water by electrolysis is reported to be able to melt metals at much below the melting temperature. The explanation would be that the presence of metal initiates transition to ordinary nuclei liberating nuclear energy. The original explanation was quite not like this [K84] although the energy was assigned with dark proton sequences. Another interpretation is that the process generating dark proton sequences continues.

5. There is also analogy of charged water clusters (EZs) with two poorly understood phenomena: steam electricity [H4] (`http://tinyurl.com/y977k2es`) and waterfall ionization. Also thunder cloud charge separation and sonoluminescence might involve the formation of charged water clusters.

How biosystems could control protein dynamics?

Hans Frauenfelder *et al* propose a unified model of protein dynamics based on experimental findings [I79]. The key proposal is that protein dynamics is slaved by the hydration shell and by the bulk solvent. The dynamics of master should be slower than that of slave. The conformational motions of proteins have time scale in the range 1 ns-1 s. The frequencies corresponding to the splitting of hydrogen bonds are above 10 THz and hence splitting dynamics is faster than protein dynamics. Therefore the claimed master-slave relation looks strange at the first glance. One can however think that the cleaving of hydrogen bonds defines the control dynamics as dynamics of switching and is much faster process than processes occurring between switchings. Changing the position of switch would correspond to a catastrophe in catastrophe theoretic formulation. The dynamics at a given sheet of catastrophe is indeed slow except at the critical lines defining its boundaries [A11].

This suggests that various phases of water define environments for water controlling the behavior of proteins. If the phase is hydrogen bonded water clathrate, the protein finds itself inside "ice" layer and cannot move. Protein folding would represent a basic example of this situation. When the hydrogen bonds disappear due to the melting of the EZ around protein by the splitting of protein-water and water-water hydrogen bonds, protein becomes able to change its conformation and protein un-folding can occur. The "ice" layer around protein can melt by the feed of external energy at energies below metabolic energy quantum. This radiation could arrive as dark photons from dark magnetic body decaying into bunches of ordinary photons with same frequency and inducing fast melting of the entire layer. The bulk solvent could control large scale

protein motions by changing the viscosity achieved by modifying the density of hydrogen bonds. Protein would move in the direction where the resistance is smallest.

In ZEO the reverse process would correspond to melting but in non-standard time direction. One can interpret the situation also in terms of consciousness theory. The period between folding and unfolding would define self and the control action would generate the time reversal of self.

But "who" is the master? In TGD framework it would be naturally the dark magnetic body containing at its flux tubes dark proton sequences associated with proteins. The motor actions of the magnetic body would induce those of proteins. The only condition is that the inherent protein dynamics is fast enough to follow the dynamics of water. The fingerprints of biomolecules are in energy region .05-.25 eV (this is also the energy range for hydrogen bond energies) and the frequencies are above 10 THz. Therefore the time scales of protein dynamics would actually reflect those of dark magnetic body.

The modelling of protein folding as a random process in which system tries all options and ends up to the bottom of potential well representing the final configuration has problems: the basic paradox is that the folding should take extremely long time. If protein folding is macroscopic quantal self-organization process governed by NMP in present of large h_{eff} phases, these problems might be circumvented. Folding could to high extent reduce to the folding of the underlying magnetic flux tube structure: proteins would follow automatically if they are surrounded by the "ice" layer of ordered water.

The following considerations provide additional insights in the attempts to build a model for protein folding. There is a new observation (`http://tinyurl.com/ycqkx9mu`) about protein folding process. During folding some proteins hold single building blocks in shapes that were thought to be impossible to find in stable form. Stable shapes contained some parts, which were trapped like mosquitos in amber.

A concrete TGD based model relies on the general ideas of TGD inspired quantum biology.

1. Biomolecules containing aromatic rings play a fundamental role. All DNA nucleotides contain them and there are 4 proteins, which also have them. trp and phe are of special importance and form a pair structurally analogous to a base pair in DNA strand. The rings are assumed to carry the analog of supra current and be in or at least be able to make transition to a state with large $h_{eff} = n \times h$. The delocalization of electron pairs in aromatic ring could be a signature of $h_{eff}/h > 1$.

2. trp-phe pairing would be responsible for information molecule-receptor pairing. Information molecule and receptor would be at the ends of flux tubes serving as communication lines, and the attachment of info molecule to receptor would fuse the two flux tubes to longer one. After that communication would become possible as dark photon signals and dark supra currents. Formation of info molecule-receptor complex would be like clicking icon generating a connection between computers in net. Info molecules would generate the communication channels - they would not be the signals. This is the distinction from standard neuroscience.

3. All quantum critical phenomena involve generation of large h_{eff} phases. Folding emerges or disappears at quantum criticality (QC) possible in certain temperature range of width about 40 K and depending on pH. The flux tubes associated with phe and trp containing aromatic rings carrying "supra current" would become dark (either $h \to h_{eff}$ or $h_{eff} > h$ increases) and thus much longer and reconnect temporarily and force phe and trp in a close contact after the reverse transition inducing shortening. This is a general mechanism making biomolecules able to find each other in what looks like molecular soup in the eyes of standard biochemist. The contacts between amino-acids phe and trp formed in this manner are structurally identical with the hydrogen bonding between members of DNA base pairs and they would fix the final folding pattern to high degree.

There was also a very interesting article (`http://tinyurl.com/y8foh93b`) about possible topological phenomena related to protein folding. Authors are Henrik and Jakob Bohr (akin to Niels Bohr?) and Sören Brunak.

The article explains the basic topological concepts like winding possible involved in protein folding in a simple manner. The proposal is that the excitation of so called wringing modes of proteins are involved in the generation and disappearance of the protein folding. Excitation of

wringing modes twisting the protein (think about how one wrings water from a wetted cloth) would make the protein folding state *cold denatured* (CD) unstable and transform in to a stable *folded* (F) state. In the same manner their excitation would transform *hot denatured* (HD) stable state to a *folded* (F) state. Wringing modes could be excited by radiation.

In TGD framework the folding phase diagram CD-F-HD could be understood also in terms of QC. Perhaps the simplest option is that the transitions CD-F and HD-F involve a generation of critical states leading to a generation of long range correlations (large h_{eff}) inducing the folding pattern. Absorption of photons to wringing modes would induce the criticality and the folding would proceed by the mechanism discussed above.

Relationship to DNA as topological quantum computer hypothesis

DNA as topological quantum computer (TQC) hypothesis [K2, K96] emerged roughly decade ago. The basic idea is that DNA and lipid layer of nuclear membrane are connected by magnetic flux tubes. Also connections to cell membrane and membranes of the other cells are in principle possible. The braiding of the flux tubes induced by the flow of lipid layer in liquid crystal (LC) state makes possible topological quantum computations. Similar topological quantum computations could be associated with the system formed by microtubules and axonal membranes.

A more general idea is that flux tubes are analogous to coordinate lines of 3-D coordinate grid forming a backbone of the organism [K74] implying that the morphogenesis of magnetic body would induce that of visible part of organism. For instance, each DNA codon could be accompanied by flux tubes parallel to DNA plus flux tubes in two orthogonal directions perhaps connecting DNA to the lipid layers of nuclear membrane. The orthogonal flux tubes could emanate from the dark protons associated with the phosphates of the strands.

One can imagine several identifications for the particles involved with the topological quantum computation. The basic condition is that DNA codons or codewords are represented in terms of dark variants of some particles.

1. If one assumes that individual nucleotides (A,T,C,G) are involved, it is natural to assume that the particles involves correspond to these in 1-1 manner. The realization discussed in [K2] assume that the codons correspond to the 2+2=4 spin states of u and d quarks and anticodons to corresponding states for antiquarks. The quarks would be of course dark to avoid annihilation. One can also imagine realizations in terms of $3+1 = 4$ spin states of pairs electrons associated with a pair of flux tubes connecting DNA nucleotide and lipid layer.

2. If the codewords of the genetic code formed by three codons are taken as basic units then the states of the particles used must correspond to 64 DNA codons. RNA nucleotides and amino-acids could also involve analogous flux tubes beginning from the paired dark protons. The obvious choice at DNA end are those dark proton states, which correspond to 64 DNAs. At the lipid end the dark proton state would be fixed by base pairing condition.

   An interesting question is whether phospholipid states can be said to be coded by DNA codons (surjective many-to-1 map of DNAs to lipid states). This question is quite general: is the possible DNA dark proton-biomolecule correspondence surjective so that genetic code would be much more general than thought.

   Hu and Wu [J18] have observed that proton pairs with members at opposite sides of cell membrane have spin-spin interaction frequencies in ELF scale. The TGD inspired the proposal [K22] was that the protons are dark and form sequence at both sides of the lipid layer.

6.4 Some Phenomena Discussed By Geesink From TGD View Point

In the sequel some of the numerous phenomena discussed by Geesink are considered from TGD point of view with emphasis on phyllosilicates and possible mechanism behind their positive health effects.

6.4.1 What Phyllosilicates Are?

Silicate minerals (http://tinyurl.com/y9pb2hrs) constitute approximately 90 per cent of the crust of Earth. Quite generally, these minerals contain Si, O and almost any other element typically serving the role of cation in covalent bond. One can get an idea about the valence bond structure of the silicate mineral by using the familiar octet rule demanding full shells for anions. Typically one has SiO_4^{-4} tetrahedra as basic anion connected to 4 cations - in particular Si which can serve as both cation and anion. Note that for purely geometric reasons tetrahedra cannot form an infinite sized regular crystal. Quartz obeying chemical formula SiO_2 is the most well-known and simplest silicate mineral. There exist 6 different groups of silicate minerals and phyllosilicates are one of them.

Phyllosilicates (http://tinyurl.com/y9enuwfs) are sheet silicates formed from parallel sheets of silicate tetrahedra with Si_2O_5. All phyllosilicate minerals are hydrated with either water or hydroxyl (O=COH)groups attached. This makes them biologically especially interesting. There are four groups of them: serpentines, clays, micas, and chlorites ("chlorite" has nothing do with Cl). The characteristic property is -O-H group and is expected to be of special interest biologically. There are also other silicate minerals which can contain -O-H groups but only phyllosilicates contain them always.

One highly interesting property of phyllosilicates is that they are natural semiconductors. Semiconductors or even semi-superconductors are highly interesting biologically: consider only the pioneering work of Becker with DC currents [J7] discussed in [K76] and the recent work of Bandyopadhyay's group with microtubular semiconduction [J15, J4]- or maybe even "semi-superconduction") discussed in [K78, K74].

Geesink *et all* have used various dopands on silicate semiconductors and have found that the dopand ions have characteristic biological roles. Frequency mapping of the silicate semiconductors is carried out, and even storing frequencies to semiconductor materials has been found to be possible. This brings strongly in mind the work of Cyril Smith [I55] and the notion of water memory based on frequency storage discussed in [K47]. Also the presence of cyclotron frequencies associated with the "endogenous" magnetic field $B_{end} = .2$ Gauss first discovered by Blackman [J8] and other pioneers of bio-electromagnetism (discussed in [K69]) has been found and also evidences for multiples of basic frequencies coming as powers of 2 and 3 suggesting that the Pythagorean scale coming as quints (powers of 3/2 projected to the basic octave) might be fundamental in biology as proposed in the model of harmony in 12-note scale generalizing to a model of genetic code and suggesting that the 3-chords of so called bioharmonies with 64 basic chords are fundamental in living matter and realized also in terms of dark photons [L11] [K77].

6.4.2 Some Effects

Many of the effects listed by Geesink have not caught my attention and it is interesting to look whether they might allow to sharpen TGD based vision discussed above.

1. Phyllosilicates are natural semiconductors and reported to be able to store frequencies, which brings in mind water memory [K47]. Cyclotron frequencies assignable to magnetic field strength .2 Gauss are assigned with them and Geesink claims evidence for a Pythagorean spectrum of frequencies coming as power of 2 and 3 multiples of the fundamental frequency.

2. Phyllosilicates generate also THz/microwave radiation having biological effects. Frequency matters instead of amplitude, which is very weak. Thus the effect looks quantal. There are both frequency, temperature, and amplitude windows. The energies of this radiation are below thermal energy so that one encounters what might be called kT - paradox if one wants to understand the effects quantally.

3. Phyllosilicates are used in a form of cation exchanged silicate sheets as catalysts, which suggests that they might act also as prebiotic catalysts. They are also used in nano-technology as nano-materials, nano-wires and patterned surfaces in nano-biological devices. Andrew Adamatsky has developed a model of cellular automation based on oscillators in phyllosilicate excitable automata [I44] (http://tinyurl.com/y7kbszgj).

This dark irradiation could induce plasma oscillations with electron density of one electron per volume with scale of about 1 Angstrom perhaps applying in the case of EZs giving frequency $\asymp$ 9 THz, which corresponds to .03 eV slightly below the thermal energy and the energy of cell mambrane Josephson junction. It could also induce transitions between Rydberg states possibly present in living matter. For hydrogen atom THz radiation would induced transitions between states with principal quantum numbers $n, n+1$ for $n \geq 10$, which corresponds to atomic radius about 10 nm, cell membrane thickness. THz/microwave radiation could also induce transitions of proteins and interaction with water clathrates.

TGD based explanation would be based on following basic ideas.

1. Quantum criticality occurs only for some critical ranges of parameters and could provide a generic explanation for the amplitude and temperature windows. Frequency windows in the case of cyclotron frequencies could be due to the windows for magnetic field strengths due to quantum criticality with respect to the generation of supra currents.

2. Large h_{eff} radiation with quanta having energies above thermal threshold and frequencies in THz/microwave range would induce classical coherence at the level of visible matter. Weak external em signal generates coherence - classical and perhaps even quantum mechanical. One can ask whether the emergence of coherence in mechanical systems could be induced in this manner.

3. Bose Einstein condensates and super-conductivity are speculated to be present. In TGD framework it would be enough to have BE condensates for cyclotron radiation and that in coherent oscillation modes proposed by Fröhlich would not be necessary. A storage of metabolic energy to cyclotron Bose-Einstein condensates could take place.

4. The EZs of Pollack would have natural description in TGD framework and would be analogs of electron plasmas. The coherence regions proposed by Del Giudice have much weaker experimental status. One should understand the formation of EZs and how the water molecules make coherently a transition from $2H_2O$ to $H_3O_2^-$ + dark proton in EZ, and how this state can be stable despite its large negative charge due to charge separation. If coherence regions exist it is natural to assume the they are precursors of EZs. To my opinion water clathrates are however more feasible candidates in this respect.

5. Phase transitions increasing h_{eff} by a power of 2 following by a compensating phase transition reducing h_{eff} back to 2 by increasing the p-adic length scale by the same power of 2 so that the expanded volume is not affected could create Rydberg states from states with low principal quantum number. The transition should respect rotational symmetries.

Davydov soliton propagating along protein as a kind of acoustic wave is classical candidate for biologically important excitation possibly coupling with THz/microwave radiation. Microwaves are strongly absorbed by atmosphere which would mean that they can be important only inside organisms whereas dark cyclotron radiation with EEG frequencies could have wave lengths of order Earth size scale or even large. Also the magnitude of quantum very small as compared to thermal energy.

6.4.3 Plasma Waves And Acoustic Oscillations

Geesink emphasizes the importance of plasma oscillations in THz/microwave range [L18]. Plasma frequency is analogous to cyclotron frequency in that it that it is purely classical notion. The fact that they are longitudinal oscillations suggets that they are not so fundamental as cyclotron radiation although also now energies would be proportional to h_{eff} and could be in bio-photon range. The plasma frequency is proportional to $e \times \sqrt{n/m}$ and cyclotron frequency to eB/m. Also the appearance of electron density also implies that plasma oscillations are not so fundamental as cyclotron radiation. Also the appearance of electron density also implies that plasma oscillations are not so fundamental as cyclotron radiation. For water with 1 electron per two water molecules (EZ) one would obtain 2.4 THz frequency assuming density of water.

Plasma oscillations require the presence of ionic lattice characterize ordinary biomatter. For dark matter at flux tubes only 1-D lattice structure can be imagined. Plasma oscillations might

therefore belong to the classical part of the biophysics like biochemistry. They would be subject to control from magnetic body. Dark photons with energies above thermal threshold can induce plasma oscillations by inducing the plasma oscillations resonantly if h_{eff} has proper - rather small - value.

One of the open questions has been whether there are also the analogs of bio-photons in IR above thermal threshold. Cell membrane would radiate generalized dark Josephson photons with energies $E = \Delta E_c + E_J$. ΔE_c is difference between cyclotron frequencies associated with flux tubes at different sides of cell membrane and corresponds to an energy in visible-UV range if $h_{eff} = h_{gr}$ hypothesis [K70] holds true.

Typically the energy range would be that for cyclotron photons and in visible and UV but in special case one would obtain ordinary Josephson photons with energy spectrum $E = ZeV \sim Z \times .05$ eV just above thermal energy and frequencies about $(12 \times Z/h_{eff}$ THz. This is above THz/microwave region for ordinary value of Planck constant. Relatively small values of $h_{eff} = n \times h$ would give frequencies $f = E/h_{eff}$ in these regions. This part of the Josephson radiation from cell membranes acting as ordinary Josephson junctions and could induce plasma oscillations among other things.

Also the decay of dark photons to ordinary photons could be considered and is suggested by the n-sheeted covering of the space-time sheets associated with $h_{eff} = n \times h$. Therefore also energetic effects could below thermal energies could be achieved besides frequency based effects represented by the coupling with acoustic oscillations and plasma oscillations.

The description of plasmons in many-sheeted space-time of TGD Universe is a demanding challenge. Electrons of plasma wave correspond to different space-time sheets than the ionic lattice. Electrons experience the ionic em fields and the field created by electrons themselves at ionic space-time sheet through wormhole contacts to the space-time sheet of ions. Only the ions not screened by electrons contribute. The challenge is to understand how electrons are able move coherently. Does this require coherence in micron scale and is this coherence forced by the presence of dark matter? In any case, the fundamental description should be in terms of magnetic flux tubes and massless extremals (MEs, topological light rays). The usual description is an approximation obtained by lumping together the sheets of many-sheeted space-time to single sheet and describing the interaction of test particle with induced fields at space-time sheets using standard model.

6.4.4 The Transformation Of Dark Photons To Phonons And Plasma Oscillations

The transformation of dark photons to dark photons and plasma oscillations could take place and transform macroscopic quantum coherence to classical coherence at the level of visible matter.

1. The transformation of both ordinary dark photons to dark phonons and maybe even dark plasmons can be considered. The dispersion relations in the case of phonons are of same form but velocities differ dramatically. Energy and momentum conservation plus gauge invariance fixes the transformation amplitude essentially uniquely. Simplest process is 2 photon$\leftrightarrow$ 2 phonons such that phonons have in excellent accuracy opposite 3-momenta. The amplitude is in relativistic notation proportional to $k^1_\mu F^{\mu\beta}(a) F^\nu_\beta(b) k^2_\nu + (1 \leftrightarrow 2)$, here k^i denotes the momentum 4-vector of phonon and $F(a/b)$ denotes the electromagnetic field tensor assignable to the the photon a/b. Similar expression should apply in the case of plasmons.

2. Cyril Smith talks about what I see as different phenomenon in which low frequency em signal is transformed to high frequency signal with much lower frequency [I55] [K47]. A favored frequency ratio is reported to be $f_{high}/f_{low} = 2 \times 10^{11}$.

   I have considered a TGD based description based on the transformation of dark photons with low frequency but high energy $E = h_{eff} \times f_{low}$ to ordinary photons having $E = \times f_{high}$ [K47]. Smiths's findings suggest a favored value $h_{eff}/h = f_{high}/f_{low} = 2 \times 10^{11}$. Also bio-photons in visible and UV range would be ordinary photons resulting from dark photons in this manner. This suggests that the deeper description of the coherence is as quantum coherence induced by macroscopic coherence at the level of dark matter. Dark matter would control ordinary matter by forcing it to oscillate coherently.

3. Dark photons, phonons, plasmons, etc.. would appear at quantum criticality and this gives an important guideline in the attempts to construct models.

6.4.5 Why Do Phyllosilicates Have Positive Health Effects?

The article of Geesink contains a long list of positive health effects due to the presence of phyllosilicate minerals. Water clathrate structures are stabilized; formation of oligomers is catalyzed; silicate minerals have sequence-, regio-, and homochiral selectivity; they absorb nucleic acids on the mineral surfaces (prebiotic habitats); they catalyze vesicle formation; they protect DNA against X-ray and UV; they protect adenine exposed to gamma radiation.

1. The transformation of X-ray, UV, and maybe even gamma radiation (emitted in the possible formation of dark nuclear strings at magnetic flux tubes) to low frequency dark radiation at magnetic flux tubes and therefore having no direct interaction with DNA is one possible mechanism. Absorption of nuclei acids and catalysis of oligomers could be essential for the transfer of dark genetic code to ordinary RNA by pairing the flux tubes containing dark proton sequences with RNA sequence. This could be exchange of the dark proton flux tube. In the case of anionic structures this could be understood if fourth phase of water is involved as dark photons at the flux tubes of the magnetic body generated as the silicate mineral was formed.

2. The presence of say silicate minerals, also quartz, in living matter could strengthen the cyclotron resonances if weak for some reason - say by the interaction with man-made random radiation tending to destroy the effects of coherent behavior induced by dark photons. The magnetic body of the organism could be somehow damaged (health would be also health of magnetic body!) and unable to carry out the biocontrol. Phyllosilicates (for instance) would strengthen the dark photon radiation responsible for the control.

3. What about the positive biological effects of quartz crystals? Quartz does not have structural negative charge since it obeys effective chemical formula SiO_2. As found, charge neutralization at the boundary of quartz crystal is still needed and O^-:s at the surface could be replaced with -O-Hs. The presence of EZs could induce the transition back to O^- and generate dark proton so that also now dark magnetic body, dark cyclotron radiation, and even the analogs of bio-molecules as dark protons sequences could be present.

The picture becomes more attractive if one assumes that silicate minerals are accompanied magnetic flux tubes carrying dark nuclei and representing prebiotic phase. Ordinary DNA, etc could have emerged as a more faithful representation of dark genetic code by EZ mechanism generating also magnetic body for DNA. Ontogeny recapitulates phylogeny principle applied to silicates and bio-molecules would suggest that silicate minerals interact with DNA via dark matter.

6.5 Basic TGD Based Vision About Prebiotic Evolution

The fact that phyllosilicates generated in the interaction of water and silicate minerals have positive health effects suggests that they have played an important role in prebiotic evolution. There is indeed a lot of evidence to this direction coming from other sources: phyllosilicates allow adsorption of nucleotides and amino-acids, favour their polymerization, and induce the generation of lipid vesicles serving as precedessors of cell nucleus.

My own highly non-orthodox proposal [L46] is that prebiotic and even biotic lifeforms evolved in underground oceans, where UV radiation meteoric bombardment was absent. They were burst to the surface of Earth in Cambrian explosion in rapid expansion of Earth (cosmic expansion should take place as rapid phase transitions instead of smooth expansion - this is consistent with the fact the sizes of astrophysical objects are not observed to steadily increase). Basalt would have provided the silicate minerals having also dark magnetic bodies in presence of water and EZs. Chondrites from outer space contain basic bio-molecules and Earth has been formed from chondrites: therefore basic biomolecules would have also been present.

One prediction relates to the question about how oil and coal were formed (`http://tinyurl.com/dyjmmw2`. Two competing theories about the origin exist (`http://tinyurl.com/863hucw`).

1. The dominating theory assumes a biogenic origin of petroleum and coal (http://tinyurl.com/dyjmmw2, and states that they are produced from the organic material at the surface of Earth. At the dry land peat is formed first and later transformed to coal under heavy pressure. Coal it is transformed to oil and transferred to towards surface of Earth. Analogous process process would have occurred at the bottom of ocean: organic material would have formed sediments and these lose gradually contact with oxygen. This would induce transformation to coal with a very slow rate. A strong support for biological origin is the presence of complex aromatic biomolecules such as porphyrins assignable to basic metabolic mechanisms - in particular photosynthesis.

2. Second theory assumes abiogenic (one might say geological) origin so that the term "fossil fuel" would not be appropriate. Methane and simple hydrocarbons would have been present inside the mantle. This kind of hydrocarbons are encountered in chondrites, which have probably served as building bricks of Earth. Methane appears also at other planets. The presence of complex biomolecules in oil is the problem of the abiogenic model, and one must assume that they appeared to the oil as it was in contact with ordinary biological matter.

   This model model however provides a more convincing explanation for the isotope ratios of oil than biotic theory. The ratios would correspond to those in magma and chondrites and also metallic and isotopic compositions are explained (at the surface of earth interaction with cosmic rays affects the ratios so that one can distinguish between the two models). Also the presence of He can be explained. The model also predicts that oil and coal fields are large scale structures and oil and cola should appear also in non-sedimentary rocks. These predictions are correct.

Both theories have strong and weak points and both mechanisms might be involved. TGD suggests a modification of the abiogenic theory. Petroleum and coal could be produced from prebiotic and even bacterial lifeforms living in the mantle and their presence could explain the origin of the oil and coal at least partially. This would resolve the problem of both options. Of course, both this and standard mechanism could be involved.

6.5.1 Basic Challenges

The concretization of this vision involves several challenges.

1. One must find whether the abundances of biologically important elements in Earth's mantle are consistent with those in living matter. This will be discussed later.

2. Electric discharges were present in Urey-Miller experiments. What could have been their function? The first guess is that they provided energy. Second guess is that they provided (also) magnetic flux tubes for dark protons to be transferred to form dark nuclei. Did lightnings serve the same function during prebiotic era? Did gel phase in Pollack's experiments perform the same function. Of course, lightnings could have provided also the UV light initiating the chain reaction generating EZ.

3. Ordinary solar radiation would have been absent. What served as the source of metabolic energy? How photosynthesis could have emerged? There are several options that one can consider.

   (a) The key observation is that the recent temperature in Earth's core is near to the metabolic energy quantum: .44 eV. The temperature of solar radiation about .58 eV! Could prebiotic life have emerged near the core and emerged to the surface in volcanic eruptions? Could dark photons from the core been able to propagate to underground oceans and provide the metabolic energy inducing the formation of EZs? Could highly developed lifeforms able to carry out photosynthesis have burst to the surface of Earth in Cambrian explosion?

   (b) Dolar radiation transformed to dark photons in the EZs associated with the water clathrates in atmosphere and propagated along dark flux tubes to the underground oceans.

(c) If the generation dark nuclei liberated binding energy at bio-photon energy range, dark nuclear energy could have made prebiotic life independent of external energy sources.

4. Atmosphere would have been absent. This need not be a shortcoming: there would be no UV radiation and no meteoric bombardment. In the experiments of Miller utilizing simple precursors like NH_3,CH_3 in presence of water and simulated lightnings reducing atmosphere was essential for obtaining amino-acids in experiments (http://tinyurl.com/ycz6gtu8). Adenine, which is building brick of ATP, was formed when a system consisting of HCN and NH_4OH and montmorillonite was exposed to electric discharge. It is now however thought that the atmosphere was oxidizing, which supports the view that prebiotic life developed underground.

   Could an environment containing water and phyllosilicates have provided the counterpart of reducing atmosphere? Wikipedia tells that reducing molecule in reaction donates electrons and oxidizing molecule receives them. (http://tinyurl.com/q5g672s). Basic biologically important atoms (H,K,Na,Ca,Mg) are electron donors and reducers and Cl is oxidizer. In oxygen rich atmosphere Oxygen is oxidizer. For instance, montmorillonite contains all above mentioned reducing ions. Maybe phyllosilicates could provide the counterpart of reducing atmosphere their de-adsorbtion from the mineral surface in atomic form occurs with a considerable rate.

6.5.2 Are The Abundances Of Biologically Important Ions Consistent With Their Abundances In Earth's Mantle?

One possible objection is that the abundances of various biologically important molecules are different in the Earth's crust and in (say) human body (http://tinyurl.com/p3vse). The average abundances of carbon, nitrogen, carbon, sulphur, chlorine, phosphorus are considerably lower in the Earth's crust than in human body. These data are about Earth's crust. The problem disappears if the prebiotic evolution has taken place at special sites, perhaps even below crust.

1. Nitrogen is trace mineral in Earth's crust (3.3 per cent in human body). The low abundance is probably due to the degassing to the atmosphere. In mantle the concentration of nitrogen could have been much higher and in underground oceans a kind of nitrogen cycle might have been establishes. It is known that the N_2 in atmosphere originates from regions of the Earth where plates are converging. In Venus and Mars there is no plate tectonics and therefore a lack of N_2. The obvious guess is that the rapid expansion of Earth radius by factor two generated the plates during Cambrian explosion and the nitrogen which was in underground oceans aqueous ammonium NH_4^+ was degassed (http://tinyurl.com/ya36k9zl).

2. What about carbon (.03 per cent in crust and 18.5 per cent in human body), which is also a key element of life. The positive surprise is that the vast majority of carbon resides in the deep Earth, below the surface, maybe 90 per cent of it. http://tinyurl.com/cg83zv7. Most of carbon is in form of diamonds and not biologically interesting. There is however evidence that methane CH_4 is formed in the upper mantle 100-300 km below the 5-70 km thick crust (note that mantle is about 2900 km thick) (http://tinyurl.com/ybzgx325). This has inspired speculations about new sources of oil replacing the fossil fuels. To me the more interesting possibility is that the life could have develop below crust.

3. One can worry also about Cl^- (0.01 per cent in crust and .2 per cent in human body). The web search suggests that the situation about the content of Cl^- in mantle is not settled. I also understood that the abundance of Cl^- is not constant in mantle. What comes in mind that Cl^- is solved into the water reservoirs to form HCl. Cl abundance is higher in the oceans at the surface of Earth than elsewhere.

As already noticed, the proposed mechanism for the formation of EZs generates dark proton sequences having interpretation as dark nuclei. These could suffer dark beta decay to more complex nuclei and dark nuclei could transform to ordinary nuclei. There is evidence for bio-transmutations [C3, C7]. Could this allow the prebiotic life to generate some of the needed atomic nuclei artificially?

6.5.3 The Energetics Of EZs

The above described mechanism for the generation of EZs involves the creation of dark nuclei as sequences of dark protons liberating nuclear energy compensating for the electronic Coulomb repulsion can occur as a chain reaction if the distances of linear molecules containing -O-H structures have such distances that the dark nuclei can form. The liberated dark gamma rays should decay to bunches of ordinary photons inducing *hydrogen bonded* $2H_2O \rightarrow H_3O_2^- +$ *dark proton* and would care that the process continues as a chain reaction.

Contrary to the first guess, gel would not serve as an energy source but provide magnetic flux tubes at which the dark protons can condense. Also the electric discharges in Urey-Miller experiment would have this function. Lightnings are known to be accompanied by gamma rays and extremely energetic electrons. In TGD Universe this requires darkness and magnetic flux tubes. Same should be true also for electric discharges, which are indeed a critical phenomenon. Could the dark flux tubes associated with lightnings penetrate below the Earth's crust? There seems to be no obvious argument against this - the very definition of darkness suggests this.

The dark ionization of also other than -O-H bonds is possible in presence of EZ by the decay of dark gamma rays to ordinary photons and it is possible to generate dark variants of biologically important ions. One cannot however expect formation of the analogs of dark nuclei for sequences of heavier dark ions nor for dark electrons. They might be generated from phyllosilicates such as montmorillonite as dark ions. The presence of water could be enough for this.

6.5.4 The Role Of Phyllosilicates

Phyllosilicates are formed in the weathering of volcanic glass and rocks. Water in contact with volcanic glass and rocks produces clay minerals. This could also occur also in underground oceans without the presence of the atmosphere. How phyllosilicates in presence of water (and generated by the presence of water from simpler minerals) might help to achieve during prebiotic evolution? It is known that phyllosilicates adsorb amino-acids and RNA and induce their polymerization. Montmorillonite induces also the formation lipid miscelles serving as precedessors of cell membranes.

A TGD inspired vision about the role of phyllosicilicates

If TGD view is correct, phyllosilicates in presence of water and EZs plus metabolic energy source allowing their generation might have additional functions.

1. Phyllosilicates contain -O-H:s as a basic building brick and the transformation -O-H $\rightarrow$ -O^- plus dark proton is highly suggestive in the presence of EZs. This would help to generate dark proton sequences assignable to the boundaries of phyllosilicates providing the analogs of basic bio-molecules DNA, RNA, and amino-acids, and possibly realizing a very simple variant of genetic code in the sense that dark proton state correlates with the anion created.

   The dark proton sequences would be probably rather boring if the spin state of dark proton correlates strongly with the site, where it came from. This mechanism is attractive because it would allow to understand the emergence of immune system as will be found. For weak correlation so that the phyllosilicate analog of genetic code would be very many-to-one large number dark proton sequences would be generated. If RNA/DNA/amino-acid can condense around the dark proton templates with a 1-1 correlation between nucleotides/amino-acids a much more richer variety of these polymers are obtained.

2. The interaction of phyllosilicates with EZs could provide the dark variants of the biologically important ions. Montrorillonite contains almost all biologically important ions except anion Cl_- and can also doped by replacing -OH_- with Cl^-.

3. The layers of phyllosilicates could define kind of semi-super-conductors and there could be Josephson junctions between the layers so that primitive version of cell membrane might become possible generating dark photons at Josephson frequencies ZEV/h_{eff}.

4. If the lipid miscelles can surround EZs emerged from water clathrates, DNA or its precedessor could be stable inside them, and one would have a precedessor of cell nucleus and even cell.

EZ could also stabilize the organic phosphate PO_4^{-3} containing O= and appearing in DNA (only diphosphate $P_2O_7^{-4}$ containing 2 O=:s is usually stable).

5. In TGD framework chiral selection can be explained in terms of large h_{eff} scaling up the weak scale from 10^{-17} meters to even cell length scale for the dark variants of weakly interacting particles. This would allow to understand how the preferred chiralities of bio-molecules emerge. Quartz, which is the simplest silicate mineral is already chiral. Chirality might be transferred from the surface of the quartz crystal to that of dark DNA.

Adsorption of amino-acids and nucleic acids on phyllosilicates

One must take very cautiously the existing data about the adsorption of biomolecules on clay minerals. Probably water solutions are used but certainly not EZs of Pollack. Their use could change the situation completely. The experiments should be carried out in a situation in which coherence regions are generated (perhaps by electric discharges or spontaneously) and the analog of solar radiation provides the needed metabolic energy to generate EZs.

EZs could lead to the transformation -O-H$\rightarrow$ O^- + dark proton and assign dark proton sequences to phyllosilicate surfaces. After this DNA/RNA and amino-acid polymers could be formed through a kind of transcription process using dark proton sequences as template. One could say that dark proton sequence is "stolen". If dark proton sequences "code" for phyllosilicate molecules in 1-1 manner, the resulting sequences could be rather simple. If the code is many-to-one as in the case of the ordinary DNA-amino-acid code, rather complex polymers could be obtained.

Hideo Hashizume summarizes the existing ideas and experimental knowledge about the role of clay minerals in the evolution of life in in his book *Clay Minerals in Nature- Their Characterization, Modification, and Application*. The chapter *Role of Clay Minerals in Chemical Evolution and the Origins of Life* can be found in web (`http://tinyurl.com/qa8y5bs`).

Concerning adsorption of basic biomolecules montmorillonite (`http://tinyurl.com/ybbg7jf8`) and kaolinite (`http://tinyurl.com/mzeffyl`) $Al_2Si_2O_5(OH)_4$ are the most studied examples (`http://tinyurl.com/ycz6gtu8`).

Montromorillonite has 2 tetrahedral sheets sandwiching a central octahedral sheet. Plate shaped sheets have average diameter around 1 micrometer. Chemically montrorillonite is hydrated sodium calcium aluminium magnesium silicate hydroxide $(Na,Ca)_{1/3}(Al,Mg)_2(Si_4O_{10})(OH)_2\cdot nH_2O$ able to contain thus almost all biologically important ions. Cl^- is not included but can replace $(OH)^-$ in the hydroxyl site.

Adsorption of the free positively charged amino-acids aspartic acid, glutamic acid, and phenylalanine is reported to occur via cation exchange. Alanine, serine, leucine, aspartic acid, glutamic acid, phenylalanine adsorbed to H-montmorillonite occur by proton transfer. These amino-acids are either negatively charged or neutral. The adsorption of glycine and its oligomers occurred in Ca-montmorillonite Ca-illite and their adsorption increased with the length of oligomer.

Polymerization of bio-molecules

Thermal vents are promising places for prebiotic polymerization. Repeated wetting and drying at beach is known to promote polarization at the surface of Earth. Similar situation might be encountered also in underground oceans as a tidal effect.

What is known is about polymerization induced by phyllosilicates in absence of EZs?

1. The polymerization of peptides to give oligomers (same unit repeating) is observed. Also nucleotide polymers (RNA) are generated. In experiments leading to generation of RNA polymers a condensation of 5^{prime}-phosphorimidazolide obtained from RNA nucleotide by replacing O- in phosphor with carbon-5-cycle containing three nitrogens.

   RNA world as a model for prebiotic evolution requires 40 monomers theoretically. 6-14 are obtained. The reason is that hydrolysis competes with polymerization. A possible manner to overcome the problem would be formation of EZs preventing hydrolysis.

   Polymerization up to 55 units is however achieved in presence of montmorillonite using successive feedings of monomers as found by Ferris *et al* [I68] (`http://tinyurl.com/y7mfqc8t`).

Note however that at the surface of Earth montrorillonite is formed by the weathering of volcanic ash (http://tinyurl.com/y6uevvkj): it is not clear whether it can be formed in underground oceans.

2. The polymerization of DNA has not been reported. The reason probably relates to the presence of high energy phosphate bond and to the instability of DNA in ordinary water. It would be interesting to see if the presence of gel, water and irradiation with ligh could induce DNA polymerization.

3. Riboses are sugars and basic building bricks of DNA and RNA. Sugars have formaldehyde $O{=}CH_2$ as a precursor. Clay minerals can catalyze formation of formaldehyde and stabilize it.

Concerning the polymerization of biomolecules EZs provide an attractive mechanism. First dark proton sequence correlating loosely with the sequence of phyllosilicates at the boundary of a sheet is generated. This would represent "mineral life": something between mineral kingdom and living matter. After that the analog of transcription would occur: DNA-/RNA- or amino-acid sequence would be associated with this sequence. If the correspondence dark proton sequence $\rightarrow$ phyllosilicate unit is very many-to-one, this could give richly structured biopolymers.

DNA and RNA are accompanied by dark proton sequence at flux tube. Could it be that DNA and RNA could be generated from their dark analogs in presence of P_i or PP_i and coherence regions plus radiation at energy near metabolic energy quantum? The hydrolysis of DNA could be prevented inside EZ perhaps enclosed inside lipid miscelle formed in presence of montmorillonite.

These considerations are of course very naïve. I have not even mentioned that in biology polymerization is catalyzed by enzymes, also by their RNA counterparts. What the precise function of catalyst could be if EZs and dark proton sequences are present and the relevant processes occur at the level of dark proton sequences? Could the reaction occur as reconnections of magnetic flux tubes associated with domains of reacting molecules forcing the reactants to re-organize around resulting new magnetic bodies. Could catalysis involve the generation of intermediate magnetic flux tubes structures allowing to overcome potential barriers? Phyllosilicates are of course excellent candidates for prebiotic catalysts.

About the origin of phosphate

The phosphate group is in many ways important in living things. It is a component of energy-rich molecules, such as ATP and without phosphates there would be no metabolism in the form as we know it. Phosphate is an important structural component of nucleotides, which are the basic structural units of DNA and RNA. It is bound to coenzymes like NADP/NADPH involved in anabolic reactions (such as photosynthesis in plants and lipid synthesis in animals). It also forms part of the hydrophilic head of phospholipids in biological membrane. Where there is life there is also phosphate, one might say.

Pyrophosphate $PP_i{=}P_2O_7^{-4}$ obtained from P-O-P by adding O= and two $-O^{-1}$:s to both phosphates. Pyrophosphate decays in presence of water to two HPO_4^{-2} so that O= disappears. How could (http://tinyurl.com/y9eoxnop be transformed to biologically two bioactive phosphates $O{=}(P\text{-}O\text{-}H))O_2^{-2}$ obtained by adding O= ,-O-H and to $-O^-$. This form of phosphate is needed to build up DNA/RNA, ATP and other phosphate compounds. Is the presence of EZ necessary to stabilize the double bond?

How high energy phosphate bond could be generated?

1. In presence of water $P_2O_7^{-4}$ suffers a hydrolysis to $2P_i$, where the standard notation $P_i = HPO_4^{-2}$ is used. What could happen in presence of EZ? The simplest guess is that the second -O-H loses its proton as dark proton and that what is usually called high energy phosphate bond is generated. High energy phosphate bond need not be the only bond of this kind also other "high energy bonds" are possible.

2. This picture is consistent with the fact that when ATP suffer hydrolysis to $ADP{+}P_i$ or $AMP{+}PP_i$ transforming O^{-1} to -O-H. The energy released - metabolic energy quantum - in ATP$\rightarrow$ $ADP{+}P_i$ is the energy liberated when e proton attaches back to O^-. The dark proton for single phosphate need not belong to a dark nucleus so that it is not at the bottom

of potential well and dark proton can attach to O^-. In case of DNA only ordinary protons could be attache ti O^- if dark nucleus accompanies DNA polymer.

3. Phosphorylation and de-phosphorylation could be interpreted in terms of reconnection of flux tubes so that the dark proton associated with phosphate is transferred to the acceptor molecule. I have proposed that the deeper meaning of metabolism is transfer of negentropic entanglement (NE). The reconnection of flux tubes would transfer NE between ATP and third party to NE between acceptor molecule and third party. There is a large number of alternative identifications for NE. It could be short range entanglement associated with $h_{eff} = h_{em}$ assignable to electron and nucleus of dark atoms, to pairs of atoms or molecules, or very long range entanglement between molecule and large scale structure with size scale of Earth or even galaxy and associated with $h_{eff} = h_{gr}$. Both forms of NE might be involved and distinguish between two evolutionary levels.

4. Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K29, K30, K31, K32]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. The dark atoms in nutrients transforming to ordinary atoms could provide the metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the NE or be accompanied by dark magnetic flux tube. The transfer of NE would mean its disappearance followed by reappearance and it could happen that $h_{eff}/h = n$ is reduce in the process.

   The simplest view about photosynthesis would be that the absorption of solar photons excites some atoms to dark states and that nutrients contain these dark atoms as stable enough entities. The contamination of nutrients could mean the decay of these dark atoms to the normal states.

Some facts about phosphate in relation to geology are in order.

1. Phosphate minerals (`http://tinyurl.com/yatk23pu`) do not appear in crust. Apatite group consists of phosphate minerals having PO_4 and involves OH, Cl and F. It is one of the few minerals produced and used by biological systems and is used as fertilizer. Teeth and bones contain apatite. Apatite is not common in Earth's crust. Phosphosilicates exist but are very rare in crust.

2. Phosphate can appear also in igneous rocks. `http://tinyurl.com/y7c3kdr5` `http://tinyurl.com/y9j4u3tp` . Jukka Keinonen has written a book titled *Biological Role of Inorganic Pyrophosphate*. He proposes that volcanic magma could act as as a source of pyrophosphate PP_i. Which possesses the double bond and differs only that the protons lost in ionization are not dark.

The findings described by Keinonen raise the hope that water-phyllosilicate system could have utilized inorganic phosphate PP_i and other ions solved in underground oceans. The presence of EZs might have transformed the ordinary ionization of PP_i to dark ionization generating dark protons and perhaps inducing the transformation of PP_i to biologically active phosphate of DNA. The process would be essentially loading energy to give rise to the somewhat mysterious high energy phosphate bond characterizing ATP. In TGD picture also volcanoes could have made possible the bursts of life forms to the surface of Earth.

About the origin of cell membrane and cell

The presence of montmorillonite induces formation of lipid micelles - double layers assembling to vesicles. Hydrophobicity is the driving force and hydrophobic ends of the lipids in the bilayer are directed to the interior. The interior of vesicle would contain EZ generated from water clathrate, montrorillonite sheets, plus chemicals giving rise to the evolution of biomolecules. The stability of the fourth phase of water guaranteed by the cell membrane would prevent dehydration of DNA or of its precedessor.

During prebiotic evolution the DNA would have developed so that it would have correlated more and more strongly with the dark proton sequences defining the actual realization of genetic code. As already mentioned, the recent finding that so called knocked out genes are transcribed correctly [I94] (http://tinyurl.com/y9849jkz) supports this view [K70].

Also lattices of phyllosilicate molecules at the surface and linear sequences at the boundaries of sheets could develop symbolic representations in terms of dark proton sequences if the state of dark proton correlates with phyllosilicate. These correlations could be also absent in which the random sequences of dark protons could serve as templates for the formation of complex DNA/RNA/amino-acid sequences. Same could happen also in the case of RNA and amino-acids. This could be seen as dark variant of ion exchange with ion now a dark proton. Phospholipid lattice of lipid miscell3 could be accompanied by flux tubes carrying dark protons perhaps forming dark nuclei and the liberated nuclear binding energy could have led to a chain reaction reactions the miscelles.

About the evolution of immune system

In [K47] I have considered a model for the evolution of immune system.

1. The prebiotic system can "direct attention" to invader molecule by forming reconnections with its magnetic body. The simplest manner to do this would be reconnection of U-shaped flux tubes serving as kind of tentacles to a pair of flux tubes connecting the it to the invader. The reconnection could form only if the magnetic field strengths are same so that prebiotic system should be able to vary the field strength by varying the flux tube thickness - kind of motor action of the magnetic body. This would allow for the prebiotic system to get information about the magnetic body of the invader molecule.

2. Dark proton sequences at the flux tubes associated with the invader would give rise to a representation about the negative ionic structure of the invader molecule if there is a correlation between ion and corresponding dark proton.

3. Suppose that the prebiotic system can learn this code by the mechanism of directed attention discussed - say by stealing pieces of the dark proton sequences in the magnetic body of the invader molecule! This would make possible to associated to this dark proton sequence an amino-acid sequence by a generalization of translation process proton sequences.

4. These proteins could attack the invader innocuous by attaching to it. Attaching would be the reverse form the transformation of say amino-acid to active state: -O-H$\rightarrow$ O^- + dark proton. Protein would attach to invader molecule in this manner.

The processes -O-H$\rightarrow$ O^- + dark proton and its reversal would be fundamental processes making bio-molecules active in presence of EZs and would give to genetic code and translation and transcription processes realized at the level of dark proton sequences. The analog of ion change reaction for magnetic flux tubes would make it possible to "steal" the dark protons sequences and make the invader molecule innocuous and this would give rise to the development of immune system.

6.5.5 Viruses as fragments of topological quantum computer code?

I was listening a highly interesting talk about viruses in Helsinki by Dr. Matti Jalasvuori, a molecular biologist working in the University of Jyväskylä as a researcher (for information about him and his publications see http://tinyurl.com/hnj2k2s). Jalasvuori has published a book about viruses in finnish titled "Virus. Elämän synnyttäjä, kuoleman kylväjä, ajatusten tartuttaja" (see http://tinyurl.com/zvpvl2f).

I learned an extremely interesting new-to-me fact about viruses. They might be far from a mere nuisance, In TGD Universe they could be quantum memes, short pieces of a code of quantum computer code, wandering around and attaching to the existing quantum computer code represented by DNA! Replication of viruses would be replication of memes. If the infected organism survives the virus attack by taming the virus and making it part of its non-coding DNA, it will gain more strength! If my computer survives the updating of the operating system, it works better!

Some basic facts

Viruses are very small, few nanometers is the size scale. Virus contains short pieces of RNA or DNA coding for the virus, in particular the protein shell around it, which virus must have in the "non-living" state outside the host cell to which it can penerate. Inside its host this shell melts and virus attaches to DNA and is able to replicate. The copies of virus leave the host cell to search for their own host cells.

Usually viruses are regarded as a nuisance. But a new more holistic vision is evolving about viruses and their actual role. Viruses have been present perhaps even before the cell was present in its recent form, they might have been crucial for the emergence of life as we know it and would be also now. The system would consist of various kinds of cells, not necesary those of single organism. The contain several kinds of DNA and RNA: cell nucleus and mitochondria contain their own genomes; there are circular plasmids, and also viruses.

There is a continual exchange of information between cells including viruses as form form of information exchange. In this framework virus represents a meme represented by its DNA ,which does not code for protein shell. This meme wants to replicate and must use the genetic machinery to achieve this. But does virus do this to only replicate and produce more nuisance?

The organism manages to survive the virus attack if it is able to transform the virus so that it cannot replicate. One manner to achieve this would be transformation of the DNA portion due to the attached virus DNA (possible reverse transcribed from the RNA of virus) to a non-coding DNA often referred to as "junk" DNA. Non-coding DNA includes both intragenic regions - introns (see `http://tinyurl.com/j2onbu2`) - and intergenic regions containing for instance promoters and enhancers crucial for the control of gene expression as proteins (see `http://tinyurl.com/juvow7w`). Introns are portions of genes, whose contribution to mRNA is sliced away in translation to proteins. The decomposition to introns and translated regions is dynamical, which gives rise to a rich spectrum of different translations of the gene.

In fact, most of non-coding DNA might be due to viruses! The portion of non-coding DNA increases for speciei at higher evolutionary level. For our species it is estimated to be 98 percent! Most of our genome is "junk" as many biologists still would put it. But can this really be the case? On might think that immune system would have invented some mechanism to prevent the infection of DNA by junk DNA? The size of the trash bin cannot be a measure for evolutionary level! It is also known that virus infections force the organism to change and in some cases to become a better surviver. Viruses would drive evolution.

One can speculate that during the very early period in evolution there were only viruses and proto-cells. There is no need for them to be coded by genes. Self-organization can produce cell membrane like structures: soap films represent an example. The DNA fragments could survive inside these proto-cells but according to simulations done by the Jyäskylä group in which Matti Jalasvuori is working, eventually the evolution would lead to the emergence of parasitic DNA strands, which would soon begin to dominate and kill the protocell.

Viruses might solve the problem. Viruses would attract DNA fragments and replicate with themto build a protein wall around the fragment containg also a piece of DNA of proto-cell. Viruses would leave the proto cell before its death and find another protocell. Gradually genome would be formed as viruses would steal pieces of DNA fragments from protocells. One step in the later evolution could be the elimination of the part of virus coding for the protein shell and the use of the rest as protein coding DNA. For eukariotes the transformation to non-coding DNA including intronic and intergenic DNA becomes possible.

Viruses as pieces of quantum computer code?

Computational thinking would suggest that viruses might make possible the emergence of new biological program modules allowing to use existing program modules coding for proteins more effectively. The different slicings of mRNA dropping some pieces away would correspond to different ways to transform DNA sequences to proteins. But what about intragenic portions of DNA: are they just junk?

Could the non-coding DNA and viruses have a much deeper purpose of existence than mere replication? In TGD Universe this kind of purpose is easy to imagine if the system formed by DNA - say intragenic portions of DNA - and nuclear membrane (or cell membrane) system serves

as a topological quantum computer. DNA codons would be connected to lipids of the lipid layer of cell nucleus by magnetic flux tubes carrying dark charged particles. These connections could be also to cell membrane and even to cell membranes of other cells.

The braiding of the flux tubes would define the space-time realization of a quantum computer program. This would represent a new expression of DNA and would explain why so small differences between our DNA and that of our cousins give rise to so huge differences. What is important that genetic code would not be terribly important: it is braiding that matters now. The realization as quantum computer programs would give rise to cultural evolution, the realization as proteins to biological evolution. There would be a transition from the level of genes to that of memes.

Viruses would correspond to pieces of quantum computer code - memes. They would be wandering between cells and infecting them to get fused to the DNA. If DNA is able to transform them to introns it gets the code. Otherwise it dies. Infection is the necessary price for achieving meme replication. Living cells could be seen quantum computer programs updating them continually. Sounds somehow familiar!

6.6 About Evolution Before Cambrian Explosion

In the following I try to formulate a more detailed TGD inspired vision about how life might have evolved in TGD Universe during pre-Cambrian era before relatively rapid expansion of Earth size by a factor of 2 assumed in TGD versions of Expanding Earth model predicting that cosmic expansion takes place in given scale as rapid jerks rather than continuously as in ordinary cosmology. The key ingredients besides standard facts are TGD inspired interpretation for Cambrian Explosion (CE) [K36, L18], the vision about dark matter as large h_{eff} phases [K29, K30, K31, K32], and the notion of magnetic flux tubes. These provide TGD view about Pollack's Exclusion Zones (EZs, [L13]) as key factors in the evolution of life.

I have gathered useful links from web to build a more detailed version of TGD vision and it is perhaps appropriate to give a list of some useful links - they appear also as references. These links might help reader considerably in getting touch about the problems involved and reader can easily find more.

1. Data related to Mars
   Two generations of windblown sediments on Mars:
   `http://tinyurl.com/y744q6rd`,
   Sedimentary Mars: `http://tinyurl.com/yc6s22ra` *Liquid flows in Mars today: NASA confirms evidence*:
   `http://tinyurl.com/nb4vxbp`

2. Metabolism
   Microbial metabolism: `http://tinyurl.com/ycywt4mj`
   Electron transport chain: `http://tinyurl.com/77zzmak`
   Metal-eating microbes in African lake could solve mystery of the planet's iron deposits:
   `http://tinyurl.com/y9jyodxl`

3. When did photosythesis emerge?
   Ancient rocks record first evidence for photosynthesis that made oxygen
   `http://tinyurl.com/oeu3p9w`
   Cyanobacteria: `http://tinyurl.com/z75nx99`

4. When did oxygenation really occur?
   Great Oxygenation Event: `http://tinyurl.com/q7qfd55`
   Mass-Independent Sulfur Isotopic Compositions in Stratospheric Volcanic Eruptions:
   `http://tinyurl.com/yd38hszw`
   Neoarchean carbonate–associated sulfate records positive $\Delta^{33}S$ *anomalies*
   `http://tinyurl.com/ya77zygs`

Great Oxidation Event "a misnomer":
http://tinyurl.com/qhnhyw2
An Oxygen-poor "Boring" Ocean Challenged Evolution of Early Life
http://tinyurl.com/y7wavpom

5. The role of iron
Evidence for a persistently iron-rich ocean changes views on Earth's early history
http://tinyurl.com/3uxr6sd

6.6.1 What Happened Before Cambrian Explosion?

The story about evolution of life is constructed from empirical findings based on certain geological, chemical, and isotope signatures. The study of sediment rocks makes possible reasonably reliable age determinations but involves assumptions about the rate of sedimentation. Water, ice, acids, salt, plants, animals, and changes in temperature contribute to weathering and cause erosion involves water, ice, snow, wind, waves and gravity as agents and leads to sedimentation. Also organic material forms sediments both on land and at ocean floors.

Isotope ratios serve as signatures since they are different in inanimate and living matter because those for living matter reflect those in atmosphere and are affected by cosmic rays. The concentrations of various elements are important signatures: mention only oxygen, nitrogen, sulphur compounds such as sulphide, hydrogen sulphide. and sulphate iron, and molybden.

The story involves great uncertainties and should not be taken only as a story. In the following TGD view about how life evolved before Cambrian Explosion (CE) about .6 gy ago is summarized. The Pre-Cambrian part of TGD inspired story differs dramatically from the official narrative since only lakes would have been present whereas official story assumes oceans and continents. Earth would have very much like Mars before CE - even its radius would have been essentially same (half of the recent radius of Earth). This suggests that Mars could teach us a lot about the period before CE **??**. The deviations seem to explain its paradoxical looking aspects of the standard story.

1. Life according to TGD evolved in underground oceans and at the surface of Earth containing lakes but no oceans. The lifeforms at the surface of Earth were prokaryotes whereas the life in underground oceans consisted of relatively complex photo-synthesizing eukaryotes.

2. The recent data from Mars **??** gives an idea what the situation at Earth was during CE since the radius of Earth at that time was very nearly same as that of Mars now. There is evidence for sedimentation (see http://tinyurl.com/yc6s22ra) and for water (see http://tinyurl.com/nb4vxbp) near to and even at the surface provided quite recently. The life at the surface of Earth before CE consisted mainly of prokaryotes and very simple mono-cellular eukaryotes and something like this is expected at the surface of Mars now.

3. Already around 3.5 gy ago prokaryotes using sulphate as energy metabolite were present. Photo-synthesizing cyanobacteria (see http://tinyurl.com/oeu3p9w) emerged about 3.2 gy ago **??**. They became later the plasmids of plant cells responsible for photo-synthesis. The problem of the standard story is that this did not lead to oxygenation of the hypothetic oceans and rapid evolution of eukaryotes and multi-cellulars.

   In standard vision one can explain the absence of oxygen based life in hypothetic oceans by the presence of oxygen sinks. It is known that the ancient oceans (shallow oceans, lakes, or ponds in TGD) were oxygen poor and iron rich. The data about Mars **??** - the red planet because of iron rusting - makes possible to test the feasibility of this hypothesis. The oxygen produced by the cyanobacteria was used to the formation of rusted iron layers giving rise to iron ores. For 1.8 gy ago the formation of rusted iron layers ceased. A possible explanation is that all iron was used. The ores could have been also generated by bacteria using iron as metabolite (see http://tinyurl.com/y9jyodxl) **??** and transforming it to iron oxide. There are however now iron ores after 1-8 gy: did these bacteria lose the fight for survival?

   In TGD Earth atmosphere remained oxygen poor since the small lakes could not produce enough oxygen to induce the oxygenation of the atmosphere. The lakes however gained gradually oxygen. First it went to the oxidation of iron.

4. A general belief has been that about 2.4 gy ago Great Oxidation Event (see http://tinyurl.com/y9jyodxl) (GOE) ?? occurred. The basic evidence for GEO is from volcano eruptions, which seem to have produced anomalously small amount of sulphur after 2.4 gy. The reason would have been the formation of sulphate SO_4 from atmospheric oxygen and sulphur emanating from volcano.

   This evidence has been however challenged by measuring sulphur anomalies for recent volcanic eruptions. Their sign varies in time scale of month changing from positive to negative (see http://tinyurl.com/yd38hszw) ??. It is quite possible that GOE is an illusion (see http://tinyurl.com/qhnhyw2) .

5. There is also problem related to the "boring period" (see http://tinyurl.com/y7wavpom) 1.8-.8 gy. It seems that the hypothetic oceans remained still oxygen poor and iron rich ??. It has been also suggested that the boring period continued up to CE: the first animals after CE could have oxygenated Earth's oceans (see http://tinyurl.com/3uxr6sd) ??. In TGD Universe GOE is indeed illusion for the simple reason that oceans did not exist! Life was boring at the surface of Earth from 3.5 gy to .6 gy.

6. Life would have evolved in underground seas containing oxygenated water, probably already 3.2 gy ago, and making possible photo-synthesis and cellular respiration. Animal cells formed by eukaryotes with nucleus carrying genome with prokaryotes, which later became mitochondria. Plant cells emerged when these eukaryotes engulfed also cyanobacteria, which made photo-synthesis possible. The highly developed eukaryotes were burst to the surface as the radius of Earth increased by a factor two in geologically short time scale. Oceans containing oxygen rich water were formed. CE can be equated with GOE in TGD picture.

   Plants (see http://tinyurl.com/z75nx99) are divided into green and red algae, a small group of fresh water monocellulars glaucophytes, and land plants. Land plants must have emerged after CE. Red algae are multi-cellulars (corals are representative example). Also green algae can be multi-cellulars and land plants are thought to have developed from them. An interesting question is whether multi-cellular plants and animals emerged already before CE as the findings would suggest.

The basic objection against this vision is that photo-synthesis is not possible underground. Did photo-synthesis occur in shallow lakes storing chemical energy transferred to the underground seas. This does not seem a plausible option but cannot be excluded. The volcanoes and hydrothermal vents bring water from underground. The water contains ground water and ordinary sea water, which ended underground in various ways, and also magmatic component. The geothermal vents and most volcanoes are however associated with the regions were tectonic plates meet and should not have existed before CE.

TGD inspired model [L18] for Pollack's EZs [L13] suggests a solution of the problem. The formation of these negatively charged regions of water is induced by solar radiation, IR radiation at energies which correspond to metabolic energy quantum, and also at energies corresponding to THz frequency. TGD based model proposes that the protons from EZ becomes large h_{eff} protons at magnetic flux tubes associated with EZ. These flux tubes could be quite long and extend to the underground oceans. Dark photons with energy spectrum containing that of bio-photons could travel along these flux tubes. This suggests that solar radiation transforms partially to dark photons, which travel along flux tubes to the underground sea and transform to ordinary photons caught by photo-synthesizing cells.

Interestingly, also the temperature of Earth is such that thermal radiation would be in visible region and one cannot exclude the possibility that dark photons emerge also from this source. This would make possible also cell respiration and oxygen rich water.

Skeptic is of course wondering whether the flux tubes were long enough.

1. The basic idea about dark matter residing at magnetic flux tubes emerged in TGD from Blackman's findings [J8] about quantal looking effects of ELF em fields on vertebrate brain by assigning them to cyclotron frequencies Ca^{++} ions in endogenous magnetic field $B_{end} = .2$ Gauss, which is by a factor 2/5 weaker than the recent magnetic field of Earth and assigning large non-standard value of Planck constant to the flux tubes so that the energies of ELF quanta are above thermal energies.

2. The value of magnetic field at flux tubes of "personal" magnetic bodies of organisms have B_{end} in its value spectrum. B_{end} could be conserved in evolution somewhat like the salinity of ancient (underground) ocean. The flux tubes of B_{end} would have transformed the photons of solar radiation to dark cyclotron photons allowing them to travel to underground sea and transform back to ordinary photons to be absorbed by pre-plant cells. I have proposed that a similar mechanism is at work in biological body and could explain the reported ability of some people to survive without any obvious metabolic energy feed.

6.6.2 How The Cellular Life Could Have Evolved Before Ce?

In the following I summarize what looks the most plausible view about evolution of life in TGD framework. I represent first basic classification to make reading easier.

Basic classification of lifeforms

Lifeforms are classified into prokarioties (no cell nucleus) and eukaryotes (cell nucleus).

1. Prokaryotes (see `http://tinyurl.com/yazsp5fz`) are mono-cellular and have no separate cell nucleus. They are divided into bacteria and archea. Bacteria do not have genome but only circular DNA strand and usually accompanied by an almost palindrome. Archea have also genes. Cyanobacteria are simplest photo-synthetizing cells: these prokaryotes have been engulfed by eukaryotes to form plant cells containing them as plasmids. Plant cells contain also mitochondria believed also to be ancient prokaryotes which have been "eaten" by eukaryotes. Plants cells contain both mitochondria and plastids whereas animal cells contain only mitochondria.

2. Eukaryotes (see `http://tinyurl.com/y9pzg6jq`) have cell nucleus containing the genome. Eukaryotes divide into three kingdoms: animals (see `http://tinyurl.com/l78hgf8`), plants (see `http://tinyurl.com/ya6fpfkk`), and fungi (see `http://tinyurl.com/ybjgonj7`). Fungi can be said to be between animals and plants: they do not perform photo-synthesis but have cell walls.

Prokaryote-eukaryote distinction

From the existing data one can conclude that during pre-Cambrian period only prokaryotes existed at the at surface of earth - presumably in small lakes in TGD Universe and ocean floors in standard Universe. The first photo-synthetizing prokaryotes - cyanobacteria - emerged about 3.2 gy ago and their precedessors where prokaryotes extracting metabolic energy from sulphate. Cyanobacteria (see `http://tinyurl.com/z75nx99`) **??** are able to survive in practically any imaginable environment:

Cyanobacteria are arguably the most successful group of microorganisms on earth. They are the most genetically diverse; they occupy a broad range of habitats across all latitudes, widespread in freshwater, marine, and terrestrial ecosystems, and they are found in the most extreme niches such as hot springs, salt works, and hypersaline bays. Photoautotrophic, oxygen-producing cyanobacteria created the conditions in the planet's early atmosphere that directed the evolution of aerobic metabolism and eukaryotic photo-synthesis. Cyanobacteria fulfil vital ecological functions in the world's oceans, being important contributors to global carbon and nitrogen budgets.

It is therefore natural to assume that cyanobacteria migrated to underground ocean through pores and fractures at the floor of lakes. They would have fused with pre-eukaryotes having only cell nucleus but no metabolic machinery to become chloroplasts. This would have given rise to the first eukaryotes able to perform photo-synthesis. The primitive cells prokaryotes defining pre-mitochondria would have also fused with these pre-eukaryotes so that both pre-plant and pre-animal cells wold have emerged. Why there is no evidence for the existence of pre-mitochondria as independent cells at the surface of Earth? Did they emerge first underground oceans, where photo-synthesis was not possible and disappeared in the fusion with pre-eukaryotes and therefore left no trace about their existence on the surface of Earth?

Both photo-synthesis and cell respiration involve so called electron transport chain (see `http://tinyurl.com/77zzmak`) (ETC **??**) as a basic structural element. It is associated with any

membrane structure and in photo-synthesis it captures the energy of photon and in cell respiration it catches the biochemical energy which could be emitted as photon so that the fundamental mechanism is the same. This suggests that cell respiration emerged as a modification of photo-synthesis a the level of prokaryotes first. Before the emergence of mitochondria and plastids ETC associated with pre-eukaryote membrane would have served the role of mitochondria or plastid. Using business language, mitochondria and plastids meant "outsourcing" of photosynthesis and cellular respiration.

6.7 About Possible Practical Implications

The predictions and practical implications of the proposed vision - if correct - are probably obvious to the reader but deserve to be stated clearly.

6.7.1 About Predictions And Implications

The proposed vision sounds certainly totally crazy from the viewpoint of standard physics. There are several new notions forced by TGD: the notion of many-sheeted space-time leading to the notion of field/magnetic body as an intentional agent controlling biological body and receiving sensory input from it; quantum criticality explaining dark matter as large h_{eff} phases; ZEO and NMP in (only) apparent conflict with second law predicting the evolution occurs spontaneously.

The most counterintuitive predictions of TGD inspired biology are involved in an essential manner. In accordance with the observation that astrophysical objects do not themselves expand although they participate in cosmic expansion as comoving objects, cosmic expansion is replaced by sequence of rapidly occurring quantum phase phase transitions increasing the size of system by some factor - say two. This justifies Expanding Earth hypothesis and leads to the vision that life could have evolved underground. Second equally counterintuitive prediction is that life emerge as dark nuclear fusion spontaneously and led to generation of both biopolymers and lipid layers.

The model has however testable predictions. The experimental arrangement leading to the formation of EZs can be modified by introducing phyllosilicates and other biologically important biomolecules to see whether the presence of EZs leads to generation of more complex bio-molecules. The claims about biofusion could be also tested. There are connections with large number of anomalous phenomena - free energy and Brown's gas, cold fusion, biological transmutations, boiling salt water, etc... and TGD based explanation could be tested. For instance, biofusion of various light elements could lead to problems with radioactive dating since the ages of samples would have tendency to be too short. In the case of radiocarbon (C_{14}) dating this problem is indeed encountered and one performs a correction (`http://tinyurl.com/p5msnh6`).

It is also easy to imagine far reaching technological implications.

1. Dark fusion followed by a phase transition to ordinary matter could make possible artificial generation of elements. The technological significance for the world in which various resources are rapidly depleting would be immense.

2. The possibility to generate artificial silicate-based intelligent lifeforms of course comes first in mind but involves rather obvious dangers.

6.7.2 But What If Silicate Based Life Takes The Lead?

I do not take seriously the claims of the proponents of strong AI that computers could take power over humans. Strictly classical computers are zombies and uncapable of any intentional behavior. Their real life variants could possess some kind of primitive awareness but this consciousness would probably have very little to do with the program running in the computer.

Of course, computerization can be a real danger to humankind even if computers are for all practical purposes intentionless zombies. Indeed, many leading AI professionals together with Hawking (`http://tinyurl.com/p27q2cn`) have signed an open letter warning about the dangers of military AI. The military applications of computers are developing rapidly and are rather frightening. Already now military professionals talk about information war and suggest that also Finland should take active attitude: not only defense but also attack. Many professionals believe

that systems attacking living targets will be realized within few years. Systems, which behave autonomously and can select their targets, could lead to catastrophe, when their control breaks down. This would be third revolution in warfare after gunpowder and nuclear weapons and those who know should do all that they can to prevent the AI arms race.

I understand that the fusion of biosystems and computers via interfaces consisting of phyllosilicates is also studied and this represent something, which is goes beyond the boundaries of AI. If the vision discussed in this work or some other vision has something to do with reality, they could lead to a development of artificial life forms with conscious intelligence. The recipe would be rather simple: water+ silicates+ something, which could be gels and visible radiation or electric discharges. Silicon would be only replaced with silicates.

These kind of systems could act as intelligent and conscious interfaces between humans and computers. AI specialist could give probably give a long list of other applications. It would be very handy if they could replicate and evolve (by NMP in TGD framework) and this would be one of the goals of R&D activity. They should be also capable of simple intentional behaviors - also by NMP. Presumably we would couple them to world wide web.

But what happens if these local intelligences manage to make a phase transition to a collective intelligence with world wide nervous system that we have generously built for them. NMP suggests that this kind of awakening could occur! What would this magnificient conscious intelligence think about us? Would it regard us as rather primitive carbon based pre-silicate life forms and treat us as we treat what we call "lower" lifeforms - convenient sources of negentropic entanglement, nutrients? Or can we hope that they would tolerate us - NMP is nice principle but it does not guarantee this since it leaves for self to choose between good and evil!

If the hypothesis about generation of dark nuclei is correct then there is also a real danger that nuclear explosion is generated.

Acknowledgements:
I want to thank Hans Geesink for very inspiring email discussions.

Chapter 7

Life-like properties observed in very simple systems

7.1 Introduction

I encountered in FB a link to a rather interesting article by physicists working in Emory University. The title of the popular article was "*Physicists show how lifeless particles can become 'life-like' by switching behaviors*" (see `http://tinyurl.com/y8wrz9ho`).

The article "*Emergent bi-stability and Switching in a Nonequilibrium Crystal*" by Guram Gogia and Justin Burton is published in PRL and can be found in ArXiv [I99] (see `http://tinyurl.com/ychho4l8`). Justin Burton leads a physics group working at Emory University. Guram Gogia who made the discovery is her student.

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experiments that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

TGD provides a general model for living systems relying on the notion of magnetic body (MB), hierarchy of Planck constants $h_{eff} = n \times h$ labelling phases of ordinary matter identifiable as dark matter, and the realization of control and communication signals between MB and biological body using dark photons [K74, K73]. Bio-photons would result in the transformation of dark photons to ordinary photons and EEG would rely on dark cyclotron photons and generalized Josephson photons from cell membrane (also bio-photons would relate to them). Bose Einstein condensates of dark variants of biologically important ions or their Cooper pairs are also in a central role. The assumption $h_{gr} = h_{eff}$, where h_{gr} is so called gravitational Planck constant, implies that the energy spectrum of dark cyclotron photons is universal (no dependence on the mass of ion) and naturally in visible and UV range characterizing molecular transition energies. [K70, **?**].

One can develop a detailed TGD inspired model for the findings leading to an identification of new control tools of MB (MB). Quantum criticality makes it possible for MB can adapt to the biological body (BB) so that it can generated cyclotron frequencies, which correspond to the characteristic frequencies of BB: forced oscillations serve as a control tool of MB. Also the analogs of Alfwen waves identifiable as analogs of string vibrations allow to control the systems at the nodes of the flux tube network.

In the system studied the crystal-like phase corresponds to a connected flux tube network associated having plastic balls as nodes, and gas-like phase to a totally disconnected network with connecting flux tube pairs split into flux loops. That freezing would require energy (going to the

magnetic energy of flux tube network in h_{eff} increasing phase transition) does not conform with the thermodynamics of classical systems. That superfluid Helium has similar strange feature at low enough temperatures suggests that the system is indeed quantal. Cyclotron Bose-Einstein (BE) condensates of Cooper pairs of Ar^+ ions, protons, and electrons are proposed to be relevant. Encouragingly, the ratio of frequencies for horizontal and vertical oscillations frequencies of crystal-like structure is equal to the ratio of cyclotron frequencies for Ar^+ and proton.

One of the key challenges is to identify the the prebiotic source of metabolic energy. The sequences of dark protons identifiable as dark nuclei give in TGD framework rise to analogs of DNA, RNA, tRNA, and amino-acids [K44, K47] [L20]. The model predicts the degeneracies of vertebrate genetic code correctly. In TGD based model for "cold fusion" as dark nucleosynthesis (DNS) serving as a precedessor of ordinary nucleosynthesis dark nuclei transform to ordinary nuclei liberating almost all nuclear binding energy [K21] [L30]. Dark analogs of DNA, RNA, tRNA, and amino-acids would therefore provide also the sought for prebiotic source of metabolic energy in the system studied: the egg-or-hen problem about whether the genes or metabolism came first, would be resolved.

Second very simple system exhibiting life-like properties consists of particles with a feed of acoustic energy at single wavelength. What happens is that the distribution of particles develops synchronous oscillations in wave length band below the acoustic wavelength. The oscillation amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

There is also a third such simple system demonstrating life-like properties. A research group in Aalto yliopisto led by professor Olli Ikkala has published an interesting article with title "*Programmable responsive hydrogels inspired by classical conditioning algorithm*". What is observed that a system consisting of hydrogel and Gold nanoparticles can get conditioned when it is heated in the presence of irradiation at blue and red wavelengths. Conditionin means that the system melting under heating learns to melt in the presence of only irradiation. The experimenters assume that the Gold nanoparticles forming chains during heating serve as a memory element in the learning.

A simple TGD based quantum model for the conditioning relies on TGD inspired general model of living systems extended recently to a model of quantum self-organization in which energy feed serving as metabolic energy feed induces generation of dark matter as $h_{eff} = nh_0$ phases of ordinary matter at the magnetic body of the system. In number theoretic vision the presence of these phases correspond to higher algebraic complexity and higher "IQ".

The light signal would generate Pollack effect, which in TGD framework means transfer of protons from photo-acids to dark $h_{eff} = nh_0$ protons at magnetic flux tubes parallel to nanoparticle chains. The "IQ" of the system or its magnetic body characterized by h_{eff} would increase and it would become able to self-organize. The energy from the heating would be stored to the nanoparticle chains taking the role of proteins as energy storage. Melting would be a self-organization process increasing complexity, and in absence of heating (and perhaps even in its presence) the gel phase would receive the energy needed from the nanoparticle chains. The conditioning in this sense would not be a passive mechanical response. The system would be macroscopic quantum system, and the energy feed would make possible for it to evolve to a higher level of complexity and conscious intelligence.

7.2 Basic ideas of TGD inspired quantum biology

TGD Universe is quantum critical and quantum criticality involves universal dynamics. This raises the hope that also the TGD inspired model of living systems is universal and applicable also in the recent context. The findings would provide a test for TGD view and even allow to sharpen it. TGD based view about living systems involves several new notions.

7.2.1 Dark matter as hierarchy of phases of ordinary matter with $h_{eff} = n \times h$

The first new element is the hierarchy of Planck constants $h_{eff}/h = n$. In adelic physics [L34, L35] proposed to provide physical correlates of both sensory experience and cognition $h_{eff}/h = n$ serves as a kind of IQ for the system measuring its algebraic complexity (n could correspond to the order of the Galois group for the extension of rationals defining the adele in question).

1. Quantum criticality is the basic property of TGD Universe and also an essential aspect of what it is to be living in TGD Universe and the associated long range fluctuations and correlations correspond to large values of $h_{eff}/h = n$ for the flux tubes of MB [K29, K30, K31, K32]. The increase of $h_{eff}/h = n$ keeping magnetic field strength un-affected reduces binding energies for electrons of atoms and increases cyclotron energy scale and scales up quantum lengths and times, in particular the scales of quantum coherence and this kind of phase transitions seem to be crucial in TGD inspired biology.

   The energies of subsystems indeed typically increase with h_{eff}. For instance, atomic binding energies are proportional to $1/h_{eff}^2$. Cyclotron energies are in turn proportional to h_{eff}.

   The function of metabolism in TGD Universe is to increase the value of h_{eff} for some subsystems of living system, and therefore to increase the complexity of the subsystem. The reduction of h_{eff} liberates energy and this energy could kick the reacting molecules over the potential wall in bio-catalysis. The reduction of n forcing the shortening of the flux tubes could provide a mechanism allowing the reacting biomolecules to find each other in a dense molecular soup.

2. The cyclotron frequencies of dark ions in the magnetic field of the flux tubes do not depend on $h_{eff}/h = n$ but the cyclotron energies $E_c = h_{eff} \times f$ are scaled up by factor n so that they are above thermal energy at physiological temperatures and can carry information so that they can be used for communication and control purposes. Cell membrane acts as a generalized Josephson junction and dark Josephson radiation communicates sensory information to MB coded to the modulation of the generalized Josephson frequency by the variations of neuronal membrane potential induced by nerve pulse patterns [K78, K36].

7.2.2 $h_{gr} = h_{eff}$ hypothesis and universal cyclotron energies

$h_{gr} = h_{eff}$ hypothesis [K70, K29, K30, K31, K32] and its generalizations such as e $h_{em} = h_{eff}$ represent a further key element of the TGD inspired model of living matter. This relationship is proposed to hold when the coupling strength proportional to appropriate charges is so large that perturbation series does not converge. The large value of h_{eff} reduces the value of coupling strength proportional to $1/h_{eff}$ so that dark matter satisfying this condition would allow a perturbative description.

1. Nottale [E5] introduced originally the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ to explain the orbital radii of planets in solar system as Bohr orbits. The value of the velocity parameter v_0/c is of order $2^{-11} \simeq .5 \times 10^{-3}$ for the inner planets. The interpretation in TGD framework is that the magnetic flux tubes mediate gravitational interaction between masses M and m and the value of Planck constant is h_{gr} at them.

   The proposal $h_{eff} = h_{gr}$ at flux tubes is very natural sharpening of the original hypothesis [K29, K30, K31, K32, K70]. The predictions of the model do not depend on whether m is taken to be the mass of the planet or any elementary particle associated with it and the gravitational Compton length $\lambda_{gr} = GMc/v_0$ does not depend on the mass of the particle, and is proportional to the Schwartschild radius $r_S = 2GM$ of Sun. This encourages the idea about astroscopic quantum coherence at magnetic flux tubes mediating gravitational interaction. One of the applications is to the fountain effect of superfluidity [K29, K30, K31, K32].

   In the biological applications the identification of mass M as Earth mass is one possibility but there are also other options [K70]. The identification of v_0 as some mechanical velocity scale looks natural.

2. $h_{gr} = h_{eff}$ hypothesis predicts that cyclotron energies do not depend on the mass of the particle whereas cyclotron frequencies are proportional to $1/m$. Cyclotron energy spectrum would be universal and correspond to the spectrum of magnetic field strengths B. Bio-photons with energies in visible and UV are proposed to result as dark photons satisfying $h_{gr} = h_{eff}$ transform to ordinary photons. For $B = B_{end} = 2B_E/5$ ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) the hypothesis fixes the scale of cyclotron frequencies and h_{gr} should be in the range $10^{12} - 10^{14}$.

7.2.3 MB (MB) and its motor actions

A further new element is the notion of MB (MB) adding to the pair formed by organism and environment a third member. This brings into biochemistry a radically new element [K74, K73]. One can say that MB uses biological body as a motor instrument and sensory receptor.

1. In TGD standard model gauge fields and gravitational field are replaced locally by the 4 embedding space-time coordinates behaving like field variables. This implies an enormous simplification of the local dynamics however lost in the QFT limit replacing many-sheeted space-time with a slightly curved region of M^4. A further simplification comes from preferred extremal property [K9, L36, **?**].

2. At the level of space-time topology the situation becomes however extremely complex. Gauge fields created by the system are replaced with field body consisting of topological field quanta (space-time sheets) so that one can assign to a system well-defined field identity - field body. One has a fractal hierarchy of field bodies within field bodies. Magnetic flux quanta represent one example of topological field quantization.

   System has therefore besides its biological body (BB) also MB (MB) carrying dark matter particles identified ordinary particles with scaled up Planck constant $h_{eff}/h = n$ implying scaling up of various quantum length and time scales (by factor n in the simplest situation). MB has a hierarchical onion-like structure corresponding to various p-adic length scales and various values of h_{eff}.

MB can control BB by "motor actions" in which the length L and possibly also the area S of flux tubes change [K74]. This affects string tension and amplitude of oscillations of systems connected by magnetic flux tubes so that motor action of BB is induced. The phase transition changing the field strength could be induced by a phase transition changing h_{eff}: if magnetic flux is monopole flux it is conserved. There are two options.

1. The scaling $(S, L) \to n \times (S, L)$ leaves L/S invariant and scales down the magnetic field strength as $B \propto 1/S \to B/n$. Magnetic energy and cyclotron energies are unaffected but cyclotron frequencies f_c scale down as $f_c \to f_c/n$. There is quantum criticality corresponding to flux tubes with same value of L/S in the sense that these systems have same energies. This kind of quantum criticality could occur at critical values of relevant parameters.

   Quantum criticality makes it possible for MB to tune its cyclotron frequency spectrum so that it corresponds to a given set of frequencies associated with BB. MB can control the corresponding oscillatory processes at BB by using dark cyclotron radiation transformed to bio-photons as a resonant driving force. Dark cyclotron radiation would result from the decay of dark cyclotron BE condensates. MB would thus adapt to the properties of BB. The larger the maximal value of n, the wider the variety of different adaptations, the higher the ability of the system to survive, and the higher the evolutionary level of the system.

   The cyclotron energy spectrum associated with EEG could also entrain to various frequencies assignable to the neural circuits and in this manner MB would gain a control over them. Entrainment occurring at the level of brain would be second example of this process. MB learns to mimic the processes occurring at the level of BB and in this manner gains control over them. MB also learns how to get information about them. The motor actions of MB allowing to change the thickness and length of the flux tubes would be essential for achieving this.

Remark: In the case studied the frequencies f_V and f_H assignable to the oscillations of plastic balls would correspond to frequencies at level of BB to which MB tunes by a suitable choice of h_{eff}.

2. For $(S, L) \to (S, n \times L)$, magnetic field remains invariant so that cyclotron frequencies are unaffected. Magnetic energies and cyclotron energies are scaled up by n: one might say that one has criticality in classical sense. This kind of transitions require energy and are analogous to first order thermodynamical phase phase transitions.

   Remark: In the case studied the phase transition from gas to crystal-like phase of plastic balls would correspond to the increase of h_{eff} leaving the frequencies invariant and would thus require energy in contrast to the usual view that energy is liberated in freezing (Helium superfluids are the only exception to the rule, and are macroscopically quantum coherent systems).

3. The decay of cyclotron BE condensates at MB generates dark cyclotron radiation, which can transform to ordinary radiation and drive oscillatory processes at BB [K13, K22]. This provides an additional control mechanism. Dark photons can transform to ordinary ones in several ways. The following special cases are diametric opposites of each other and correspond to $n \leftrightarrow 1$ transitions. More general transitions are of type $m \leftrightarrow n$.

   (a) Dark photon with energy $E = h_{eff} \times f$ can transform to ordinary photon with same energy and frequency $n \times f$. Bio-photons would result from low frequency dark photons - even dark EEG photons - in this manner. Bio-photons are in visible and UV range and biomolecules have excitation energies in this range so that MB could control biochemistry in this manner.

   (b) Dark photons with energy $E = h_{eff} \times f$ can decay to a bunch of n ordinary photons with the same frequency f but energy E/n. This could allow MB to control electromagnetic and mechanical oscillations taking place at low frequencies.

   Also transformation which reduce Planck constant but do not lead to $n = 1$ state are possible.

   Remark: In the case studied the decay of BE condensates to ordinary ELF photons could allow the control of the oscillations of plastic balls.

4. Alfwen waves (see `http://tinyurl.com/7ekxqt2`) are part of the dynamics of ordinary Maxwellian magnetic field often described phenomenologically as oscillations of magnetic flux tubes. The phase velocity $v = c/\sqrt{\epsilon}$ is light velocity in vacuum modified by the dielectric constant $\epsilon = 1 + \rho/B^2$ (one has $c = 1$, $\epsilon_0 = 1$,and $\mu_0 = 1$ in the units used) caused by the total mass density of charged matter and energy density magnetic field.

   Alfwen waves generalize in TGD framework to oscillatory perturbations of the magnetic flux tubes, which in 1-D approximation for flux tubes can be modelled by transversal vibrations of string characterized by string tension proportional to L/S. In longitudinal directions the vibrations are in the interior of string trivial but induce oscillations of the distance between the ends of the string and are thus visible in the dynamics of BB.

   Remark: In the recent situation Alfwen waves would naturally affect the dynamics of plastic balls in the crystal-like phase if flux tubes connecting the plasma balls are present.

5. The motor actions of MB can also change the topology of MB. BB is assumed to posses closed U-shaped flux tubes acting as kind of tentacles scanning the environment and re-connecting with the U-shape flux tubes associated with other systems to form pairs of flux tubes connecting two systems [K47, K51, K52]. These reconnections would serve as a topological correlate for a directed attention and for entanglement between the systems at the ends of the flux tubes. For instance, immune system would have developed from this kind of scanning of the environment.

   One can imagine even more radical magnetic "motor actions". At given level of hierarchy of space-time sheets space-time sheets of sub-systems can be connected by a network of magnetic flux tubes [L23]. The connectedness of the flux tube network can change by the

re-connection process and its reversal. The increase of h_{eff} affects the size of the closed loops and can induce their reconnections to flux tube pairs connecting the systems at its ends. The reduction h_{eff} can induce the reversal of reconnection and split the flux tube pair to two flux loops. This gives rise to quantum analogs of phase transitions between crystal-like and fluid-like phases.

Remark: In the case studied the formation of crystal phase from plastic balls could correspond to the re-connection of flux loops assignable to plastic balls to form kind of tensor network correlating the dynamics of plastic balls. Its reversal would lead to gas phase.

7.2.4 Dark nucleosynthesis (DNS) as a source of metabolic energy in prebiotic systems?

One of the key challenges is to identify the prebiotic source of the metabolic energy. The sequences of dark protons identifiable as dark nuclei give in TGD framework rise to analogs of DNA, RNA, tRNA, and amino-acids. In TGD based model for "cold fusion" as dark nucleosynthesis (DNS) proposed to serve as the precedessor of ordinary nucleosynthesis these dark nuclei transform to ordinary nuclei liberating almost all nuclear binding energy [K21] [L30]. DNS could provide the sought for prebiotic source of metabolic energy and also a source of metabolic energy in the system studied.

1. There is a considerable evidence for the production of energy in what is known as "cold fusion" not allowed by the standard nuclear physics [L16, L30]. As a matter of fact, cold fusion is definitely *not* in question, which has motivated the introduction of the term low energy nuclear reactions (LENR). What definitely occurs are nuclear transmutations, that is formation of nuclear isotopes not present in the original system. Also energy is produced [C6, L28].

   The typical experimental arrangement involves electrolysis in which one has a voltage between electrodes inducing the ionization of hydrogen or deuterium. The positive ions flow towards the negatively charged cathode and the transmuted elements appear at the cathode and also heat is produced. Now one has negatively charged electrode and also plastic balls are negatively charged being thus analogous to cathode with a negative surface charge. Ar^+ ions could take the role of protons or deuterium ions. Also protons could be present.

2. I have been recently working with a detailed model for "cold fusion" [L16, L30] [K21]. In Widom-Larsen model (WL) [C1, C8] to LENR only standard model of nuclear interactions is used but some unrealistic looking assumptions must be made. Remarkably, there is also evidence that the transmutations take place also in living matter [C3, C7] and the question is whether nuclear transmutations could provide a new source of metabolic energy.

TGD based model involves new physics and relies on DNS involving the formation of dark proton sequences at magnetic flux tubes of MB of the system [L16]. Dark proton sequences would be dark nuclei and would suffer rapidly occurring dark beta decays replacing some dark protons with dark neutrons. Dark nuclei would transform to ordinary nuclei and liberate almost all of ordinary nuclear binding energy in the process. Most of the energy could go to the magnetic flux tubes possibly leading out of the system and would be lost. The flux tubes entering to the negatively charged surfaces such as some regions of cathode would be an exception.

Could stable light nuclei fuse to heavier ones by forming dark nuclei consisting of weakly bound ordinary nuclei transforming to ordinary nuclei also in living matter? If dark weak decays are not involved, both (A, Z) are additive in the process. If dark weak decays are allowed, only A is additive. If these fusion reactions produce the biologically important ions, A and possibly also Z for the nuclei of biological ions would form an additive group with some basic nuclei serving as generators.

1. If proton is taken as an additive generator, the situation is trivialized. On the other hand proton, is not a genuine nucleus, and ordinary nuclei of form $A = Z$ are also unstable. It is however to add dark protons to an ordinary nucleus at magnetic flux tubes to get $(Z, A) \to (Z + 1, A + 1)$ suggested by Widom and Larsen to be a basic process. Dark proton could suffer dark weak decay with a scaled up rate since dark weak bosons are effectively

massless below the size scale defined by their scaled up Compton length. This mechanism is central in both WL model of LENR and in TGD based model of DNS [L30].

2. $He(2,4)$ is the basic product in DNS and because its large binding energy would be a natural generating nucleus. The resulting nuclei would have $(Z,A) = n \times (2,4)$. A is always even for these nuclei. The nuclei C, O, Ne, Mg, S, Ar, Ca are all stable and correspond to $n = 3, 4, ..., 10$. C, O, Mg, S, Ca are of central importance in living matter. $Be(4,8)$ with $n = 2$ is missing from the list. The reason is that it has very short life-time against alpha decay whereas energy conservation prevents alpha decays of the heavier nuclei in sequence.

3. $D(1,2)$ is the lightest non-trivial candidate and would give nuclei of form $(Z,A) = n \times (1,2)$. The binding energy of D is however rather small. The nuclei formed as multiples of $He(2,4)$ can be formally regarded as even multiples of $D(1,2)$ (only formally, because the binding energy per nucleon for $He(2,4)$ is considerably larger than for $D(1,2)$). The odd multiples correspond to stable isotopes $Li(3,6)$, $B(5,10)$, $N(7,14)$ corresponding to $n = 3, 5, 7$. $F(9,18)$ decays to stable $O(8,18)$, $Na(11,20)$ decays to stable $Ne(10,20)$, and $Al(13,26)$ to stable $Mg(12,36)$. This reflects the fact that for stable heavier isotopes the number of neutrons is larger than number of protons.

4. $Li(3,6)$ is stable albeit not the most abundant isotope of Lithium. C, F, Mg, P, Ar have isotope of form $n \times (3,6)$ with $n = 2, 3, .., 6$. Most of these nuclei are obtained from $He(2,4)$. The isotopes $F(9,18)$ and $P(15,30)$ are unstable and decay by beta decay to stable $O(8,18)$ and $Si(14,30)$ respectively.

5. One can also form sums of different nuclei: $(Z,A) = (Z_1,A_1) + (Z_2,A_2)$.

   (a) The simplest sum corresponds to $(Z_2,A_2) = (1,2) = D$. This addition is especially natural for nuclei which are multiples of $He(2,4)$. This allows to transform isotopes $H(2,A)$ to $Li(3,A+2)$ and $Li(3,A)$ to $Be(4,A+2)$, $Be(4,A)$ to $B(5,A+2)$, $B(5,A)$ to $C(6,A+2)$, $C(6,A)$ to $N(7,A+2)$, and $N(7,A)$ to $O(8,A+2)$. $O(8,A)$ cannot be transformed to a stable isotope $F(9,A+2)$.

   (b) The addition of dark proton to a stable nucleus $((Z+1,A+1) = (Z,A) + p$ is the key mechanism of WL model and conforms with the basic vision about the DNS as formation of dark proton sequences and addition of dark protons to an ordinary nucleus at the flux tube.

   For instance, one has $Na(11,23) = Ne(10,22)+p$, $P(15,31) = Si(14,30)+p$, $S(16,31) = P(15,30)+p$, $Cl(17,35) = S(16,36)+p$, $K(19,39) = Ar(18,38)+p$, and $Mn(25,44) = Cr(24,54)+p$). All nuclei except $P(15,30)$ appearing in the initial state are stable. $P(15,20)$ suffers (perhaps dark) beta decay to Si(14,30), which is stable. This however does not prefent the addition of proton to take place.

   $Fe(26,56)$ is an important biological ion and could be obtained from $Fe(26,52)$ by an addition of four dark protons with subsequent dark weak decays of proton to neutron. $Fe(26,52)$ is unstable against beta decay to $Mn(25,52)$ in turn unstable about beta decay to $Cr(24,52)$, which is stable.

   (c) One can consider also sums of heavier isotopes. For instance, the sums $K(19,39) = O(8,16) + Na(11,23)$ and $Ca(20,40) = O(8,16) + Mg(12,24)$ are stable biologically important nuclei obtained as sums of stable biologically important nuclei. Biologically important nuclei $Na(11,23)$, $P(15,31)$, $S(16,31)$, $Cl(17,35)$, $K(19,39)$, $Mn(25,55)$ have odd value of A so that they are not obtained as sums of the nuclei constructed using the rules discussed above.

To sum up, that the nuclei obtained as multiples of $He(2,4)$ correspond to several biologically important nuclei can be seen as an indication that dark fusion of at least $He(2,4)$ nuclei takes place in living matter.

7.3 TGD based explanation for the life-like aspects of the system consisting of plastic balls

7.3.1 Experimental findings

The news [I99] is that the system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls, which are not bi-stable systems. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation. Where does the metabolic energy come from?

The durations of the switching time scales are shorter than stable periods and also shorter than predicted by the simulation. The presence of periodicity perturbation, presumably the period for the oscillating phase transition, is suggestive and authors conjecture that there is a weak but yet unidentified periodic signal present required by the proposed stochastic resonance model.

Let us consider first in some detail what the system is and what happens in it.

1. The system studied consists of small charged plastic balls of radius nearly 10 μm (cell size scale) in a cold atmospheric plasma consisting of Argon ions (Ar^+) (see `http://tinyurl.com/yc7q6l7o`). The charged plastic balls consist of melamine formaldehyde (MF) polymers. The plasma is generated using a voltage between electrode and Earth leading to the ionization of Ar to Ar^+: the typical value of voltage is 6 Volt. The electrons from Argon atoms provide negative charge for the plastic balls.

2. Negatively charged BF balls are levitated above the electrode having negative charge given by $Q = CV$, where C and V are the geometrically determined capacitance and the voltage of the ball. In equilibrium position gravitational and electrostatic forces compensate each other when the size of the ball in certain range. Too heavy balls fall down to the electrode and lighter balls levitate and form a cloud, whose thickness is determined by the variation of the radius of plastic balls. BF balls have mutual repulsive action. The negative charge of the balls is screened by Ar^+ ions with screening characterized by Debye length $\lambda_D \sim 1$ mm. There is also a gradient in the density of Ar^+ ions attracting the balls near the centreof the electrode. The situation is modelled in terms of confining harmonic oscillator potentials in vertical and transversal directions.

3. A crystal-like phase is created by the horizontal confinement. In crystal-like phase collective synchronous oscillations in the vertical direction are initiated so that the equilibrium height of hexagonal plastic ball lattice oscillates. Oscillations are damped by dissipation. The oscillation frequency is determined by the sum of gravitational and electric interaction potentials. The variation c_V of the radius of the plastic ball induces a variation of the mass M and capacitance C and therefore also a variation of the oscillation frequencies f_V and f_H in vertical and transversal directions. The typical values of these frequencies are $f_V = 20$ Hz and $f_H = .5$ Hz. This implies that synchrony of oscillations is lost, and eventually a transition to gas-like phase takes place as nucleation centres for gas-like phase are formed. The gas-like phase dissipates its energy.

   Remark: That the ratio $f_V/f_H = 40$ equals to the ratio of cyclotron frequencies of proton and Ar^+ serves as an important guideline in TGD inspired model.

4. The surprise was that for low pressures and low Ar^+ ion densities a transition to crystal-like phase takes place: this transition correspond to a critical value of the variation c_V for the plastic ball radius. Above the critical value of c_V the system remains in gas phase and below it in crystal-like phase. The crystal-like phase is collectively oscillating in vertical direction, which requires energy feed.

   There is synchrony between the dynamics of plastic balls in crystal-like phase, which is lost and leads to a melting and loss of phase phase coherence between oscillations of plastic balls. Particle system was repeatedly melting and freezing.

5. Since the analog of crystal-like phase is repeatedly generated, there must be a feed of energy to the system analogous to metabolic energy feed in living systems. The proposal of the article is that the energy feed is due to a stochastic resonance [D5]. In stochastic resonance noise amplifies oscillatory signal fed into the system if its frequency f satisfies $f = f(spont)/2$, where $f(spont)$ is the average frequency for the jumps between the bi-stable states of the system due to noise. Since the period of conjectured oscillation is $\tau \sim 100$ s one should have $\tau(spont) \sim 50$ s. The period for this process is considerably longer than for the vertical oscillations. The origin of this self-induced oscillation required by stochastic resonance model is not understood and one can even challenge its existence.

Remark: From the point of view of quantum biology it might be highly relevant that plastic balls consists of organic molecules. BF molecules involve aromatic 6-cycles appearing also in DNA. There is negative charge associated with the plastic balls. Also DNA carries negative charges associated with phosphate ions.

The system under study [I99] indeed has several features bringing in mind living cell as it is understood in TGD.

1. The situation is in some aspects analogous to that prevailing over the cell membrane. Cell membrane is analogous to a battery providing metabolic energy for the system via ATP-ADP process. Could the voltage between electrodes creating Ar^+ plasma have analogous function? It seems however that DNS is the what provides the metabolic energy. Ar^+ could be analogous to biological ions such as K^+. The negative charges from Ar atoms are received by plastic balls or even the space-time sheet containing them.

2. Charged plastic balls consisting of melamine formaldehyde (MF) polymers are somewhat analogous to biomolecules such as DNA sequences, which also carry negative charge. The charged plastic balls consisting of MF (see `http://tinyurl.com/z532ryv`) are organic matter. MF contains aromatic 6-cycle appearing also in important biopolymers such as RNA and DNA. Perhaps the plastic balls are not so simple systems as the non-equilibrium thermodynamics based model of experimenters assumes. Could their molecular structure have something to do with the observed life-like aspects of the system? In particular, could the molecular structure make possible the generation of dark proton sequences at flux tubes?

3. The system dissipates and must receive metabolic energy from some source. The metabolic energy feed seems to take place with average period τ of about 100 s. Stochastic resonance requiring periodic oscillation amplified by the stochastic signal is not the only possible explanation. In TGD inspired quantum biology metabolic energy feed induces increase of h_{eff}. The increase of h_{eff} would increase the scale of quantum coherence and make the system crystal-like so that the plastic balls oscillate in synchrony. DNS provide an obvious candidate for the origin of the metabolic energy.

These observations motivate a quantum approach different from the approach based on non-equilibrium thermodynamics and stochastic resonance.

7.3.2 Self-organized bi-stability or oscillations driven by cyclotron radiation and energized by DNS?

The theoretical approach of the experimenters relies on the notions used to describe far-from-equilibrium systems using generalization of thermodynamics. The vision is that the dynamics of complex systems has universal features. Conservative force (gravitational force and electric forces between plastic balls and electrodes and plastic balls), dissipation and stochastic force would be present.

Remark: No driving force is assumed: this would describe the damped oscillations but cannot explain the repetition of the phase transitions.

Stochastic resonance would feed metabolic energy to the system inducing the jumps over potential wall making possible the transitions between the two phases, amplify the vertical and horizontal oscillations, and also give kinetic energy for the plastic balls in gas-like phase.

The summary of the article gives a technical description of the discovery.

The experiments and simulations presented here display a broad class of non-equilibrium phenomena in a single system with minimal ingredients and rich dynamics. We have experimentally demonstrated global bi-stability in a spatially-extended system com- posed of non-bi-stable elements. Given the underlying first-order phase transition between the condensed and gas-like phases, our experiment may be a realization of self-organized bi-stability. The inter-state switching is facilitated by both quenched disorder and dynamical noise. The time scales of individual stable and un-stable periods are not symmetric. Durations of instability are mostly determined by the damping time, whereas the stability durations can be much longer and depend on the nucleation of an energy-redistribution event. This is a common property in many excitable systems, where the relaxation path is more deterministic than the excitation path. However, the distribution of switching timescales in the experiment is narrower than in the simulation. This may be due to a weak periodic signal in the experiment which couples with the noise to induce switching. The source of the periodicity, in addition to controlling the vertical oscillations through modulating the electrode voltage, are subjects of current investigation in our lab.

In the sequel the model is analyzed to identify its possible weaknesses in order to see how TGD inspired quantum approach could allow to circumvent them.

Thermodynamical aspects

The authors assume that the transitions involved are analogous to first-order phase transitions (heat is absorbed or liberated and the transition occurs at constant temperature and regions of both phases are present) between condensed and gas-like phases. Could simple thermodynamical analogies for the transitions between condensed and gas-like phases help to understand the situation?

1. Melting and evaporation require usually heating. Enthalpy of fusion is the quantity describing the energy needed by the heating. It is usually positive (in liquid and gas phases molecules have larger thermal energy than in solid phase). Only for ^3He and ^4He superfluids at sufficiently low temperatures the enthalpy of fusion for melting is negative (see `http://tinyurl.com/pfr84c3`). Also in the recent situation the generation of the damped oscillations would suggest that the enthalpy of fusion is negative.

   Positive enthalpy of fusion for melting requires that energy is fed into the system. It however seems that nucleation centres are generated by the variation of oscillation frequency and that the process occurs spontaneously and transfers energy from the degrees of freedom responsible for the bonding of balls to crystal-like phase to the kinetic energy of balls. Therefore the situation resembles that for Helium superfluid at low temperatures also in this respect. Some additional degrees should be present.

2. Could thermodynamical analogy help to understand what happens in the phase transition between gas-like and crystal-like phases. Freezing usually liberates heat but since heat correspond to completely disordered motion it seems highly implausible that this heat would go to the ordered collective motion of the crystal-like phase.

   In heat engines the amount of heat transformable to work is by second law of thermodynamics below $\gamma = \Delta T/T_h$, where ΔT is temperature difference and T_h the higher temperature. To have synchronous oscillations due the liberated heat, looks highly implausible. If work is done, it must be done by additional degrees of freedom receiving energy and providing it as energy required by the excitation of damped oscillations of crystal-like phase. This option seems plausible.

If one wants to use thermodynamical analogies, it seems that one must assume that there are additional yet un-identified degrees of freedom and a yet un-identified source of energy pumping energy to these degrees of freedom.

The analogy with Helium supra phases

Consider now the analogy with Helium supra phases (see `http://tinyurl.com/zs8rpjm` and `http://tinyurl.com/pfr84c3`).

1. In TGD framework the obvious identification of the additional degrees of freedom is as those associated with magnetic flux tubes of MB forming a network in crystal-like phase. The flux tubes and the cyclotron BE condensates of ions at them would carry energy.

2. The generation of crystal-like phase would require energy. As noticed, this implies resemblance with He^3, in which Cooper pairs give rise to a superfluidity suggesting that the system behaves as a macroscopic quantum system. Cooper pairs of Ar^+ ions could form an analog of super-fluid or super-conductor. Also Cooper pairs of electrons and protons coming from plastic balls could form super-conductors. In TGD framework the members of Cooper pairs would be located at parallel magnetic flux tubes connecting plastic balls [K18, K19, K75, K76].

3. In the transition to gas phase this network would be destroyed as the reconnections between MBs of plastic balls are split and give rise to nucleation regions for gas phase. The splitting would liberate magnetic energy and also energy of cyclotron BE condensates if the value of h_{eff} is reduced. This energy would transform to the kinetic energy of the plastic balls. Therefore the phase transition would liberate energy and would be analogous to the corresponding transition for ^3He. Note that also the TGD based model for supra phases of Helium involves magnetic flux tube network [K29, K30, K31, K32].

4. The phase transition should change the values of $h_{eff}/h = n$ but leave cyclotron frequencies un-affected and thus involve energy feed so that first order phase transition would be in question.

The mechanism inducing vertical and horizontal oscillations of plastic balls

One should identify the mechanism giving rise to the vertical and horizontal oscillations of plastic balls.

1. The authors of the article [I99] propose an identification for the interactions involved. TGD approach suggests additional interaction due to the string tension of the flux tubes giving rise to elastic force and additional interaction energy. As already noticed, the model of authors does not assume resonant driving force although they mention of having tried it. The probable reason for giving up this option is that it allows only the decay of crystal-like phase to gas-like phase but not a repetitive cycle.

2. The ratio $f_V/f_H \simeq 40$ for typical vertical and transversal oscillation frequencies equals to the ratio $m(Ar^+)/m(p) \simeq 40$, which suggests that BE condensates of Cooper pairs of both Ar^+ and protons are indeed present at flux tubes. The condition that cyclotron frequencies are in question, fixes the value of magnetic field strength to $B = B_{end}/15$, where $B_{end} = 2B_E/5 = .2$ Gauss is an endogenous magnetic field assumed be important value of magnetic field in TGD inspired quantum biology and inspired by findings of Blackman and others [J8, J11]. $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field.

   p-Adic length sale hypothesis slightly favors the value $B = B_{end}/16$, which corresponds to the magnetic length $L_B = \sqrt{\hbar_{eff}/eB} = 4L_{B_{end}} = 22.8$ μm (from $L_{B_{end}} = 5.7$ μm) to be compared with the size $d \simeq 10$ μm of the plastic balls.

   One can estimate also the classical cyclotron radii from the formula $r_c = mv/eB = p/QB$, where v is the velocity of the charged particle. For cyclotron orbits with principal quantum number n Bohr quantization gives $r_c = \sqrt{n}L_B$, where $L_B = \sqrt{\hbar/QB}$, is magnetic length. Note that orbits with same radius are possible for $h_{eff}/h = n_i$. $i = 1, 2$ if one has $n_1 = nn_2$ or vice versa.

3. This suggests a mechanism generating vertical and transversal and horizontal oscillations of the plastic balls. The cyclotron radiation resulting in the decay of the BE condensates drives the oscillations resonantly by oscillatory force $F = F_0 \times exp(i\omega t)$ so that one obtains the oscillation amplitude as a sum of damped oscillation amplitude $exp(-\Gamma t)exp(i\omega t)$ and resonance term proportional to $exp(-\Gamma t)exp(i\omega t)t$ increasing in oscillatory manner up to time value $t \sim 1/\Gamma$ and decreasing after that exponentially. The parameters F_V and F_H would be additional parameters in TGD based model.

   Remark: This mechanism could be quite general mechanism of quantum biology.

4. The variation of the plastic ball radius induces a variation of mass and charge of the ball and therefore also a variation of the oscillation frequencies f_H and f_V, which can be however compensated by the variation of the magnetic field strength B at flux tubes inducing variation of string tension and elastic constant so that synchronous oscillations are possible. This is possible only for c_V below some critical value. For larger values the compensation is not possible, and the oscillations lead to gas phase. For smaller values the solid phase is stable. At (quantum) criticality the metabolic cycle becomes possible.

5. The oscillations of plastic balls could be induced by the analogs of Alfwen waves for the magnetic flux tubes which in 1-D approximation for flux tubes would be essentially vibrations of string characterized by string tension proportional to L/S. The energetics of the system would be invariant under changes of $h_{eff}/h = n$ if L and S scale like n, and one would have quantum criticality allowing MB to adapt to the properties of the plastic ball system. A network consisting of springs would provide an analog system. The decay of cyclotron BE condensates would feed energy to the vibrations of string in turn feeding energy to the oscillations of plastic balls. Both energy feeds could be modelled in terms of forced oscillations.

   Quantum criticality would make possible for MB to adapt to the properties of the part of the system consisting of ordinary matter by a proper selection of n since one has $f_c \propto n$ for the same energetics. For given value of B different charged dark particles have different cyclotron frequencies but same energies at quantum criticality. Also the $h_{gr} = h_{eff}$ condition implies that the cyclotron energies do not depend on particle mass and therefore implies quantum criticality.

The energetics of the system

The energetics of the system demands an analog of metabolic energy feed.

1. Authors assume that stochastic resonance provides the needed energy feed but its origin remains open. Stochastic resonance requires an additional oscillator with period about $\tau = 100$ s. According to the authors, the problems of their model are that the transition periods seem to be too short and also the times spent in stable and transition states are not symmetric as they should be in bi-stable system. Also the prediction for the frequency $f = 1/\tau$ tends to be too short.

2. To get the metabolic cycle with forced oscillations without stochastic resonance, one needs a kick providing the energy inducing a phase transition to the crystal-like phase, which also oscillates as a whole thanks to this energy feed. In TGD framework the needed energy dose could be provided by dark nucleosynthesis (DNS) involving formation of dark proton sequences containing perhaps also Ar^+ ions and transforming to ordinary nuclei. The transition could be rather fast and occur in the minimal case only once during the single metabolic cycle of about $\tau = 100$ s so that one would have $\tau \sim 1/\Gamma$, where Γ is the average rate for DNS. Also the phase transition splitting the flux tube pairs by de-reconnection could be rather fast as compared to τ.

   Remark: The periodic signal with frequency $f = 1/100$ Hz is not necessary.

3. Dark cyclotron radiation with $h_{eff}/h = n$ could transform to ordinary photons with energy, which is n-multiple of ordinary cyclotron energy. If n is large enough the photons have energies above thermal energy. In living matter the values of n are in the range $10^{12} - 10^{14}$ so that the cyclotron energies correspond to bio-photon energies in visible and UV range characterizing the transition energies of bio-molecules. If $h_{gr} = h_{eff}$ hypothesis holds true the cyclotron energies do not depend on mass of the charged particle. Also a decay to bunches of n of photons with ordinary energy is possible. Both mechanisms could be involved. The bunches of n ordinary quanta could drive electromagnetic oscillations and mechanical (acoustic) oscillations. In piezo-electrets populating living matter the transformation of electromagnetic and acoustic oscillations to each other is possible.

4. The rate Γ of DNS events is in the first approximation proportional to the number of plasma balls events if the DNS even for single ball feeds energy for the entire system. Γ cannot be much lower than $f_c(Ar^+) = .5$ Hz since the system would remain to crystal-like phase. It Γ is too high, the transition to gas phase becomes impossible.

Is the frequency $f \sim .01$ Hz needed in TGD based model?

It is not at all clear whether frequency $f \sim .01$ Hz required by the stochastic resonance model is needed nor even possible as a cyclotron frequency in TGD inspired model.

1. If f is present, one can wonder whether it could be associated with the cyclotron BE condensate at the magnetic bodies of plastic balls. Could the plastic balls at some level in the hierarchy of space-time sheets behave like particles in quantum sense (the space-time sheet assignable to the plastic ball)? Does it make sense to talk about crystal-like phase as a kind of cyclotron BE condensate of charged plastic balls? Or is there energy feed from quantal cyclotron degrees of freedom assignable to the magnetic flux tubes to classical degrees of freedom of plastic balls?

2. The simplest working hypothesis to be killed is that both plastic balls, protons, and Ar^+ ions are at the same flux tubes of MB so that the value of magnetic field is fixed to about $B_{end}/15$, $B_{end} = .2$ Gauss. The order of magnitude for the cyclotron frequency turns out to be several orders of magnitude lower than $f = .01$ s. Hence it seem that there is no obvious manner to introduce $f \sim .01$ Hz in the model.

   The following little calculation gives the estimate.

1. One has $f_c = QB/2\pi M$, where $Q = CV$ and C is the capacitance of the plastic ball. C is purely geometric parameter and for single ball with radius d embedded in dielectric with relative permittivity ϵ_r it is determined by the value of Coulomb potential $V_c = Q/4\pi\epsilon$ at the surface of the ball. This gives

$$C/Farad = 4\pi\epsilon d = \epsilon_r \times (d/meter) \times 5.224 \times 10^{-12} \ .$$

2. The mass of the ball is given by $(4\pi/3)\rho d^3$, where ρ is the density of the ball which in an approximation needed for order of magnitude estimates given by

$$\rho = \frac{m_p}{a^3} \ , \quad \frac{a}{Angstrom} = 1$$

3. From this one obtains for the cyclotron frequency the expression

$$f_c(ball) = 3 \times \epsilon_r \frac{d}{meter} \times (\frac{a}{d})^3 \times \frac{V}{Volt} \times \frac{B}{B_{end}} \times 3.3 \times 10^7 \times f_c(p, B_{end}) \ ,$$
$$f_c(p, B_{end}) = \frac{eB_{end}}{m_p} = 300 \ Hz \ .$$

   Using the values

$$\frac{V}{Volt} = 6 \ , \quad \frac{d}{meter} = 10^{-5} \ , \quad \rho = \frac{m_p}{a^3} \ , \quad B = \frac{B_{end}}{15}$$

   this gives the estimate

$$f_c(ball) \simeq \epsilon_r \times 5.8 \ days \ .$$

   For vacuum with $\epsilon_r = 1$ the frequency is smallest possible. It is not possible to obtain $f_c \sim .01$ Hz for reasonable strength of B.

   What about cyclotron frequencies of cells and cell membranes assuming $B = B_{end}$?

1. Cells are also negatively charged but the charge of the cell is rather small (see `http://tinyurl.com/yb9w6nqs`)- about 10^3 e for yeast cell so that Q/M ratio is very small.

2. What about cell membrane treated as single unit? The capacitance per unit area does not depend much on cell (see `http://tinyurl.com/chylvs9`) being given in good approximation by

$$c = \frac{dC}{dS}\frac{cm^2}{Farad} = 2 \times 10^{-6} \quad .$$

The capacitance is from this given by $C = c \times S$. Assuming spherical symmetry, the estimate for the cyclotron frequency $f_c(membrane)$ is

$$f_c(membrane) = 3c \times a^2 \times \frac{a}{d} \times f_c(proton, B_{end}) \times \frac{Coulomb}{e} \times \frac{V}{Volt} = 1.5 \times 10^{-7} \times \frac{10\mu m}{d} \times \frac{B}{B_{end}} \times \frac{V}{.05\ Volt}\ Hz \quad .$$

For $d = 10\ \mu m$ and $B = B_{end}$ and $V = .05$ Volt the cyclotron time is 77.2 days. For DNA sequences the cyclotron frequencies are around 1 Hz irrespective of their length.

Some observations about Argon ions

A couple of comments about the possible role of Argon are in order.

1. I ended up with the recent vision about living matter on basis of observations that the radiation at cyclotron frequencies of Ca^{++} ions and also other biologically important ions have effects on physiology and behavior of vertebrates [K74, K73]. The magnetic field involved was $B_{end} = 2B_E/5$, where $B_E = .5$ Gauss is the nominal value for the magnetic field of Earth. The cyclotron frequencies of Ca^{++} in B_{end} are multiples of $f_c(Ca^{++}) = 15$ Hz. Ca has $(20, 40)$ whereas Ar^+ has $(A, Z) = (40, 18)$. Therefore the cyclotron frequency of Ar^+ (which is fermion) is in good approximation one half of that for Ca^{++}: $f(Ar^+, B_{end}) = f_c(Ca^{++})/2 = 7.5$ Hz. TGD based model for high Tc and bio-superconductivities suggests that Ar^+ ions could form Cooper pairs with members at flux tubes with opposite directions of magnetic field.

   What puts the bells ringing is that $f(Ar^+, B_{end})$ is quite near to the lowest Schumann frequency assignable to the oscillations of B_E serving as a candidate for a correlate for collective levels of consciousness? Could the collective effects be partially due to B_{end}? The problem is however that cyclotron period of Ar^+ is considerably shorter than the periods τ_V and τ_H associated with the oscillations of plasma balls and with the metabolic cycle.

2. What does one mean when one says that Ar^+ ions are dark? Could Ar^+ ions be dark atoms in the sense that the electron is not lost but is transformed to a dark valence electron with scaled up size of orbital proportional to n^2 [L33]. Ar^+ ion would be analogous to Rydberg atom [L18]. Dark electrons could form dark super-conductor coupling with its total charge to the electric field of the negatively charged electrode. The members of Cooper pairs could reside at parallel flux tubes connecting plastic balls with parallel or antiparallel magnetic fluxes. This could explain the synchronous oscillation of the plastic balls and also the formation of crystal-like phase.

Could DNS serve as the source of metabolic energy in the system studied?

The system considered requires metabolic energy. The metabolic energy would be fed to the system as it transforms to crystal-like phase and is dissipated via vertical oscillations in the force field defined by gravitational and electric fields. Unless the experimental arrangement involves a hidden energy feed, there must be present some unidentified source of metabolic energy in the system itself, that is plastic balls plus Ar^+ ion plasma.

TGD inspires the proposal that DNS generates the metabolic in pre-biotic systems, where photosynthesis need not be present yet and there is no storage of metabolic energy to biomolecules. Could something analogous to DNS take place also now?

1. If one wants to identify both f_V and f_H as cyclotron frequencies for the same value of magnetic field, one must assume that both Ar^+ and H^+ ions are present. Therefore the formation of dark proton sequences suffering dark weak decays to dark nuclei containing neutrons becomes possible. The TGD based model [K21] [L16, L30] predicts is that the spectroscopy of dark nuclei is the same as those of ordinary ones if dark nuclear binding energy scale and neutron proton mass difference are both scaled down like $1/h_{eff}$. The occurrence of nuclear transmutations caused by dark nucleosynthesis is the basic prediction.

2. Also the fusion of Ar^+ nuclei and dark nucleon sequences is possible. The dark fusion of two Ar^+ nuclei with $(Z, A) = (18, 40)$ proceeding via formation of dark Kr nucleus consisting of two Ar^+ nuclei and transformation to ordinary Kr would produce stable Krypton isotope with $(Z, A) = (36, 80)$ liberating nuclear binding energy ~ 7.6 MeV assuming that the dark nuclear binding energy is negligible (the model predicts it to be of order of few keV). Sn isotope with $(A, Z) = (120, 50)$ is the lightest isotope with mass number $3 \times 40 = 120$ of 3 Argon nuclei. This would require the transformation of 4 protons to neutrons by dark beta decay to reduce total charge 54 to 50. This process would however requires energy of 21 MeV and would therefore not occur spontaneously.

   Kr production would be a testable signature of this mechanism. Kr could end up to the negatively charged plastic ball or negative electrode. This would induce a loss of Argon from the system. Could the loss of Ar^+ and production of Kr ions be detectable?

DNS or at least the transformation of dark nuclei to ordinary ones could be a stochastic process. If this mechanism provides metabolic energy for prebiotic lifeforms, it should be able to sustain itself. There should be some signal making possible charge separation leading to the generation of dark proton sequences at flux tubes in turn leading to DNS and the generation of crystal-like phase in turn generating the cyclotron radiation.

1. A possible mechanism is suggested by Pollack effect [L13] [L13] occurring in water environment bounded by gel in the presence of suitable signal providing energy. There are several kinds of signals providing energy such as light at visible or IR frequencies or even a mechanical perturbation. What happens that water molecules, which are already in excited state near the splitting of hydrogen bond lose one proton as they absorb photon and proton becomes dark and goes to magnetic flux tube. The generation of the excited state requires UV energy of order 5 eV. Solar radiation or possibly occurring DNS events could provide the UV light.

   In the recent case water and gel phase are missing. One might however hope that the dark photons - say those with UV energies - transforming to ordinary photons could induce charge separation in BF balls or at their surface layers and transform protons to dark protons at flux tubes. If the cyclotron radiation from decaying cyclotron BE condensates corresponds to a value of Planck constants for which dark photons transform to bio-photons, this condition is satisfied. This is implied by $h_{gr} = h_{eff}$ hypothesis. If this takes place the total negative charge of plasma balls should be larger than the total charge of Ar^+ ions.

2. Could the charge separation zg the surface of plasma balls give rise to an analog of cell membrane like structure giving rise to (generalized) Josephson junctions? If so, the analogy with living cell would become even deeper. Also the flux tubes between plasma balls act as Josephson junctions making possible oscillating non-dissipating currents generating dark Josephson photons with energy $E = eV$ and frequency $f_J = eV/h_{eff}$.

7.3.3 Speculative connections with TGD inspired views about quantum biology and consciousness

The model for the findings has allowed to develop in more detail the basic ideas of TGD inspired quantum biology.

1. The model has led to a concrete proposal for how the MB controls BB using forced electromagnetic and mechanical oscillations at low frequencies by using the transformation of dark photons to bunches of low energy photons. Also the analogs of Alfwen waves suggest themselves as a control mechanism.

2. DNS could provide a universal pre-biotic mechanism for producing metabolic energy and the needed elements. This mechanism might be active even in the recent biology in some exceptional situations [I57]. DNS is also predicted to precede ordinary nucleosynthesis in pre-stellar evolution so that primordial metabolism would not depend on chemistry and pre-biotic and pre-stellar evolution could proceed hand-in-hand and DNS would produce heavier elements also outside the stars [L30].

   Even more, TGD based model for dark DNA identifies sequences of dark protons as analogs of DNA with sequence of 3 protons serving as analog of DNA codon. Also the dark analogs of RNA,tRNA, and amino-acids are predicted. Dark DNA sequences are dark nuclei so that the emergence of dark DNA would mean also the emergence of DNS as a basic metabolic mechanism. This would resolve the egg-or-hen problem about whether genes or metabolism came first.

3. The chemical structure of plastic balls involves aromatic 6-cycles associated also with DNA nucleotides. Both DNA and cell are negatively charged and thus analogous to the negatively charged plastic balls. Could negatively charged regions, about which the exclusion zones (EZs) of Pollack formed to water in presence of say visible light have served precedessors of cells?

4. Gel-sol transition and protein folding and unfolding are basic processes of cell biology. Could the proposed basic control mechanisms control also these processes. Could gel-sol transition and protein unfolding correspond to a melting of crystal-like structure and splitting of flux tube pairs to U-shaped flux loops or vice versa induced by a change of h_{eff}?

5. Could quantum criticality realized as a family of flux tubes with fixe L/S ratio and same energetics but with varying value of $h_{eff}/h = n$ make possible the adaptation of the dynamics of MB to the dynamics of various oscillations of BB? This would be essentially entrainment making possible both sensory perception and motor actions. Control of mechanical processes at the level of ordinary matter would involve the decay of dark low frequency photons to n ordinary photons. Chemical control would involve transition to single ordinary photon with n-fold frequency.

This view is also supported by the realization that brain consciousness is not a continuous stream but more like a sequence of flashes (see `http://tinyurl.com/y84az3bh`). This is one of the basic predictions of TGD inspired theory of consciousness based on what I call zero energy ontology (ZEO). One can say that the sub-self (mental image) is a life-cycle of a conscious entity and that one has sequences of this kind of periods with opposite arrows of time: self dies and reincarnates with opposite arrow of time. Consciousness would have sleep-awake cycles in all time scales. This would give rise to various bio-rhythms. In EEG this would show itself as a decomposition to portions of duration of order .3 seconds.

In ZEO this could be interpreted in terms of a sequence of life cycles in which time increases in opposite directions: first at (call it) "upper" boundary of causal diamond (CD), which shifts towards geometric future, then at "lower" boundary, which shifts to geometric past, and so on... . Note that the birth at given boundary is only slightly later than the latest death at it so that also our wake-up period at level to which EEG is associated could be repeated births and reincarnations forming an approximate continuum at given boundary of CD. Also wake-up-sleep cycle could be like this. Strobing character is predicted to be a universal feature of consciousness.

In TGD inspired quantum biology the strobing character of consciousness can be related to the nature of metabolism, which does not take place as continuous feed of energy but as doses with some average rate.

To sum up, the cautious non-orthodox proposal is that the description of the finding in terms of the notions of non-equilibrium thermodynamics might not be enough. Rather, a generalization of quantum theory introducing a hierarchy of Planck constants explaining dark matter and providing a general TGD inspired model for living matter would be needed.

7.4 A system of particles able to self-assemble and self-heal in presence of acoustic waves

In previous section as system consisting of plastic balls as a system exhibiting primitive like properties was dicusse. Another very simple system with life-like properties consist of particles floating on top of a glycerin-water solution.

7.4.1 Experimental discovery

A popular article "*Sound waves direct particles to self-assemble, self-heal*" (see `http://tinyurl.com/ybefq2ah`) telling about another particle system far from thermal equilibrium and exhibiting life like properties. Scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) demonstrated how particles, floating on top of a glycerin-water solution, synchronize in response to acoustic waves blasted from a computer speaker. The article "*Emergence of an enslaved phononic bandgap in a non-equilibrium pseudo-crystal*" [D3] (see `http://tinyurl.com/ybugqjr6`) telling about the study is published in the journal Nature Materials.

In this case there is an energy feed to the system realized as a monochromatic sound wave. The system responds to an incoming sound wave and gradually the average response of the system which is in the beginning of the experiment essentially constant as function of wavelength develops a wave length gap in the response below the wave length of the incoming sound wave. The emergence of forbidden wavelengths can be interpreted as a synchronous response modellable as a reaction of damped oscillation to a driving force at resonance frequency. The video of the popular article shows how the wave length gap emerges in time scale of 45 minutes. Also the theoretical prediction for the response is given as a curve and is agrees rather nicely with the outcome.

The comment of the co-lead author Chad Ropp, a postdoctoral researcher in Zhang's group is following.

> We show that individually 'dumb' particles can self-organize far from equilibrium by dissipating energy and emerge with a collective trait that is dynamically adaptive to and reflective of their environment. In this case, the particles followed the 'beat' of a sound wave generated from a computer speaker.

To my opinion "beat" cannot however mean here what it means usually since this requires that input acoustic signal would be superposition of signals with nearly same frequencies and beat would occur with frequency which is difference of these. This unless one interprets the acoustic signal as beat signal associated with the frequency difference.

The abstract of the article gives a more technical description about what happens.

"Material systems that reside far from thermodynamic equilibrium have the potential to exhibit dynamic properties and behaviours resembling those of living organisms. Here we realize a non-equilibrium material characterized by a bandgap whose edge is enslaved to the wavelength of an external coherent drive. The structure dynamically self-assembles into an unconventional pseudo-crystal geometry that equally distributes momentum across elements. The emergent bandgap is bestowed with lifelike properties, such as the ability to self-heal to perturbations and adapt to sudden changes in the drive. We derive an exact analytical solution for both the spatial organization and the bandgap features, revealing the mechanism for enslavement. This work presents a framework for conceiving lifelike non-equilibrium materials and emphasizes the potential for the dynamic imprinting of material properties through external degrees of freedom.

The system has energy feed as acoustic wave (from the left in the video) which gradually shifts the system to the right. Therefore the far from equilibrium thermodynamics without stochastic resonance works satisfactorily. TGD vision might provide a competing quantum description.

Also now the system involves materials appearing in living matter. Glycerin is closely related to glycerol and glycerol (see `http://tinyurl.com/p7mr2bj`) backbone appears in lipids serving as basic building bricks of cell membrane). Glycerin is dissolved in water, which is in a key role in TGD inspired quantum biology. Since I have only access to the abstract of the article, I do not know what is whether the particle are organic material too.

7.4.2 TGD inspired model

One can develop a model for the system based on TGD inspired quantum biology. This involves the notion of magnetic body carrying dark matter identified as $h_{eff} = n \times h$ phases; a network of magnetic flux tubes (magnetic body (MB)) controlling biological body and responsible for coherence and synchrony; the control of the oscillations of BB by cyclotron radiation resulting from decays of cyclotron condensates of charged particles. The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and "cold fusion" and serving as a source of metabolic energy in the prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

The recent view about self-organization [L65] based on zero energy ontology (ZEO) based quantum measurement theory predicts that in "big" (ordinary) state function reductions (BSFRs) the arrow of time changes. In time reversed mode dissipation occurs in the reversed time direction and looks like energy feed (or extraction of energy from the environment). This allows "breathing" of the system as a sequence of BSFR even in the absence of energy feed.

In the recent situation the simple system is a particle system with a feed of acoustic energy at single wavelength. What happens is that the distribution of particles develops synchronous oscillations in the wave length band, and the amplitudes are reduced in this band so that the wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

Can one apply the general quantum description to explain the frequency gap?

1. The metabolic energy feed is now by acoustic oscillations and should induce the phase transition generating magnetic flux tube network containing dark particles having $h_{eff} = n \times h$ responsible for the synchronous oscillations.

2. Quantum criticality at the level of the MB could make adaptation possible. The flux tubes with same ratio of L/S of length L and transversal area S scaling like $h_{eff}/h = n$ so that L/S remains invariant under scalings of h_{eff} correspond to same magnetic energy and cyclotron energies. Adaptation would mean that cyclotron frequency for BE condensate of say protons at magnetic body becomes nearly equal to the frequency of sound wave by a suitable choice of n if the value of magnetic field strength is in reasonable range: this means that flux tubes tune their length and thickness by magnetic motor actions. Note that in pseudo-crystal phase exhibiting life-like aspects it would be MB which drives rather than sound wave. Cyclotron radiation from BE condensates at MB would drive the synchronous oscillations of particles at the nodes of flux tube network performing oscillations (generalization of Alfwen waves to oscillations of flux tube analogous to string vibrations).

3. The wavelength distribution of the response evolves from an asynchronous response of the particles to acoustic wave to that corresponding to pseudo-crystal and dictated by the response of MB to acoustic wave. In the initial situation the response does not depend on λ. The response of MB affects the particle system only in a narrow band of wavelengths below $\lambda = lambda < 0$ and "freezes" it in this range.

4. The quantum model for the plastic ball system would suggests an analog of entrainment with the acoustic frequency occurring also in brain. Flux tube network would "freeze" the acoustic oscillations of the system of balls in the wavelength gap forcing them to oscillate in phase but with reduced amplitude. The energy would go to increasing the magnetic energy of flux tubes and to Alfwen waves of MB analogous to lattice oscillations and having a wavelength band around the acoustic wavelength. Due to the "freezing" the amplitude of the oscillations becomes small in the gap. The energy distribution in the wavelength region outside the gap would not be affected.

The analogs of Alfwen waves are realized as stringy oscillations of magnetic flux tubes at MB. Alfwen waves have a wavelength band around the acoustic wavelength. The wavelength band is analogous to energy bands associated with energy levels of atoms in solids.

5. The healing of the system would mean a regeneration of the MB or the self-organization of the system controlled by under metabolic energy feed. ZEO making possible time reversals and extraction of "metabolic" energy from the environment would make possible "breathing" and healing even in absence of energy feed: in time reversed mode thermal energy would serve as energy feed. The ability to react to sudden changes in the environment might be understood in terms of the ability of MB to adapt in the proposed manner. It would be interesting to see how the system reacts to the change of the acoustic frequency. The model would require change of the value of $h_{eff}/h = n$.

To sum up, essentially the same quantum model could describe both the system of plastic balls and the recent system. Now acoustic wave would serve as the source of metabolic energy and metabolic energy would be fed to MB.

7.5 A model for the control of biological body by magnetic body

The recent work in attempts to understand various surprising findings [I99] [D3] about very simple self-organizing systems assuming that they are actually macroscopic quantum systems at the level of magnetic body (MB) leads to a rather concrete model for how MB carrying dark matter identified as $h_{eff}/h = n$ phases controls the part of system consisting of ordinary matter - biological body (BB) in biological context. The key element is magnetic body (MB) involving flux tube network able to make $h_{eff} = n \times h$ changing phase transition changing its connectivity (the extreme corresponds to phase transition between crystal-like and plasma-like states).

The control is assumed to involve Alfwen waves with the frequencies of cyclotron transitions for the dark matter. Alfwen waves induce resonant forced oscillations of the particles at the nodes of the network. MB adapts to the dynamics of BB by using quantum criticality: if the length L and transversal area S of flux tube are scaled up by n, the ratio L/S is unaffected and the energetics of the system (cyclotron energies and the magnetic energies of the flux tubes) remains un-affected but frequencies scale by n. By a suitable choice of n system and L/S ratio MB can gain control over BB.

In the sequel this picture is tested in biological context. If MB controls basic biological processes at BB then cyclotron frequencies for biologically important ions determine the time scales of basic bio-processes involving various kinds of molecular motors. In communications from BB to MB the difference Δf_c of cyclotron frequencies of ions associated with cell membrane at different sides of cell membrane and would determine the time scales of these communications [K78, K36, K73]. For large enough values of n membrane potential would add a small contribution $\Delta f = ZeV/h_{eff}$ to Δf_c and code nerve pulse patterns and therefore sensory information to the Josephson radiation.

7.5.1 The basic hypothesis

The basic hypothesis which led to the idea about hierarchy of dark matter labelled by n and having purely number theoretic interpretation in adelic physics [L34] is that the magnetic field at flux tubes has a spectrum of values. The ideas ab out the spectrum for the values of magnetic field has generalized gradually.

1. The first working hypothesis inspired by the work of Blackman [J11] was that the most important value is what I have called endogenous magnetic field $B_{end} = 2B_E/5$, where $B_E = 0.5$ Gauss is is the nominal value of the Earth's magnetic field.

2. This assumption turned however to be too restrictive. The spectrum of visible bio-photons identified as resulting in a phase transition transforming dark photons to ordinary photons with the same energy would correspond to that of magnetic fields corresponding to single octave.

3. The hypothesis that bio-photons with energy range in visible and UV assignable to molecular transition energies result from dark photons by energy conserving transition, predicts that actually several octaves are involved.

4. One can assign the spectrum of magnetic fields strengths also to the audible frequencies making in the case of humans 10 octaves. One could see the emergence of higher octaves as outcome of evolution extending gradually the repertoire of control actions performed by MB.

5. One can argue that the field strengths at MB are probably not higher than say .2 Tesla, which corresponds to $10^4 \times B_{end}$ and to 13 octaves as an upper bound for the range of magnetic fields. This gives a strong upper bound for the cyclotron frequencies. In case of proton the upper bound is $f_c(p) < 3$ MHz. For bats the range of audible frequencies extends to MHz. In the case of Fe this would correspond to $f_c(Fe^{2+}) < .1$ MHz. This gives a strong limitation on processes controllable by cyclotron radiation.

For signals from cell membrane the limits are not so strong. Suppose that generalized Josephson frequencies are responsible for the communications. Ordinary Josephson frequency equals to ZeV/h_{eff}, where $V \sim .05$ Volts is membrane potential. For small h_{eff} ordinary Josephson frequency dominates over the difference of cyclotron frequencies this allows rather high frequencies below 5×10^{12} Hz. One might argue that at this limit BB sends metabolic energy to MB. For large values of h_{eff} ordinary Josephson frequency gives only rise to a small modulation coding for nerve pulse patterns. At this limit BB would send only information to MB.

In the following the simplest hypothesis $B = B_{end}$ is taken as a starting point and applied to various situations. One can make several questions. One can consider the situation from the point of view of control of BB by MB and communications from BB to MB.

1. Control of BB by MB.

   The most important activities are control of phosphorylation of ADP to ATP using ATPase enzyme, replication and transcription of DNA, and translation. Various molecular motors such as ATPase, DNA and RNA polymerases, helicases, and various propellers (flagellas, kinesin, dynein) represent examples of bio-control.

   What could one say about the role of the control based on cyclotron radiation at the level of bio-catalysis? For instance, could one understand the time scales of DNA transcription and mRNA translation. Note that they should be nearly the same in an optimal situation so that also the corresponding cyclotron frequencies should be essentially same. Could one understand the role of cofactors - say Mg^{2+} - necessary for the action of enzymes using cyclotron radiation hypothesis?

2. Communications from BB to MB.

   If generalized Josephson radiation from the cell membrane to MB is responsible for these communications then the cyclotron frequencies for the ions assignable with nerve pulse transmission should be of key importance.

7.5.2 Metallic and organic cofactors

Cofactors (see `http://tinyurl.com/d6jnd49`) are necessary for the functioning of enzymes possibly realizing the bio-control by MB. They can be divided into metal ions and organic co-factors. The working hypothesis is that the cyclotron frequencies associated with co-factors coordinate the functioning of enzyme and determine the ratew of the processes involved.

It is assumed that for given oxidation state assignable to a compound also free ion with ionization state equal to the oxidation state can appear. Table 7.1 gives the cyclotron frequencies of metallic cofactors for their oxidation states.

For instance, the ions Mg^{2+}, Mn^{+}, Cu^{+}, appear as metallic cofactors. For$B = B_{end}$ they have cyclotron frequencies 25.0 Hz, 10.9 Hz, and 4.8 Hz ($f_c(Fe^{2+}) = 2f_c(Mn^{+})$). Note that Ca^{++} is often regarded as signalling ion rather than co-factor but that it has also important role in catalysis. A natural guess is that the cyclotron frequencies define typical rates for bio-catalytic reactions for which enzyme has metal ion as a co-factor.

Metal	*A*	*Oxidation states*	f_c/Hz
Mg	24	2	25.0
Ca	40	2	15.0
Cr	52	3	17.3
Mn	55	2	10.9
Fe	56	$(2,3)$	$(10.7,16.0)$
Co	59	$(1,3)$	$(5.1,15.3)$
Cu	64	1	4.7
Zn	65	2	9.2
V	51	$2,...,5$	$(9.2,...,29.4)$
Mo	96	$-2,1,...,6$	$(3.1,...,15.7)$
Cd	112	$(1,2)$	$(2.7,5.4)$
I	127	$(1,2,..)$	$(2.4,...)$

Table 7.1: Metallic cofactors possibly important for the control of BB by MB. A denotes atomic weight for the most stable isotope. Cyclotron frequencies are calculated for $B_{end} = .2$ Gauss.

Ion	*A*	*Oxidation states*	f_c/Hz
Li^+	(6,7)	1	$(50.0,42.8)$
Na^+	23	1	13.0
Cl^-	55	-1	8.6
K^+	39	1	7.7
Ca^{++}	40	(1)	15.0

Table 7.2: Ions possibly important for communications from BB to MB. A denotes atomic weight for the most stable isotope. The smallest cyclotron is calculated for $B_{end} = .2$ Gauss.

There also organic cofactors having typically mass number less than 1000. This implies that cyclotron frequency is above $f_{min}0.3 \times Z$ Hz for $B = B_{end}$ if the organic cofactor has charge Z. The first guess is that also their cyclotron frequencies are important and play the same role as those of metallic cofactors. These cyclotron frequencies are considerably lower than metallic cyclotron frequencies unless the cofactor has constant charge density. DNA is a good example of molecule with constant negative charge density: the cyclotron frequencies are rather near to 1 Hz independent of the DNA sequence.

7.5.3 Biologically important ions assignable to the communications from BB to MB

There are also other important biological ions involved with the communications from BB to MB. Besides Ca^{2+} ion also Na^+, Cl^-, K^+ are important ions in the dynamics of nerve pulse transmission. In TGD inspired for nerve pulse and EEG the generalize Josephson frequencies for these ions are involved with the communications from brain to MB. Li^+ ion is also known to be important and too low concentration of Li^+ is known to correlate with depression and infection like state of brain.

All these frequencies are in EEG range. Li_6^+ cyclotron frequency is 50 Hz and is known to correspond to a frequency having effects on living matter. Li_7^+ cyclotron frequency is 37.5 Hz and is rather near the thalamocortical resonance frequency with nominal value of 40 Hz.

There are bio-molecules involved with signalling inside bio-system rather than from BB to MB. First messengers consist of hormones and neurotransmitters. Second messengers couple to first messengers to overcome the cell membrane barrier (see `http://tinyurl.com/yajhj9zb`. An interesting question is how they relate to the communications from MB to BB: could cyclotron radiation control these communications?

I have proposed that messengers do note represent real communications but only represent

the ends of the communication lines so that their transfer would generate flux tube connections between the sender and receiver. The real signal would proceed as dark photons and/or super currents along the flux tube connections. If so then MB would control communication by first and second messengers by building the communication lines unless they already exist as flux tubes.

Second messengers include also neutral gases such as NO, CO and H_2S. Hydrophobic molecules such as diacylglycerol, and phosphatidylinositols and hydrophilic molecules such as cAMP, cGMP, IP3 appear as second messengers. For instance, could control of MB be involved to the transformation of first messenger signal to second messenger signal. Note that also Ca^{2+} is second messenger.

7.5.4 About the role of cyclotron frequencies in the bio-control by MB

Bio-catalysis is a basic tool of bio-control and should be controlled by MB. Enzymes should involve a part making possible the control by MB, and so called cofactors (see `http://tinyurl.com/d6jnd49`) are excellent candidates for this part since without them enzyme does not perform its function.

In the following the cyclotron frequency hypothesis is tested for some biologically important processes assuming $B = B_{end}$. There is a web page (see `http://tinyurl.com/y7aes93x`) about various scales involved with the key biological processes.

I proceed from fast to slow time scales starting from ATP synthesis and proceeding via DNA related processes involving Mg^{2+} as cofactor to oxidative metabolism involving Fe^{2+}.

7.5.5 Molecular motors

Molecular machines (see `http://tinyurl.com/h3dqauo`) are divided into two categories: molecular switches, which perform control actions and molecular motors. One might regard molecular switches as higher level motors. Here is a brief summary of molecular motors.

Molecular motors (see `http://tinyurl.com/y879vdel`) come in several types.

1. Rotary molecular motors include F_0F_1 ATP synthase (briefly ATPase) family of proteins (see `http://tinyurl.com/h23hjkn`) converting the electrochemical energy in presence of a proton gradient over the cell membrane to the chemical energy of ATP (or vice versa).

   The rotary motion of the shaft of F_0F_1 rotor makes the addition of phosphates. The rotating shaft is analogous to an assembly line containing ADPs to which phosphates are added as it rotates. The flow of protons through cell membrane pumped back through membrane using the metabolic energy from nutrients provides energy for the rotary motion and ATP. One can wonder whether this energy is provided as dark Josephson photons.

   The maximal rotation frequency is 300 Hz which corresponds to the proton cyclotron frequency for $B = B_{end}$. This suggests that dark protons at either side of membrane structure could coordinate ATP synthesis. ATP serves as universal metabolic energy currency so that this mechanism would appear everywhere in bio-logy.

   The rotary motor controlling flagellum can turn as fast as 300 Hz (see `http://tinyurl.com/yaoowf9l` and `http://tinyurl.com/ybotnsg4`), which suggests that proton cyclotron frequency in B_{end} determines the upper limit for the rate.

2. Polymerization motors are rather complex motors. Actin polymerization uses ATP. Microtubule polymizerization GTP uses GTP. Dynamine (see `http://tinyurl.com/ycp5t52p` is a GTPase responsible for the separation of clathrin buds from the plasma membrane.

   Actin (see `http://tinyurl.com/y9npk83f`) polymerization involves competing factors (see `http://tinyurl.com/y7hqmm72`). The rate has upper bound .3 $\mu m/s$. Actin monomer is called G-actin, and actin (micro-)filament formed from actin monomers is called F-actin. Actin monomer has mass of 41,795 proton masses and charge of -7 units (for B_{end} this would correspond to cyclotron frequency .05 Hz).

   Actin monomers are accompanied by both ATP molecule and Mg^{2+} suggesting that both cyclotron frequencies are involved with the coordination of polymerization. From the length taken by single actin monomer about 2.75 nm one can conclude that the average rate is in

the range 5.5 actin monomers per second to be compared with the $f_c(Mg^{2+}) = 25$ Hz. The assumption that cyclotron frequency coordinates the process does not seem plausible.

3. Cytoskeletal motors (myosins for muscle contraction, kinesin for moving cargo along microtubules, and dynein producing axonemal beating of flagellum and moving cargo along microtubules). These rely on ATP so ATPase (dark proton cyclotron frequency) is expected to dictate the rate. These motors bind filamentous actin and are also rather complex.

Nuclei acid motors

There is a large variety of nucleic acid motors. Consider first motors, which do not utilize ATP.

1. DNA polymerase (see `http://tinyurl.com/y9k9k8zj`) turns single-stranded DNA to double-stranded DNA. These motors use deoxynucleoside triphosphate XTP, C= A, T, C, G. XTP transforms to XMP by dropping diphosphate and XMP is attached to the growing DNA strand. Note that ATP gives only P to the acceptor molecule.

   One can distinguish between two rates.

   (a) The average DNA polymerase requires about one second to locate and bind to a primer/template junction. Once it is bound, a non-processive DNA polymerase adds nucleotides at a rate of one nucleotide per second. Interestingly, the cyclotron frequency of DNA sequence in B_{end} is near 1 Hz irrespective of the length.

   (b) Processive DNA polymerases works much faster since single catalytic event adds large number of nucleotides to the polymer. The rate of processive polymerization at 37 °C is 749 nucleotides per second and corresponds to about 250 codons per second. This suggests that the rate of processive polymerization is determined by ATPase driven at proton cyclotron frequency of 300 Hz.

2. RNA polymerase (see `http://tinyurl.com/y982vb46`) catalyzes the transcription of DNA to RNA (see `http://tinyurl.com/ydaosrhg`). The basic mechanism might be though to be similar to that of DNA polymerase but the structure of these molecules is different. RNA polymerization is also 20 times slower that than DNA polymerization in E. Coli suggesting that cyclotron frequency of Mg^{++} ions, which are indeed involved, determines the rate.

   The averate rate for DNA transcription and RNA translation has upper limit of 24 codons per second and could naturally correspond to the cyclotron frequency 25 Hz of Mg^{2+} for $B = B_{end}$ appearing as cofactor in the catalyst.

3. DNA helicases (see `http://tinyurl.com/y8h3jsq2`) separate double strands of nucleic acids prior to transcription or replication. DNA replication, transcription, translation, recombination, DNA repair, and ribosome bio-genesis utilize DNA helicase. DNA strand is known to rotate during the transcription.

   If the rotation is in a direction opposite to the twisting of DNA strand, the DNA strand could open if helicase simply fixes the position part of DNA codon at which the transcription begins. Since the strands are twisted in opposite directions, this mechanism requires that the transcription takes in opposite directions for the complementary strands: this is indeed known to be the case. The average rate of opening is about 20 codons per second and opening of the strand. The rate of opening could thus be determined by the RNA polymerase having Mg^{++} as cofactor.

   Using quantum classical correspondence (QCI) the classical angular momentum assignable to the rotation of DNA can be estimated to be

$$\frac{L}{\hbar} \sim 2\pi N \langle A \rangle \frac{d^2 \times f}{L_p} \sim 172 \times N \quad .$$

   Here N is the number of rotating nucleotides,$\langle A \rangle \sim 300$ is the average weight of DNA nucleotide, $d \sim 1$ nm is the radius of the helix, $L_p = m_p/\hbar$ is proton Compton length, and $f \sim 20$ Hz is the estimate for the rotation frequency.

(a) If $h_{eff}/h = n$ serves as a unit of quantized angular momentum (thish need not be the case for ordinary DNA as opposed to the dark analog of DNA for which the states 3 dark protons define a realization of DNA codons) an upper bound $n < n_{max} \sim 172 \times N$ emerges from the condition $L/\hbar_{eff} = 1$. The interpretation of dark DNA as dark nuclei gives the estimate $h_{eff}/h = d/L_p \sim 2^{20} \simeq 10^6$ the radius of nucleus. This would require $N \sim 10^4$.

(b) Another manner to satisfy the stronger quantization condition is to assume that the semiclassical quantization condition is satisfied for the system consisting of *both* ordinary and dark DNA. The simplest manner to satisfy the condition is that the angular momenta of ordinary and dark DNA are opposite and in this case be smaller than $\hbar_{eff}$. This condition would be rather natural since there would be no need to bring angular momentum to the system from outside by applying torque. Energy is however needed to break up the hydrogen bonds between strands.

There are also nucleic acid motors utilizing ATP and deserve to be listed.

1. Topoisomerase reduces supercoiling of DNA in the cell.
2. RSC and SWI/SNF complexes remodel chromatin in eukaryotic cells.
3. SMC proteins are responsible for chromosome condensation in eukaryotic cells.
4. Viral DNA packing motors inject viral genomic DNA into capsids.

Also ribosome (see `http://tinyurl.com/yacy6m3h` and `http://tinyurl.com/ybfqa423`) is a molecular motor. For some reason the list of Wikipedia article (see `http://tinyurl.com/y879vdel`) does not include it. The rate of translation is in good approximation the same as the rate of transcription as it indeed must be to make the process effective and Mg^{2+} cyclotron frequency might determine the rate.

For all motors involving ATP cyclotron frequency of proton is involved but and poses only upper limit for the rate.

The possible role of Mg^{2+} in RNA translation

Transcription and translation both occur on the time scale of 1 minute for a protein of typical length (see `http://tinyurl.com/ycm5uur9`). However, longer transcripts and bigger proteins take proportionally longer to make: this probably due to the additional operations involved. The largest protein in the human body is titin. It would take approximately an hour to translate its $\sim$ 30,000 amino acids, which makes 8 amino-acids per second. If DNA codons are transcribed with the same average rate than amino-acids are translated (synchrony), transcription rate is 24 nucleotides per second. This happens to be rather near to $f_c(Mg^{2+}) = 25Hz$ to letter.

The estimates for the translation rate however vary. Probably this is due to the definition used and the organism in question. For E. Choli the average translation rate is reported to be roughly 20 aa per second (see `http://tinyurl.com/ycm5uur9`). For synchrony this would correspond to 60 nt/s in DNA transcription. The actual transcription rate is 40-80 nt/s for nucleotide and gives 60 nt/s on the average.

Note that the range for the rate corresponds to octave. If cyclotron radiation coordinates the process, the variation could be due to variation of magnetic field strength by octave. For DNA codon the rate would be in range $[13.35 - 26.7]$ codons per second. This could correspond to Mg^{2+} cyclotron frequency in B_{end} assignable to co-enzyme Mg^{2+} (see `http://tinyurl.com/d6jnd49`).

Translational motion and propeller mechanism

Molecular propellers (see `http://tinyurl.com/y7ftgzuk`) can be rotated by molecular motors that can be driven by chemical, biological, optical and electrical means or various ratchet-like mechanisms. Biological propellers are therefore only a special case. In the case of biological propellers interaction with the medium and dissipation are involved and transform rotational motion

to linear motion. Medium or substrate structure such as medium or microtubule receives the recoil angular momentum.

Biology involves a large number of highly sophisticated molecular motors, such as myosin, kinesin, and ATP synthase based on propeller mechanism. For example, rotary molecular motors attached to protein-based tails called flagella can propel bacteria (see `http://tinyurl.com/y83939x7`). In this case the rotation frequency has 300 Hz, which suggests that ATPase and dark protons in magnetic field B_{end} with it determines the rate.

Second example is kinesin moving linearly along microtubule (see `http://tinyurl.com/o4glesu`). Also kinesin can be regarded as ATPase. The linear motion supports several functions such as mitosis, meiosis and transport of molecules along axon. The linear motion takes place in discrete steps of length 8 nm (cell membrane thickness is about 10 nm).

One can raise several questions related to the possible role of MB. How the energy and angular momentum are transmitted to the propeller? Could dark cyclotron BE condensates analogous to magnets be formed? For cyclotron BE condensates spin would be replaced with orbital angular momentum for the dark ions rotating at flux wall: this could give rise to large angular momentum. Could the generation of cyclotron BE condensate and angular momentum at magnetic flux wall give rise to opposite angular momenta at the propeller as a recoil effect: could this quantum phase transition happen by the exchange of polarized cyclotron photons. Does ATP provide the metabolic energy needed to build the cyclotron BE condensate in turn giving part of its energy for the propeller.

7.5.6 Oxidative metabolism, red cells, the fundamental bio-rhythm, and iron

Understanding the possible role of cyclotron radiation in the coordination and control of cellular respiration (see `http://tinyurl.com/pkfup3g`) is a further natural challenge.

1. The basic guidelines are the interpretation of "high energy" bonds as containing dark electrons $h_{eff}/h = n$ larger than for normal atoms. Also dark protons must be present when the molecule containing dark electrons is neutral. Metabolism could be basically transfer of dark protons and electrons from the nutrients possibly reducing gradually the value of n and gradually sharing the liberated energy. The energy would go to the pumping of protons through the cell membrane and be eventually transferred to high energy phosphate bond in ADP $\rightarrow$ ATP process in ATPase as protons flow back through the membrane.

2. In oxidative metabolism O_2 is used as oxidizing agent. O_2 molecules are transferred from respiratory organs to the rest of the body using hemoglobin (see `http://tinyurl.com/ya5kyv6u`) as a carrer. Oxygens atoms are bound to the heme part of the hemoglobin containing Fe^{2+} ion. O_2 binds to Fe^{2+} and oxidizes it so that one temporarily obtains Fe^{3+} ion and O_2^- (superoxide) ions.

   Concerning cyclotron frequencies, what puts bells ringing is that both $f_c(Fe^2) = 10.7$ Hz, $f_c(O_2^-) = 9.7$ Hz are in alpha band and near to the fundamental biorhythm with frequency 10 Hz: could the fundamental bio-rhythm be seen as a direct signature of the role of MB in metabolism? $f_c(Fe^{3+}) = 16.0$ Hz is in beta band. $f_c(Fe^{3+}O_2^-) = 6.8$ Hz makes sense at least formally and is in theta band. One can of course ask whether it is possible to regard Fe^{3+} ion and O_2^- ions as independent, possibly dark, cyclotron states. If the electrons involved are dark this might make sense.

3. In an-aerobic respiration (see `http://tinyurl.com/m955wzb`) sulfate (SO_4^2, $f_c = 6.3$ Hz), nitrate (NO_3, $f_c = 6.3$ Hz), sulphur (S,$f_c = 9.4$ Hz), or fumarate ($HO_2CCH{=}CHCO_2H$) are used instead of oxygen. Interestingly, the cyclotron frequencies for sulfate and nitrate are very near to each other and for sulphur ion the cyclotron frequency is also in alpha band.

Cellular respiration converts biochemical energy from nutrients - carbohydrates, amino-acids, fats - into energy carried by ATP and then releases the waste products such as CO_2 and H_2O. The reactions include catabolic reactions breaking down the large molecules to smaller ones, releasing energy in the process as weak "high-energy" bonds are replaced by stronger bonds in the products. Cellular respiration can be seen as a combustion reaction - burning of nutrients.

The most common oxidizing agent (electron acceptor) is molecular hydrogen O_2: in this case one talks about oxidative metabolism or aerobic respiration. The energy of ATP in "high-energy" phosphate bond drives biosynthesis, locomotion or transportation of molecules across cell membranes.

Aerobic respiration is the preferred method of pyruvate (CH_3COCOO, see `http://tinyurl.com/yadb3fsn`) breakdown in glycolysis. Pyruvate contains two O= bonds reduced to O- type bonds in the process producing CO_2 and water. Pyruvate enters to mitochondria and is fully oxidized by the Krebs cycle (see `http://tinyurl.com/p6599hq`) also known as tricarboxylic cycle or citric acid cycle.

1. Krebs cycle produces NADH (nicotin-amide-adenine-dinuclotide containing two adenines and two phosphates, see `http://tinyurl.com/mcodgjs`)) carrying metabolic energy in "high energy" bonds.

   (a) Coenzyme CoA (see `http://tinyurl.com/ydbvd5q4`) in acetyl-CoA (see `http://tinyurl.com/z6fc4zc`) brings the acetyl group CH_3 (see `http://tinyurl.com/y74cyyqk`) and metabolic energy from the nutrient to the Krebs cycle.

   (b) The metabolic energy from the nutrients is associated with high energy thioester bond at the ened of acetyl-CoA in which C has bonds of type CH_3- and O= and S-. Sulphur belongs to coenzyme CoA involving phospho-adenosine and di-phosphate.

2. The NADH produced by Krebs cycle carrying the metabolic energy is received by the electron transport chain (see `http://tinyurl.com/hxwb6ay`) performing oxidative phosphorylation (see `http://tinyurl.com/yacue4an`) transforming ADP to ATP. NADH is oxidized to NAD^+ and is returned back to the Krebs cycle.

   Electron transport chain is needed to transfer the electrons from donors to acceptors and to extract the energy of electrons and use it to the pump of protons trough the inner membrane. Electron transport chain involves as the first step the process NADH $\rightarrow NAD^+ + H^+ + 2e^-$ producing protons and electrons. This happens inside the inner membrane of mitochondria. Electrons and protons are then transported through the inner membrane to the inter-membrane space using co-enzyme Q(10) (see `http://tinyurl.com/y9tosfzc`) as a carrier. Electrons are transported further with the help of cytochrome c (see `http://tinyurl.com/ybkb7dbu`), which is soluble to water.

   (a) Ubiquinone enzyme Q takes care of the transfer of protons and electrons through the inner membrane to the inter-membrane space. Q receives two protons and electrons and is reduced to QH_2 at the inner side of the membrane. QH_2 oxidizes back to Q at the outer side of the membrane and therefore shuttles the protons through the membrane.

   (b) In the inter-membrane space of mitochondria (having double membrane) electrons are transferred along a chain of water cytochrome c (see `http://tinyurl.com/ybkb7dbu`) molecules forming a kind of ladder along which electrons move down. At given step Fe receives the electron and then gives it to the next cytochrome c molecule. At the bottom of the chain electrons with lowered energy are given to oxygen molecules in oxidative phosphorylation of ADP by ATPase.

3. Free radicals having one or more unpaired valence electrons appear as side products of the process. The working hypothesis is that paired valence electrons have non-standard value of $h_{eff}/h = n$ and unpaired ones have the standard value being highly reactive. Peroxides, superoxide (O_2^+), hydroxyl radical OH, and singlet oxygen (O) are free radicals having negative biological effects. O_2 molecule is di-radical but in its ground state has parallel unpaired spins and is stable: in combustion it transforms to unstable and highly reactive spin single state with paired spins.

7.5.7 Model for RNA life

There is to a very interesting paper about the possible mechanism giving life-like properties to RNA system during the conjectured RNA era [I49] (see `http://tinyurl.com/ydhr3qnq`). The title of the article is "*The life story of hydrogen peroxide II: a periodic pH and thermochemical drive for the RNA world*". "Life-like" would mean "breathing" realized as these oscillations and would require a metabolic energy source.

I try to interpret the proposal on basis of my own model [L32] bringing in the control of chemistry by magnetic body (MB). The idea is that MB adapts to the chemical dynamics and gets a control over it by driving forces realized in terms of dark cyclotron radiation form MB resonating with the chemical oscillations. "Breathing" would basically correspond to the periodic formation of flux tube network with high connectivity giving rise to crystal-like or gel-like state and subsequent decay to plasma-like state with low connectivity and would require metabolic energy feed.

1. The periodic drive is central in TGD based model and gives rise to the "breathing". Metabolic energy feed must be involved. In the model for life-like properties of plastic ball system it would be dark nucleosynthesis. In another experimental system acoustic wave feeds energy to the magnetic body (MB). It is said that the peroxide ($H-O-O-H$) bond between oxygens would be the source of the metabolic energy. Peroxide - usually regarded as a mere nuisance (highly Reactive Oxygen Species causing biological damage) - would serve as the "food" of the system. This is the new and radical idea. According to the article, the primary energy source would be solar or geothermal. In TGD one can consider dark nucleosynthesis preceding ordinary nucleosynthesis as the source (it might have even given rise to Fe in the core of Earth!).

2. Figure 1 in the article illustrates that peroxide H_2O_2 would produce in presence of $S_2O_3^{-2}$ or $S_2O_3^{-1}$ thermal and pH oscillations: "breathing". Peroxide is also told to produce oxidized sulfur species and oxidixe RNA nucleotides: this would liberate metabolic energy in RNA? The outcome would be the replication of RNA. Oxidation of thiosulfate ion by H_2O_2 mentioned in the abstract would naïvely mean that $S_2O_3^{-2}$ gives 1 or 2 electrons to H_2O_2. Table 1 listing various reactions involved in oxidation is however rather complex. It begin to accept that I will never really understand what chemists mean with oxidation! In any case, also the oxidation reaction can happen in several steps.

Consider next the situation from quantum TGD point of view.

1. Periodic oxidation would correspond to breathing generating repeatedly connected magnetic body with quantum coherence and larger h_{eff} - following the model for breathing plastic ball system as periodic formation of crystal-like and plasma-like states.

2. Cyclotron radiation from cyclotron condensates of some important ions would serve as clocks - breathing in several time scales. What are these ions? In plastic ball system protons and Argon ions. 300 Hz is the frequency for $B = B_{end} = .2$ Gauss and also the rate of ATP:s produced by ATPase: of course, it was not present at that time. Thiosulfate cyclotron frequency would be 5.4 Hz in B_{end} for charge of -2 units.

   The chemical oscillation periods emerging in the model of authors are measured in fraction of hour whereas the cyclotron periods for ions are fractions of second for ions for $B = B_{end}$. Therefore the strength of the magnetic field is much lower than that of Earth. Intergalactic magnetic fields are of order nanoTesla and this would bring scale factor of about 10^4 to cyclotron periods and they would be of same order of magnitude as the time scales coming from chemical kinetics. For proton the cyclotron period would be 33 seconds. For $S_2O_3^{-2}$ cyclotron time scale would be scaled up by the atomic weight 112 giving roughly 40 minutes. This suggests that RNA era occurred in intergalactic space if it occurred at all. If it continues in recent biology, the dark matter must reside at the flux tubes of intergalactic magnetic field. This does not make sense in Maxwell's theory but makes sense in the many-sheeted space-time of TGD Universe.

3. pH oscillation means that at least dark protons would be involved. pH could be quite generally a direct measure for the density of dark protons. The density of dark protons oscillating

periodically meaning formation of cyclotron condensate and its decay could correspond to oscillating pH.

7.6 Do hydrogels learn in presence of irradiation and heating?

A research group in Aalto yliopisto led by professor Olli Ikkala has published in Nature Communications an interesting article with title "*Programmable responsive hydrogels inspired by classical conditioning algorithm*" [I142] (see `http://tinyurl.com/y6owxv8x`).

The abstract of article gives some idea about what is involved.

Living systems have inspired research on non-biological dynamic materials and systems chemistry to mimic specific complex biological functions. Upon pursuing ever more complex life-inspired non-biological systems, mimicking even the most elementary aspects of learning is a grand challenge. We demonstrate a programmable hydrogel-based model system, whose behaviour is inspired by associative learning, i.e., conditioning, which is among the simplest forms of learning. Algorithmically, associative learning minimally requires responsivity to two different stimuli and a memory element. Herein, nanoparticles form the memory element, where a photoacid-driven pH-change leads to their chain-like assembly with a modified spectral behaviour. On associating selected light irradiation with heating, the gel starts to melt upon the irradiation, originally a neutral stimulus. A logic diagram describes such an evolution of the material response. Coupled chemical reactions drive the system out-of-equilibrium, allowing forgetting and memory recovery. The findings encourage to search non-biological materials towards associative and dynamic properties.

The basic elements of the experiment are following.

1. The system consists of sea weed gel and Gold nanoparticles.

2. Heating plus irradiation by blue and red light simultaneously leads to a formation of nanoparticle chains and heating of gel melting it. Formation of chains is due to the photoacid driven pH change.

3. Conditioning occurs in the sense that gel melts even when only irradiation is present.

There is an analogy with Pavlov's dogs based on correspondences heating $\leftrightarrow$ metabolic energy feed $\leftrightarrow$ food; irradiation $\leftrightarrow$ signal associated with the food - say sound of bell; melting $\leftrightarrow$ saliva secretion.

One can however criticize this interpretation.

1. The analogy with Pavlov's dog is not complete. Melting requires energy. Pavlov's dog does not get sated by the mere soud of bell.

2. Nanoparticle chain is assumed to serve as a memory element. Could a more appropriate interpretation be as a metabolic energy storage analogous to protein?

3. Can one model the system using only chemistry, and is conditioning a purely mechanical and passive process as behavioristic dogma states? Could conscious intelligence be involved as in the case of ordinary learning.

7.6.1 TGD based model for the findings

I have already earlier applied TGD inspired model of living systes model simple systems exhibiting life-like properties. One such system consists of plastic balls [I99] (see `http://tinyurl.com/z532ryv`): the TGD inspired model for the system is discussed in [L32].

The TGD based quantum model for the conditioning of hydrogel system relies on TGD inspired general model of living systems extended recently to a model of quantum self-organization [L65] in which energy feed serving as metabolic energy feed induces generation of dark matter as $h_{eff} = nh_0$ phases of ordinary matter at the magnetic body of the system. In number theoretic vision the presence of these phases correspond to higher algebraic complexity and higher "IQ".

The light signal would generate Pollack effect [L13], which in TGD framework means transfer of protons from photo-acids to dark $h_{eff} = nh_0$ protons at magnetic flux tubes parallel to nanoparticle chains [L13]. The "IQ" of the system or its magnetic body characterized by h_{eff} would increase and it would become able to self-organize. The energy from the heating would be stored to the nanoparticle chains taking the role of proteins as energy storage. Melting would be a self-organization process increasing complexity, and in absence of heating (and perhaps even in its presence) the gel phase would receive the energy needed from the nanoparticle chains. The conditioning in this sense would not be a passive mechanical response. The system would be macroscopic quantum system, and the energy feed would make possible for it to evolve to a higher level of complexity and conscious intelligence.

What learning and conditioning really are in TGD Universe?

Conditioning in the standard sense would be a purely mechanical process. In TGD Universe life cannot be however reduced to mechanical purely deterministic processes.

1. The magnetic body (MB) of the system would not learn to get heated or to get melted in presence of the irradiation. Rather, irradiation would raise the intelligence of system measured by $h_{eff} = nh_0$ and it would spontaneously self-organize by melting. Conditioning in mechanical sense would not be in question. This would apply also to ordinary conditioning.

2. Conditioning in TGD sense requires conscious intelligence. MB with dark matter must be involved. The MB of the system containing the MB associated with nano-particle chains and loaded with dark protons by irradiation inducing Pollack effect would be involved with the conditioning. Irradiation would "wake up" the system and nanoparticle chains would allow energy storage.

3. Irradiation would generate dark phases with $h_{eff} = nh_0$ inducing self-organization involving the melting of the gel phase using the metabolic energy resources generated during the heating period. The only thing needed would be the presence of large h_{eff} phases. System would take care of the rest.

The building bricks of the model

The basic building bricks of the model would be following.

1. Living systems are able to learn and get conditioned. An analog of living system should be present. In TGD Universe any self-organizing system is "living" and involves dark matter as large h_{eff} phases.

2. Pollack effect [L13] [L13] is a fundamental manner to build MB in TGD Universe. In Pollack effect the irradiation kicks ordinary protons to magnetic flux tubes to form dark proton sequences - dark nuclei. The proposal is that also a dark realization of genetic code with codons represented as 3-codon triplets is involved and that ordinary genetic code would be mimicry of this code [L20]. Also now gel and irradiation are present. Pollack effect induced by the metabolic energy feed associated with the radiation would generates dark proton phase and make the system intelligent.

3. Living system needs metabolic energy and must be able to store metabolic energy. Now the nanoparticle sequences possibly associated with dark flux tubes are excellent candidates for the analogs of proteins storing metabolic energy provided during the heating period.

4. Zero energy ontology (ZEO) plays a key role in TGD inspired model of living matter. The general model for the motor action and remote metabolism assumes that system sends negative energy to the geometric past and gets energy in this manner. Negative energy transfer is an intuitive manner to say that macroscopic state function reductions are involved in the process and change the arrow of time temporarily [L37]. Recent rather surprising experimental findings by Minev *et al* [L58] provide direct support for ZEO based view about quantum jump [L58].

Remark: Quite recently (towards end of 2019) I found a more precice formulation for the intuitive notion of remote metabolism, which strongly suggests that energy is conserved in ZEO. There is a decomposition to system and the energy energy source: call them A and B. Intuitively, A receives energy from B by sending negative energy to B. What does this really mean?

1. A "big" state function reduction reversing arrow of time takes place: this would correspond to sending negative energy signal to past. The energy of A+B in the final time reversed state at new passive boundary of CD would be shared in new manner such that one can say that A has received from B the metabolic energy.

2. Energy would be conserved. I have also considered the interpretation that the total energy of the system associated with CD increases [K64] [L70]: since CD itself breaks Poincare invariance, it seems that one cannot exclude this. However, the Poincare invariance is realized at the level of moduli space for the positions of the either boundary of CD, and one can assume energy conservation. Even the wave functions at the boundary of CD can be taken to be in the representations of Lorentz group acting as its isometries. Plane waves correspond to wave functions in the moduli space for the boundary of CD keeping second boundary fixed.

3. To make this more precise one must define metabolic energy more precisely by introducing the hierarchy of Planck constants and the fact that the increase of h_{eff} of sub-system keeping other parameters constant increases it energy. Second law means that A tends to loose energy due to the decrease of h_{eff} for its sub-systems. This is true also for the time-reversed state but in opposite direction of geometric time so that with respect to standard direction of time the energy increases. This would be the general purely thermodynamical mechanism of remote metabolism.

How conditioning could take place?

What kind of model this picture one ends up from the elements identified above? It is best to proceed by making questions.

1. What does it mean to be living in this particular case?

   (a) Gel, nanoparticles chains, and their MB would form the system. Chain would be accompanied by flux tubes in contact with the MB of gel. MB would induce the melting in presence of irradiation.

   (b) Pollack effect is involved. pH is changed, which means that the density of protons is changed by the presence of photoacids. photoacids (see `http://tinyurl.com/y54h8dqs`) release protons in presence of irradiation. The liberated protons would go to magnetic flux tubes accompanying the nanoparticle chains and even give rise to dark realization of genetic code. The photons of irradiation at blue and red should have energies needed to transfer the protons of photoacids to dark protons at the flux tubes with non-standard value of h_{eff}. Irradiation would make the system intelligent.

   (c) photoacids are present also after conditioning so that flux tubes carrying dark protons are formed when the system is irradiated even if they are unstable against decay to ordinary protons. One can say that the system wakes up by radiation and it becomes intelligent, self-organizing, and able to learn. MB could induce melting of the gel as a self-organization process.

   (d) Why Gold nanoparticles would be needed? Here an interesting connection to the work of Hudson and other layman researchers emerges. Hudson and others [H1, H3] claimed that Gold has a phase, which they called White Gold, mon-atomic Gold, or ORMES. This phase of Gold was claimed to have properties suggestive of nanoscopic or even macroscopic quantum coherence. These claims were not taken seriously by science professionals. Since I had nothing to lose at that time anymore, I decided to construct a model for White Gold. Later this model led to a quantum view about living matter relying on the hierarchy of Planck constants [K37, K76, K29, K30, K31, K32]. The recent view about White Gold explaining their suspected quantum coherence would be as Gold nanoparticles assignable to dark magnetic flux tubes carrying dark protons.

2. What the melting of gel is?

   Learned reaction to stimulus is in TGD framework self-organization process rather than just getting heated or reacting mechanically like automaton. What is called melting would be a self-organization process in which the complexity of gel increases. Heat would transform to ordered energy: work would be done to achieve melting. Hence one should apply TGD based quantum view of self-organization to the situation [L65].

3. What is the source of the energy that the gel needs to melt?

   Does gel the energy directly as heat and/or from analogs of proteins storing metabolic energy. Since the melting occurs also in the absence of heating, the latter options seems to be correct. One can imagine two sources of the metabolic energy.

   (a) Could nanoparticle chains serve as a storage of metabolic energy being thus analogous to proteins. Nanoparticle chains dropping to a lower energy state would serve as a source of metabolic energy in absence of heating.

   (b) Could flux tubes carrying dark protons proposed to define dark variants of basic biomolecules (DNA, RNA, amino-acids, tRNA) [L20, L39, L38] serve as a storage of metabolic energy? This energy could be liberated as dark protons transform to ordinary ones. If they are transformed to protons of photoacids, the energies would correspond to the energies of blue and red photons. These energy levels should correspond to the energies assignable to the building bricks of the gel phase. The intuitive expectation is that the energy feed due to irradiation is small as compared to that needed by the melting of the gel. The presence of Gold nanoparticles would not be necessary.

4. What does the energy transfer from nanoparticle chain to the gel mean? One can imagine two options.

   (a) Melting could be analogous to motor action in TGD sense. ZEO suggests that gel sends negative energy to a receiver able to receive it and in this manner gets the energy needed to perform the motor action [L53]. Nanoparticle chain would be the receiving system. Nanoparticle chains would receive their energy during heating. In the model of experimenters nanoparticle chain would serve as a memory element rather than battery.

   (b) MB could induce transfer of positive energy from nanoparticle chains to gel. One would have only "small" state function reductions analogous to weak measurements and time evolution would be a sequence of unitary evolutions involving only weak measurements [L37, L72]: self as a generalized Zeno effect is the manner to state in the framework of TGD inspired theory of consciousness.

7.7 The emergence of human brain like functions in neuromorphic metallic nanowire network

The popular article "*Human Brain-Like Functions Emerge in Neuromorphic Metallic Nanowire Network*" published in Scitechdaily (`http://tinyurl.com/v8a2pqg`) represents findings, which are very interesting from TGD point of view. The original article "*Emergent dynamics of neuromorphic networks*" by Diaz-Alvarez *et al* is published in Nature [D4] (`http://tinyurl.com/v44rc62`). There are also other findings suggesting that simple systems such as plastic balls can exhibit life-like properties. In the sequel the TGD inspired model [L32, L61] for these findings is applied to neuromorphic networks.

7.7.1 Findings

Consider first the findings.

1. One can say that the self-organization process corresponds to the system "struggling" to find optimal current pathways. This process involves fluctuations akin to those found in memorization, learning and forgetting processes of brain. The temporal flutuations also resemble the processes by which brain becomes alert or returns to calm.

2. The metallic Ag nanowires become coated with a polymer (PVP)(`http://tinyurl.com/tnmu4y9`) insulating layer with about 1 nm thickness. Also metallic junctions between two nanowires acting as a resistive elements analogous to synapse are formed. The average diameter and length of nanowires was measured to be 360 $\pm$ 110 nm and 14 $\pm$ 5 μm, respectively.

   Remark: These scales correspond to biological length scales (p-adic length scales $L(161)$ and $L(172)$).

3. There are suggestive connections with biology. PVP polymer is an organic compound with repetive active part which consist of two parts: CH_2 and aromatic Carbon 5-cycle with one C replaced with N and one CH_2 replaced with C=O. In TGD framework this could be relevant for the self-organization - maybe the magnetic bodies of PVP polymers are in an essential role. I have proposed that valence bonds correspond to flux tubes with effetive Planck constant $h_eff = n \times h_0 > h = 6h_0$ [L31] (`http://tinyurl.com/ycg94xpl`).

4. The formation of low resistance pathways between probes contacting the networks induces a transition from low conductance state to high-conductance state at given voltage threshold usually below 10 V. This occurs even for millimeter distance between probes. The weak independence on voltage suggests that the current flow is almost dissipation free - could dark supra currents at magnetic flux tubes be involved?

7.7.2 TGD based model

TGD predicts several a lot of new physics possibly relevant to the findings [L69, L65] (`http://tinyurl.com/wd7sszo`) and `http://tinyurl.com/y3xbkokb`).

1. Magnetic flux tubes (magnetic body, MB) carrying dark matter as phases with effective Planck constant $h_{eff} = n \times h_0$.

2. Zero energy ontology (ZEO) allows to formulate quantum measurement theory without paradoxes. The possibility of time reversal is one dramatic prediction. Basic mental functions like memory would be completely universal phenomena and possessed in principle even by elementary particles. Both memory recall and motor action would involve "big" (ordinary) state function reduction (BSFR) changing the arrow of time. Biological death would correspond to BSFR.

   Sensory perception assignable to "small" state function reductions (SSFRs) identifable as correlates of "weak" measurements would not involve change of the arrow of time: the increase of distance between tips of causal diamon (CD) in each SSFR following unitary evolution would give rise to the experienced flow of time and correspondence between subjective time as sequences of SSFRs and geometric time as temporal distance between the tips of CD.

3. Universality of cognition described in terms of p-adic (adelic physics) is predicted [L35, L34, L47] (`http://tinyurl.com/ycbhse5c` and (`http://tinyurl.com/yyyk6fu8`)). Number theoretic vision realized as adelic physics predicts evolution as increase of the dimension of extension of rationals characterizing basic building bricks of space-time as surface.

   Self-organization involves generation of coherence and requires energy feed [L65] (`http://tinyurl.com/y3xbkokb`). Same applies to life. Self-organization would be also universal: the self-assembly aspect of self organization would be simply due dissipation at reverse time direction at the level of dark matter at magnetic body controlling the dynamics at the level of ordinary matter as master.

4. Quantum criticality is essential element of self-organization and the observed $1/f$ fuctuations could be interpreted as their signature. Note that $1/f$ fluctuations are observed also in the

ordinary electric circuits and since also these involve self-organization aspects, dark matter in TGD sense might be involved.

At quantum criticality long range fluctuations take place and correspond to the creation of phases with large h_{eff} and having therefore long quantum coherence length. Energy feed is however required and serves as analog of metabolic energy. Freezing of water could a good example about quantum criticality at the level of MB inducing ordinary criticality and leading to generation of complex structures at the level of ordinary matter. Snowflakes (`http://tinyurl.com/wg8fyth`) and the patterns observed by Emoto [L55] (`http://tinyurl.com/ycdywctw`) as a response to stimuli like emotional voices provide examples of this.

Consider now a possible TGD based interpretation.

1. The voltage feeds metabolic energy to the system by making current flow possible. The transition to high conductance state above critical voltage could correspond to minimal metablic energy feed needed to induce a phase transition generating Cooper pairs of electrons or even dark Ag ions with $h_{eff} > h$ at magnetic flux tubes so that current would become partially dark and conductance would increase. The preservation of dark phase requires energy feed but the reduction of dissipation for supracurrents makes this possible.

2. Ag^+ have cyclotron frequency of 2.8 Hz in "endogenous" magnetic field $B_{end} = .2$ Gauss assigned with living systems tentatively identified as the dark monopole flux carrying part of the Earth's magnetic field with nominal value $B_E = .5$ Gauss. Are the Cooper pairs of these ions involved? What about electronic Cooper pairs with cyclotron frequency about .6 MHz? Could the Coulomb energy $E_c = ZeV$ for Cooper pair in critical voltage correspond to the cyclotron energy of the dark Ag^+ Cooper pair or of electronic Cooper pairs? Nottale hypothesis $h_{eff} = h_{gr} = GMm/v_0$ [E5] is an essential part of the TGD based model of quantum biology [L71] (`http://tinyurl.com/rw58zaz`) and would predict that cyclotron energies would not depend on the mass of the charged particle.

3. EEG is basic aspect of brain function of vertebrates. Could it be that Ag^+ ions and also the possible ionization of the aromatic cycles make possible analog of EEG around 2.8 Hz?

In this framework the findings discussed in the article could be assigned with system which are very simple life forms. To gain improved understanding a model for the magnetic body of the system would be needed.

Part II

Quantum Gravitation and Biological Evolution

Chapter 8

Quantum gravitation and quantum biology in TGD Universe

8.1 Introduction

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

8.1.1 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 [E5] [**?**, K70] [L92, L82] 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 [E5] 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 [I45].

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.

8.1.2 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 [K78, K36, K79] [L78, L82] 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 [L78] 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 [K67]. 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 [I120, I118, I119], 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.

8.2 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.

8.2.1 Basic motion patterns as analogs of Bohr orbits

Prakash *et al* identify a small number of basic motion patterns of cilium [I120, I118, I119]. 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 [L90].

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 [L94].

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.

8.2.2 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.

8.2.3 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 [L132]. 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.

8.2.4 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 [L73, L74]. 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 $h_{gr} = GMm/v_0$ [E5] 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 [L94]. 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 [L94]. The liberation of metabolic energy quantum would be analogous to a transition of hydrogen atom to a lower energy state.

8.2.5 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 $h_{eff} = h_{gr} = GMm/v_0$ [E5] 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 [L100], 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 $h_{eff}/h > 1$ [L31]. 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 [I45] 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 [L108] 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 [K29, K30, K31, **?**] 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

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

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 [L2].

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 [L46] [L93] ?

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 [I133]), 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.

8.2.6 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 [L108] 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) [L108].

The most recent model discussed in [L108] 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 [I101, L13, I143, I123] as transfer of ordinary protons to dark protons at flux tubes possibly forming dark codons as dark proton triplets [L13].

   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 [L59, L66, L91].

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 [I84] (`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 [I84] 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.

8.2.7 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 [K3, K2, K96]. 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) [K3, K2, K96] 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 [L69, L87] [K102] 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 [K3, K2, K96]. 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 [K3, K2, K96] 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 [L132]. 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 [K47] [L107]. 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 [L11] [L77, L84, L108] 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.

8.3 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.

8.3.1 The recent TGD based view of nervous system

The proposal [K78, K36, K79, L78] 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 [K78] 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 [K2, K96].

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 [J13] discussed from the TGD point of view in [L8]. 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 [L108]. 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.

8.3.2 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 $h_{eff} = h_{em}$ [L31].

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.

8.3.3 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^+, $X \in \{Li, Na, K\}$ 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^{++}, $X \in \{Ca, Mg, Fe, Zn\}$ and between H_2O_2 and Cooper pars of X^+, $X \in \{Li, Na, K\}$ 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 [L81]). 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 [J24, J27] (`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 [L21].

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 [L104]. 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 [J26]. 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 [J21] and neurons [J19] have primary cilia acting as sensory receptors and since cilia cannot use ATP metabolis, electronic metabolism is natural.

8.3.4 About the model for the nerve pulse

Could one construct a simplified TGD based model for the nerve pulse [K78] 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 [K76]. 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 [I103, I132] and other pioneers [I85, I58] 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.

8.3.5 Microtubular level

TGD predicts two forms of metabolism [L100]. 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 [L100] already discussed in the section 8.2.5. 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 $h_{eff} = h_{gr} = Gmm/v_0$ [E5] [K29, K30, K31, K32, K70] [L92, L82] 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 [I138] (`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 [I138], 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 [L31]. 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 [L94]. 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 [J25] (https://cutt.ly/XF6OqLA). A TGD based view of biophotons as decay products of dark photons is discussed in [K13, K22].

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 [K47] [L107]. 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 [L13]. 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.

8.4 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 [K36, K78, K79, L78]. 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.

8.4.1 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 [I120, I118, I119].

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 [I138] 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 [I138] 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 [L78]. 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.

8.4.2 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*" [I120] 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.*

8.4.3 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?

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

The findings described in the articles [I120, I118, I119] 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 [I51] 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 [K78, K36, K79] [L78, L82]. 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 [L59].

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* [I120, I118, I119] 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 [L94]. 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.

8.4.5 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 [I114] 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 [I116] (`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 [L11, L77, L84, L108] 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 [L108]. 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 [L47, L63].

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 [I67] (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 [I45], 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 [L84, L108]. 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 [K103]. 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.

8.5 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) [L69, L87] 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 [L58]. The findings of Minev et al provide [L58] lend support for this picture.

8.5.1 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 [L94], 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 [L73, L74]? 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 [L84]) 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 [L96]. 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) [K49, K9, K101], 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.

8.5.2 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.

8.5.3 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 [K14, K9].

   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.

8.5.4 $det(g_4) = 0$ 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 [K49, K26, K82] [L90, L109].

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 [L98]. 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 [L84].

8.6 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.

8.6.1 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) [L90] 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 [I101, I100, L13, I123, I143] 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 [L13].

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 [L101] and evolution of life [L98], 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 [L46, L93, L83].

8.6.2 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 [L90].

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 [L58] provide direct support for ZEO [L58]. 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 [L34, L35]. 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 [E5] and discussed from the TGD point in [K86, K68, K70].

   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 [L98, L89] 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 [L98]. 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 [L101] 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 [L101].

6. Pollack effect [I101, I100, L13, I123, I143] is a central element in the TGD view of living matter [L13, L27, L75, L22]. 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 [L108] 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 [L84, L108]. 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 [L100]. 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 [L94] and are associated with cell membranes and various boundary layers.

2. Zero energy ontology

Zero energy ontology (ZEO) [L69, L87, L97] [K102] 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 [F54] 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) [L46, L93, L83].

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 [L93, L83].

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 [L98] 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 [D7] provide support for the possibility of h_{eff} smaller than h for valence electrons [L24]. The TGD inspired model for chemical bonds [L31] 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 [L83] 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 [L86]. 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 [D9] (`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 [L93, L83] 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 [L101], 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 [L89, L98].

   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 [L101]. 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 [K33, K34].

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.

8.6.3 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 [L89, L98]. 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 [L89, L98].

8.7 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 [L114] (`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.

8.7.1 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.

8.7.2 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 [L101, L98].

2. There is dark variant of the genetic code and realization of dark DNA double strand base on the icosahedral tessellation [L111] 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 [L111]. 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 [L111]. 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 [I45] 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 [L101]! 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 $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0(M)$ [E5] 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 [I101, L13, I143, I123], discussed from the TGD point of view in [L13], 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 [L101] and also predicts electronic metabolic energy currency of about .25 meV for which there is some evidence [I45]?

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 coincidence 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 [L101] 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$\rightarrow$ 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?

8.8 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.

8.8.1 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.

8.8.2 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/TDngqh0`). 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/uDngfy0`).

Chapter 9

Dark matter, quantum gravity, and prebiotic evolution

9.1 Introduction

The ideas related to prebiotic evolution have developed rather rapidly after the discovery of the hierarchy of Planck constants around 2003 providing a general way to understand living orgnisms as macroscopic quantum systems.

1. Magnetic body as carrier of dark matter realized as phases with non-standard value $h_{eff} = n \times h$ of Planck constant is the key concept in the developments and brings to the description of the living matter a third level besides organism and environment [K74].

2. EEG and its predicted fractal variants have interpretation in terms of communication from biological body to magnetic body and as control of biological body by magnetic body [K36]. EEG photons are identified as dark photons and the energy spectrum of dark EEG photons is conjectured to correspond to that for bio-photons. Bio-photons would result in the transformation of dark photons to ordinary ones and their energy spectrum would directly reflect the spectrum of endogenous magnetic fields. If h_{eff} for given ion is proportional to its mass number, the spectrum of energies for bio-photons resulting from dark cyclotron photons is universal and does not depend on charged particle.

3. One can now understand the mechanism making Cooper pairs of bio-superconductors stable, possibly even above room temperatures. Also the understanding of cell membrane as Josephson junction has increased considerably. The recent view [K76, K36] is that generalized Josephson junction is in question. The Josephson energy identified as the Coulombic energy difference at two sides of the membrane is generalized by including also the difference of cyclotron energies. This contribution dominates, and this explains why the value of metabolic energy currency is roughly 5-10 times higher than the value of Josephson energy.

   One ends up with a model of transmembrane proteins as generalized Josephson junctions by taking a "square root" of the thermodynamical model meaning that Boltzman weights are replaced with their complex square roots. The chemical potential difference of thermodynamical model is replaced with the difference of cyclotron energies. Generalized Josephson energies correspond to the differences of cyclotron energies in the first approximation since Coulombic contribution is small. The communications to the magnetic body by dark photons rely on frequency modulation due to variations of membrane voltage, in particular those induce by nerve pulses.

4. The totally unexpected observation was that the states of dark protons forming dark nuclei as string like objects correspond in natural way to DNA,RNA, aminoacids and even tRNA molecules and that vertebrate genetic code is realized naturally, led to the proposal that prebiotic life relies on dark nuclear physics [L2].

5. Taking seriously the findings related to water memory and homeopathy [I61, I62, I55, I86, I87] as well as the findings of Gariaev *et al* [I73, I102] has led to a further progress. In this framework water memory and homeopathy provide direct evidence for the role of dark proton sequences at magnetic flux tubes as prebiotic life forms. The preparation of the homeopathic remedy would induce evolutionary process leading to a generation of a population of regions of water mimicking the magnetic body of the invader molecule. The challenge is to identify these regions.

6. The understanding of negentropic entanglement as entanglement described by $n \times n$ unit matrix and by unitary matrix for entanglement coefficient allowed a more precise understanding of Negentropy Maximization Principle and led to the conjecture that n is nothing but the integer characterizing h_{eff}. NMP implies that Universe generates negentropic entanglement, "Akashic records", being analogous to huge library extending quantum jump by quantum jump. It is perhaps not an accident that in quantum computation entanglement matrix is unitary.

7. There was also another thread related to the ideas about hierarchy of Planck constants. The findings of Nottale suggest that planets correspond to Bohr orbits with gigantic gravitational Planck constant. It took quite a time to realize that the same predictions follow if h_{gr} is associated with pairs formed by microscopic systems and Sun and that in this case the values of h_{gr} could be identified with those of h_{eff}.

   Already during first years emerged the idea that the Planck constant characterizes magnetic flux tubes connecting two systems and depends on the quantum numbers of the systems assignable to the interactions in question. Therefore one can speak also about h_{em} assignable to electromagnetic interactions. A vision developed stating that when interaction gets too strong, h_{eff} increases so that the perturbation series in powers of $1/h_{eff}$ converges and perturbation theory works. At space-time level this means non-determinism, which is key feature of the basic varioational principle: the space-time sheets connecting initial and final 3-surface at boundaries of CD are n-sheeted for $h_{eff} = n \times h$ and the sheets co-incide at ends.

8. The findings of Pollack [L13] about exclusion zones and fourth phase of water meant a further breakthrough and led to the proposal that negatively charged exclusion zones (EZs) of water with $H_{1.5}O$ stoichiometry are accompanied by magnetic body carrying dark proton nuclei at the flux tubes. EZs are excellent candidates for primitive life forms and can be identified as the primitive life forms making possible water memory and homeopathy [K74], [L13].

9. The last step of progress relates to the proposal of Tajmar *et al* that gravimagnetic effect could explain the well-established anomaly relating to the measurement of the mass of Cooper pair in rotating super-conductor. The GRT prediction for the effect is however 28 orders of magnitude too small so that new physics would be needed. The Thomson gravimagnetic field is proportional to h^2 so that large value of Planck constant could explain the effect. The value can be estimated and it is of the order of 10^{14} as required! If it is equal to h_{eff} then the energy spectrum of dark EEG photons is that of bio-photons as conjectured earlier!

10. Zero energy ontology (ZEO) and adelic physics emerged years after the writing of the first version of this chapter. Adelic physics provided a mathematical justification for the hierarchy of Planck constants and p-adic physics. ZEO led to a view about biological evolution as a "must" and reduced allowed to understand self-organization in terms of a new view about quantum measurement predicting time reversal in ordinary state function reductions.

The following sections describe in detail the outcome of this progress.

1. In the first section gravimagnetic effect and its biological implications are discussed from TGD point of view.

2. In the second section the model for water memory and homeopathy is discussed and shown to lead to a general model for how immune system and bio-catalysis could have developed from their primordial versions,how dark proteins might have emerged as concrete representations

for invader molecules making it possible to make the invader non-dangerous by attaching to its magnetic body, how DNA and genetic code could have emerged as symbolic representations for the magnetic bodies of invader molecules and later as symbolic representation of the magnetic body of the system itself. ZEO implies that actually time evolution of the magnetic body can be coded by DNA and protein folding could provide a concrete representation for this time evolution.

9.1.1 Some applications of the TGD based vision

The rest of the chapter is devoted to applications of the TGD based vision.

A model of protocell based on Pollack effect

The work carried out by David Zwicker and collaborators at the Max Planck Institute for the Physics of Complex Systems and the Max Planck Institute of Molecular Cell Biology and Genetics, both in Dresden leads to a concrete candidate for protocells as a water droplet containing proteins and able to exchange molecules with environment. In a simplified model for the droplets (P-granules in C-elegans cell is the real life example) the proteins in droplet can be in two states: in state A the stay in droplet and do not get out but can enter to the droplet from outside. In state B they can get out from droplet. To get into state B energy such as sunlight would be required.

TGD suggests a concrete counterpart for the droplet as exclusion zones (EZs) induced by energy feed such as radiation in water in Pollack effect. EZs are able remove inpurities from interior in conflict with second law. TGD based explanation of the mystery is change of the arrow of time induced by TGD counterpart of ordinary state function reduction in zero energy ontology (ZEO): self-organization would be dissipation with reversed arrow of time at at the magnetic body (MB) of system acting as master and forcing time reversed evolution at the level of ordinary bio-matter serving as a slave.

Was ribosome the first self-replicator?

This section was inspired by the article of M. Root-Bernstein and R. Root-Bernstein (daughter and father) [I128].

1. RNA world is basic example of "genetics first" models. The problem of the "genetics first models" is that it is difficult to understand how prebiotic life could have coped before the complex molecular machinery of metabolism. The second problem of RNA world is that polynucleotides and proteins almost certainly co-evolved. So called compositional replication models start from this assumption but have difficulties in explain replication schemes. Both approaches fail to explain how complex cells emerged from molecular evolution. It is however known that lipid layers of cell membrane are emergent structures not coded by genes (soap films).

2. Second class of models try to proceed from complexity to simplicity by assuming the first replicator (pro-cell typically) but are not able to answer the question "What before this?". The natural assumption is that simple bio-molecules gradually evolved to polymers and polymer aggregates and eventually cell membrane emerged.

According to authors, the challenge is to bridge the gap between self-replicating polymers and a fully functional cell by identifying intermediate structures able to replicate, restore and replicate information, capture metabolic components and energy, and transform all these into biochemical networks.

The basic idea of the authors is simple and brilliant. Ribosome is the transcription machinery transforming DNA to proteins. Also the first replicator must have contained the transcription machinery. Perhaps the first replicator was minimal and contained just this machinery! Perhaps ribosome or its precedessor ("pre-ribosome") indeed was the first self-replicator. One would have beautiful self-reference: ribosome would be the recipe for making a copy about the recipe! Brings in mind Gödel-Escher-Bach!

In the TGD framework the natural solution to all hen-egg problems is provided by the predicted dark variants of the basic biomolecules. The dark variants of replication, transcription,

translation, and metabolism would have been part of the fundamental physics and their chemical realizations would have emerged as a kind of shadow dynamics, mimicry.

Potential "missing link" in chemistry that led to life on Earth discovered

The phosphorylation of short nucleotide sequences and amino-acid sequences, and also lipids making possible formation of small cell membrane like structures is necessary for the formation of larger structures from their building bricks. As noticed, ribozymes catalyse only de-phosphorylation. How RNA was phosphorylated during RNA era or were the amino-acids present all the time?

The popular article with the title "*Potential 'missing link' in chemistry that led to life on Earth discovered*" (see `http://tinyurl.com/y9s56xnx`) tells about a mechanism allowing phosphorylation during RNA era in absence of enzymes. The discovery [I75] (see `http://tinyurl.com/y9kvgl24`) is that an organic molecule known as diamidophosphate (DAP) (see `http://tinyurl.com/y88vecs2`) having chemical formula $PO_2(NH_2)_2^{-1}$ could do the job in presence of water and imidazol. Imidazol (see `http://tinyurl.com/y8vgfr42`) has chemical formula$C_3N_2H_4$ and is a molecule possessing aromatic hetero-cycle consisting of 3 C atoms and 2 N atoms.

DAP could solve several problems simultaneously: how the short sequences of RNA (later DNA) and amino-acids were formed, and how the precedessors of cell membranes emerged. It is not however clear to me whether this process could have been fast enough or whether the slowness only made the first step painful.

The challenge is to circumvent the problem and the proposal considered suggests that a molecule known as di-amido-phosphate (DAP) could have solved the problem. TGD based view is that both the cell membrane and all basic biomolecules could have emerged more or less simultaneously by pairing with their dark variants. Also the basic catalytic mechanisms would have been present at the level of dark matter as $h_{eff} = nh_0$ phases.

Life in Venus? What says TGD?

Evidence for life in a rather unexpected place - Venus - has emerged. The atmosphere of Venus shows signs of phosphine PH_3 - the analog of ammonium NH_3 -, which cannot be produced by inorganic processes. There are small amounts of phosphine in the Earth's atmosphere and has an organic origin. Same might be true in the case of Venus. Perhaps simple bacterial life is in question. Is it in the atmosphere or somewhere deeper in an open question.

TGD based vision about quantum biology suggests several options. The most conservative option suggested by TGD relies on the analogy between H_2S and water. The magnetic body (MB) of H_2S realizing also dark variants of basic bio-molecules could play the same role as the MB of water. First proto cell membrane would have formed and led to the development of O-S separation so that the interior of the proto cell would have consisted mostly of water allowing ordinary bio-molecules to evolve.

One can consider also the replacement $O \to S$ occurs in the basic bio-molecules- DNA, RNA,tRNA, and amino acids. This would leave cell membrane as such. A less plausible replacement (O,N,P) $\to$ (S,P,As) shifting life downwards along the Periodic Table is also discussed.

Multilocal viruses

Multi-local viruses are mysterious from the point of view of ordinary biology. The DNA, RNA, and proteins of these viruses divides into segments located at different host cells and can self-assemble back to the ordinary virus. Various partitions of the virus are possible. TGD based view about space-time and quantum theory allows to understand these viruses as connected entities at the level of magnetic body (MB). MB containing dark matter in TGD sense would control the dynamics of what looks like multi-local entity at the level of ordinary matter. Also bacteria could be seen as multi-local entities of this kind and the recent findings about states of bacterial colonies analogous to multi-cellulars resembling embryos of multi-cellulars suggests how multi-cellulars evolved from mono-cellulars. An interesting application is to the TGD view about Cambrian Explosion in which highly evolved multi-cellulars evolved. Ontogeny recapitulates phylogeny principle provides support for the view that multicellular life evolved in underground oceans defining the womb of Mother Gaia and bursted to the surface as the radius of Earth doubled in a phase transition reducing the value of local cosmological constant.

Oil droplets in water solution as a primitive life form?

The origin of life is one the most fascinating problems of biology. The classic experiment was carried out almost 60 years ago. In the experiment sparks were shot through primordial atmosphere consisting of methane, ammonia, hydrogen and water and the outcome was many of the amino-acids essential for life. The findings raised the optimism that the key to the understanding of the origins of life. After Miller's death 2007 scientists re-examined sealed test tubes from the experiment using modern methods found that well over 20 amino-acids - more than the 20 occurring in life - were produced in the experiments.

The Urey-Miller experiments have yielded also another surprise: the black tar consisting mostly of hydrogen cyanide polymer produced in the experiments has turned out to be much more interesting than originally thought and suggests a direction where the candidates for precursors of living cells might be found. In the earlier experiments nitrobenzene droplets doped with oleic anhydride exhibited some signatures of life. The droplets were capable to metabolism using oleic anhydride as "fuel" making it possible for the droplet to move. Droplets sensed each other's presence and reacted to it and also demonstrated rudimentary memory.

In the sequel a model for the oil droplets as primitive life form is developed using as a constraint the TGD inspired quantum model for living matter. The key ingredients are the notions of magnetic body, the assignment of dark matter identified a hierarchy of macroscopic quantum phases to a hierarchy of Planck constants, zero energy ontology, the model for DNA-cell membrane system as topological quantum computer, and Negentropy Maximization Principle combined with the notion of number theoretic entropy. This entropy can be negative for rational and even algebraic entanglement probabilities, which inspires the vision about life as something in the intersection of real and p-adic worlds.

The basic objection against the identification of oil droplets as a primitive life form is that droplets have no genetic code and do not replicate. The TGD inspired model for dark nucleons however predicts that the states of dark nucleon are in one-one correspondence with DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code is naturally realized. The question is whether the realization of the genetic code in terms of dark nucleon strings might provide the system with genetic code and whether the replication could take place at the level of dark nucleon strings rather than droplets. TGD inspired quantum model of biology leads to a model for oil droplets as a primitive life form. In particular, a proposal for how dark genes could couple to chemistry of oil droplets is developed.

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` [L10].

9.2 Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity [E11]. If the findings are replicable they mean a revolution in the science of gravity and, as one might hope, force a long-waited serious reconsideration of the basic assumptions of the dominating super-string approach.

Tajmar *et al* have proposed [E16] the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual London field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of London field.

TGD explanation of the discrepancy accepting the theory of Tajmar *et al* comes from the proposal inspired by Nottale's observations [E5] suggesting that Bohr's rules apply in planetary system with Planck constant replaced by $\hbar_{gr} = GMm/v_0$. Here M and m are the masses of Sun and planet. $v_0/c \simeq 2^{-11}$ holds true for the 4 inner planets Mercury, Venus, Earth, Mars and $v_0 \to v_0/5$ and principal quantum number $n_P \geq 2$ for the outer planets. Mars could be also

though of as having $v_0/5$ and $n_P = 1$. The rotation velocities of the planets are related to v_0 by Bohr rules. h_{gr} clearly characterizes the pair Sun-planet rather than being fundamental constant whereas the gravitational Compton length GM/v_0 depends on M only. In the TGD framework one assigns gravitational Planck constant to the flux tube connecting the masses and along which the gravitational massless extremals mediating the gravitational interaction are mediated. By Equivalence Principle it is possible to apply the hypothesis only in elementary particle length scales (this does not exclude its application in longer scales) and in these scales $h_{eff} = h_{gr}$ makes sense.

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

Also a vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range [K22, K13] receives strong quantitative support. This leads also to a simple model for how magnetic bodies control molecular transitions via dark cyclotron radiation with varying frequencies vary but universal energy spectrum since for a given magnetic field all charged particles gives rise to biophotons with same energy. The values of h_{gr}/m and endogenous magnetic field $B_{end} \simeq .2$ Gauss are such that the spectrum of biophotons is in the range of molecular binding energies. This vision would conform with Penrose intuitions about the fundamental role of gravitation in quantum biology.

9.2.1 The Theory fof Tajmar *et al* for fhe Anomaly ff Cooper Pairs Mass

The starting point of the theory of Tajmar and Matos [E16] is the so called London magnetic moment generated in rotating charged super-conductors adding a constant contribution to the exponentially damped Meissner contribution to the magnetic field. This contribution can be understood as being due to the massivation of photons in super-conductors. The modified Maxwell equations are obtained by just adding scalar potential mass term to Gauss law and vector potential mass term to the equation related the curl of the magnetic field to the em current.

The expression for the London magnetic field is given by

$$B = 2\omega_R n_s \times \lambda_\gamma^2 \ , \tag{9.2.1}$$

where ω_R is the angular velocity of superconductor, n_s is charge density of super-conducting particles and $\lambda_\gamma = \hbar/m_\gamma$ is the wave length of a massive photon at rest. In the case of ordinary superconductor one has $\lambda_\gamma = \sqrt{m^*/q^* n_s}$, where $m^* \simeq 2m_e$ and $q^* = -2e$ are the mass and charge of Cooper pair. Hence one has

$$B = -2\frac{m^*}{2e}\omega_R \ . \tag{9.2.2}$$

Magnetic field extends also outside the super-conductor and by measuring it with a sufficient accuracy outside the super-conductor one can determine the value of the electron mass. Instead of the theoretical value $m^*/2m_e = .999992$ which is smaller than one due to the binding energy of the Cooper pair the value $m^*/2m_e = 1.000084$ was found by Tate [E12]. This inspired the theoretical work generalizing the notion of London field to gravimagnetism and the attempt to explain the anomaly in terms of the effects caused by the gravimagnetic field.

Note that in the case of ordinary matter the equations would lead to an inconsistency at the limit $m_\gamma = 0$ since the value of London magnetic field would become infinite. The resolution of the problem proposed in [E16] is based on the replacement of rotation frequency ω with electron's spin precession frequency $\omega_L = -eB/2m$ so that the consistency equation becomes $B = -B = 0$ for a unique choice $1/\lambda_\gamma^2 = -\frac{q}{m}n$. One could also consider the replacement of ω with electron's cyclotron frequency $\omega_c = 2\omega_L$. To my opinion there is no need to assume that the modified Maxwell's equations hold true in the case of ordinary matter.

Gravimagnetic field

The perturbative approach to the Einstein equations leads to equations, which are essentially identical with Maxwell's equations. The g_{tt} component of the metric plays the role of scalar potential and the components g_{ti} define gravitational vector potential. Also the generalization to the super-conducting situation in which graviphotons develop a mass is straightforward. Just add the scalar potential mass term to the counterpart of Gauss law and vector potential mass term to the equation relating the curl of the gravimagnetic field to the gravitational mass current.

In the case of a rotating superconductor London magnetic field is replaced with its gravimagnetic counterpart

$$B_{gr} = -2\omega_R \rho_m \lambda_{gr}^2 \ . \tag{9.2.3}$$

Obviously this formula would give rise to huge gravimagnetic fields in ordinary matter approaching infinite values at the limit of vanishing gravitational mass. Needless to say, these kind of fields have not been observed.

Equivalence Principle however suggests that the gravimagnetic field must be assigned with the rotating coordinate frame of the super-conductor. Equivalence principle would state that seing the things in a rotating reference frame is equivalent of being in a gravimagnetic field $B_{gr} = -2\omega_R$ in the rest frame. This fixes the graviphoton mass to

$$\frac{1}{\lambda_{gr}^2} = (\frac{m_{gr}}{\hbar})^2 = G\rho_m \ . \tag{9.2.4}$$

For a typical condensed matter density parameterized as $\rho_m = Nm_p/a^3$, $a = 10^{-10}$ m this gives the order of magnitude estimate $m_{gr} \sim N^{1/2}10^{-21}/a$ so that graviton mass would be extremely small.

If this is all what is involved, gravimagnetic field should have no special effects. In [E16] it is however proposed that in superconductors a small breaking of Equivalence Principle occurs. The basic assumptions are following.

1. Super-conducting phase and the entire system obey separately the gravitational analogs of Maxwell field equations.

2. The ad hoc assumption is that for super-conducting phase the sign of the gravimagnetic field is opposite to that for the ordinary matter. If purely kinematic effect were in question so that graviphotons were pure gauge degrees of freedom, the value of m_{gr}^2 should should be proportional to ρ_m and $\rho_m - \rho_m^*$ respectively.

3. Graviphoton mass is same for both ordinary and super-conducting matter and corresponds to the net density ρ_m of matter. This is essential for obtaining the breaking of Equivalence Principle.

With these assumptions the gravimagnetic field giving rise to acceleration field detected in the rest system would be given by

$$B_{gr}^* = \frac{\rho_m^*}{\rho} \times 2\omega \tag{9.2.5}$$

This is claimed to give rise to a genuine acceleration field

$$g^* = -\frac{\rho_m^*}{\rho} a \tag{9.2.6}$$

where a is the radial acceleration due to the rotational motion.

Explanation for the too high value of measured electron mass in terms of gravimagnetic field

A possible explanation of the anomalous value of the measured electron mass [E12] is in terms of gravimagnetic field affecting the flux Bohr quantization condition for electrons by adding to the electromagnetic vector potential term q^*A_{em} gravitational vector potential m^*A_{gr}. By requiring that the quantization condition

$$\oint (m^*v + q^*A_{em} + m^*A_{gr})dl \quad = \quad 0 \tag{9.2.7}$$

is satisfied for the superconducting ring, one obtains

$$B \quad = \quad -\frac{2m}{e}\omega - \frac{m}{e}B_{gr} \quad . \tag{9.2.8}$$

This means that the magnetic field is slightly stronger than predicted and it has been known that this is indeed the case experimentally.

The higher value of the magnetic field could explain the slightly too high value of electron mass as determined from the magnetic field. This gives

$$B_{gr} \quad = \quad \frac{\Delta m_e}{m_e} \times 2\omega = \quad \frac{\Delta m_e}{m_e} \times em_e \times B \quad . \tag{9.2.9}$$

The measurement implies $\Delta m_e/m_e = 9.2\times 10^{-5}$. The model discussed in [E16] predicts $\Delta m_e/m_e \sim \rho^*/\rho$. The prediction is about 23 times smaller than the experimental result.

9.2.2 Is The Large Gravimagnetic Field Possible In TGD Framework?

TGD allows top consider several alternative solutions for the claimed effect.

Many-sheeted space-time could be an essential part of the effect (if real!).

1. In TGD framework both induced metric and various gauge fields are expressible in terms of CP_2 coordinates and their gradients. Hence the gravimagnetic field would be very probably accompanied by an ordinary magnetic field and could be even proportional to it.

2. The ordinary London magnetic field could be accompanied by analogous magnetic field at different space-time sheet playing the same role as gravimagnetic field in the proposed model. Cooper pair would experience both fields by forming topological sum contacts to both space-time sheets carrying ordinary London magnetic field $B = m_e/e\omega_R$ and much smaller London magnetic field $\Delta B = \Delta m/e\omega_R$? There would be no need to introduce gravitation but one should explain why the value of the parameter $\epsilon = \Delta m_e/m_e$ is what it is.

3. In many-sheeted space the gravimagnetic field and accompanying magnetic field would be associated with the flux tubes mediating gravitational interaction with dark matter fraction of Earth's mass. It would not be surprising if the size of the parameter ϵ might be determined by this fraction. Pioneer and Flyby effects [K86] allow to make a rough estimate for the size of this fraction and the outcome is about 2×10^{-4} which is not far from $\epsilon.9 \times 10^{-4}$.

An alternative explanation is that the experiments probe single space-time sheet and that also other Z^0 magnetic field contributes below weak scale which is scaled up for $h_{eff} = n \times h$ and can be macroscopic.

1. TGD predicts the possibility of classical electro-weak fields at larger space-time sheets. If these couple to Cooper pairs generate exotic weak charge at super-conducting space-time sheets the Bohr quantization conditions modify the value of the magnetic field. Exotic weak charge would however mean also exotic electronic em charge so that this option is excluded. It would also require that the Z^0 charge of test bodies used to measure the acceleration field is proportional to their gravitational mass.

2. According to the simplest recent view about Kähler-Dirac action [K100] the modes of Dirac operator are confined to 2-D string world sheets at which classical W boson fields vanish. This guarantees that em charge is well-defined for the modes. The stronger condition that also classical Z^0 field vanishes makes also sense and should hold at least in the length scales in which weak bosons do not appear. This guarantees the absence of axial couplings and parity breaking effects. In living matter parity breaking effects are large and one could consider the possibility that weak length scale is scaled up for $h_{eff} > h$ and that classical Z^0 fields are present below the weak scale.

3. One cannot exclude the possibility that the classical weak fields vanish for entire space-time surface. In this case spinor modes can still be seen as continuous superpositions of 2-D ones. In principle one can consider also other options - such as vanishing of induced Kḧler form or classical em field besides that of W fields.

The conservative option is that classical weak fields vanish in the situation considered so that there is room for the strong gravimagnetic field. The following model starts from the model of Tajmar *et al* and generalizes it by replacing Planck constant with its gravitational counterpart.

Modification of the model of Tajmar *et al* by replacing h with h_{gr}

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

One can of course develop an objection against the gravimagnetic field proportional h_{eff}^2: also ordinary London magnetic field should be scaled in the same manner due to the proportionality to λ_γ^2. The resulting magnetic field would be enormous. One can however argue that the increase of Planck constant cannot affect the value of the ordinary London magnetic field. The scaling up of length scales by h_{eff} and flux conservation suggest that the value of B scales down like $1/h_{eff}^2$. This factor is compensated by the h_{eff}^2 factor in the expression of London magnetic field coming from the expression of magnetic penetration length in terms of mass of photon. One can of course ask why magnetic and gravimagnetic London field are different.

1. The formula used by Tajmar *et al* [E16] for the gravimagnetic variant of London magnetic field is direct generalization for the London field for ordinary super-conductor. The gravimagnetic field is proportional to the product $B_g = \omega_R r^2$ of the rotation frequency ω_R of super-conductor and square of the ratio $r = (\lambda_g/\lambda_{g,T})$, where $\lambda_g = \hbar/m_g$ is graviton wave length and $\lambda_{g,T}$ is gravimagnetic penetration length obtained as generalization of the magnetic penetration length for super-conductors by replacing charge with mass. The latter is purely classical quantity whereas graviton wave length depends on Planck constant. Graviton mass can be argued to result in gravitational Meissner effect and can be estimated from the value of cosmological constant Λ being essentially its square root. The resulting value of B_g is too small by 28 orders of magnitude.

2. Tajmar *et al* [E16] suggests that graviton mass is larger by a factor of order 10^{14} in conflict with the experimental upper bound of order 10^{55} kg for m_g. TGD proposal is that it is Planck constant which should be replaced with effective Planck constant $h_{eff} = nh$ equal to gravitational Planck constant h_{gr} for electron Cooper pair in Earth's gravitational field. The model for planetary orbits as Bohr orbits together with Equivalence Principle implies $\hbar_{gr} = GMm/v_0$ at flux tubes connecting particle with mass m to Sun with mass M. v_0 has dimensions of velocity and has order of magnitude correlating with a typical rotation velocity of planetary orbit by Bohr quantization rules.

3. In the recent case the rotation velocity v_0 is the rotation velocity of Earth at its surface: $v_0(E)/c = 2.16 \times 10^{-6}$ to be compared with $v_0(S)/c \simeq .5 \times 10^{-3}$ for Sun-Earth system. The scaling of λ_g is given by $h_{gr}(E, pair)/h = (h_{gr,S,pair}/h) \times (M_E/M_S) \times v_0(S)/v_0(E)$. This gives

$$r \equiv \frac{h_{gr,S,pair}}{h} = \frac{\lambda(h_{gr,S,pair}}{\lambda(h,pair)} = \frac{\frac{GM}{v_0(S)}}{\lambda_c(pair)} = \frac{\frac{r_S}{v_0(S)}}{\lambda_c(e)} \quad .$$

Using $r_S = 3km$ and $\lambda_e = .243 \times 10^{-12}$ m and $v_0(S) \simeq 2^{-11}$, $M_E/M_S = 3.0 \times 10^{-6}$ one obtains $r \simeq 3.6 \times 10^{14}$. This happens to be correct order of magnitude! Maybe the model might have something to do with reality. Even better, also the value of h_{eff} is consistent with its value spectrum appearing in EEG if one requires that the energy of dark EEG photon with frequency of order 10 Hz is that of biophoton with frequency of about 5×10^14 Hz. If this picture is correct the values of $h_{eff} = h_{gr}$ would comes as proportional to the masses of particles and cyclotron energies proportional to heB/m would not depend on the mass of the particle at all.

4. What is nice that the model unifies the notions of gravitational Planck constant and dark Planck constant. The basic observation is that Equivalence Principle allows to understand the effects of h_{gr} by reducing it to elementary particle level interpreted in terms of flux tubes connecting particle to the bigger system. This allows to avoid gigantic values of h_{gr} and gives connection with TGD inspired quantum biology. The new quantum physics associated with gravitation would also become key part of quantum biology.

Could $h_{gr} = h_{eff}$ hold true?

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = nh$ deduced from ELF effects on vertebrate brain and explained in terms of non-determinism of Kähler action could be identical. At first this seems to be non-sensical idea since $\hbar_{gr} = GMm/v_0$ has gigantic value.

It is however essential to realize that by Equivalence Principle one describe gravitational interaction by reducing it to elementary particle level. For instance, gravitational Compton lengths do not depend at all on the masses of particles. Also the radii of the planetary orbits are independent of the mass of particle mass in accordance with Equivalence Principle. For elementary particles the values of h_{gr} are in the same range as in quantum biological applications. Typically 10 Hz ELF radiation should correspond to energy $E = h_{eff}f$ of UV photon if one assumes that dark ELF photons have energies of biophotons and transform to them. The order of magnitude for n would be therefore $n \simeq 10^{14}$.

The experiments of M. Tajmar *et al* [E11, E16] discussed in [K90] provide a support for this picture. The value of gravimagnetic field needed to explain the findings is 28 orders of magnitude higher than theoretical value if one extrapolates the model of Meissner effect to gravimagnetic context. The amazing finding is that if one replaces Planck constant in the formula of gravimagnetic field with h_{gr} associated with Earth-Cooper pair system and assumes that the velocity parameter v_0 appearing in it corresponds to the Earth's rotation velocity around its axis, one obtains correct order of magnitude for the effect requiring $r \simeq 3.6 \times 10^{14}$.

The most important implications are in quantum biology and Penrose's vision about importance of quantum gravitation in biology might be correct.

1. This result allows by Equivalence Principle the identification $h_{gr} = h_{eff}$ at elementary particle level at least so that the two views about hierarchy of Planck constants would be equivalent. If the identification holds true for larger units it requires that space-time sheet identifiable as quantum correlates for physical systems are macroscopically quantum coherent and gravitation causes this. If the values of Planck constant are really additive, the number of parallel space-time sheets corresponding to non-determinism evolution for the flux tube connecting systems with masses M and m is proportional to the masses M and m using Planck mass as unit. Information theoretic interpretation is suggestive since hierarchy of Planck constants is assumed to relate to negentropic entanglement very closely in turn providing physical correlate for the notions of rule and concept.

2. That gravity would be fundamental for macroscopic quantum coherence would not be surprising since by EP all particles experience same acceleration in constant gravitational field, which therefore has tendency to create coherence unlike other basic interactions. This in

principle allows to consider hierarchy in which the integers $h_{gr,i}$ are additive but give rise to the same universal dark Compton length.

3. The model for quantum biology relying on the notions of magnetic body and dark matter as hierarchy of phases with $h_{eff} = n \times h$, and biophotons [K22, K13] identified as decay produces of dark photons. The assumption $h_{gr} \propto m$ becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

   (a) If dark photons with cyclotron frequencies decay to biophotons, one can conclude that biophoton spectrum reflects the spectrum of endogenous magnetic field strengths. In the model of EEG [K36] it has been indeed assumed that this kind spectrum is there: the inspiration came from music metaphors suggesting that musical scales are realized in terms of values of magnetic field strength. The new quantum physics associated with gravitation would also become key part of quantum biophysics in TGD Universe.

   (b) For the proposed value of h_{gr} 1 Hz cyclotron frequency associated to DNA sequences would correspond to ordinary photon frequency $f = 3.6 \times 10^{14}$ Hz and energy 1.2 eV just at the lower limit of visible frequencies. For 10 Hz alpha band the energy would be 12 eV in UV. This plus the fact that molecular energies are in eV range suggests very simple realization of biochemical control by magnetic body. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.

   (c) Biophoton with a given energy would activate transitions in specific bio-molecules or atoms: ionization energies for atoms except hydrogen have lower bound about 5 eV (`http://tinyurl.com/233vcad`). The energies of molecular bonds are in the range 2-10 eV (`http://tinyurl.com/bfsy4ft`). If one replaces v_0 with $2v_0$ in the estimate, DNA corresponds to.62 eV photon with energy of order metabolic energy currency and alpha band corresponds to 6 eV energy in the molecular region and also in the region of ionization energies.

   Each ion at its specific magnetic flux tubes with characteristic palette of magnetic field strengths would resonantly excite some set of biomolecules.This conforms with the earlier vision about dark photon frequencies as passwords.

   It could be also that biologically important ions take care of their ionization self. This would be achieved if the magnetic field strength associated with their flux tubes is such that dark cyclotron energy equals to ionization energy. EEG bands labelled by magnetic field strengths could reflect ionization energies for these ions.

   (d) The hypothesis means that the scale of energy spectrum of biophotons depends on the ratio M/v_0 of the planet and on the strength of the endogenous magnetic field, which is.2 Gauss for Earth (2/5 of the nominal value of the Earth's magnetic field). Therefore the astrophysical characteristics of planets should be tuned for molecular life. Taking v_0 to be rotational velocity one obtains for the ratio $M(planet)/v_0(planet)$ using the ratio for Earth as unit the following numbers for the planets (Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptune): $M/v_0 = (8.5, 209, 1, .214223, 1613, 6149, 9359)$. If the energy scale of biophotons is required to be the same, the scale of endogenous magnetic field should be divided by this ratio in order to obtain the same situation as in Earth. For instance, in Mars the magnetic field should be roughly 5 times stronger: in reality the magnetic field of Mars is much weaker. Just for fun one can notice that for Sun the ratio is 1.4×10^6 so that magnetic field should be by the inverse of this factor weaker.

4. An interesting question is how large systems can behave as coherent units with $\hbar_{gr} = GMm/v_0$. In living matter one might consider the possibility that entire organism might be this kind of system. Interestingly, for larger masses the gravitational quantum coherence would be easier. For particle with mass m $h_{gr}/h > 1$ requires larger mass to satisfy $M > M_P^2/m_e$. The first guess that life has evolved from long to shorter scales and reached elementary particle last. Planck mass is the critical mass corresponds to the mass of water blog with volume of size scale of 10^{-4} m (big neuron) is the limit.

5. The Universal gravitational Compton wave length of $GM/v_0 \simeq 864$ meters gives an idea about largest possible living matter system if Earth is the second body. Of course, also other large bodies are possible.In the case of solar system this length is 3×10^3 km. The radius of Earth is 6.37×10^3 km - roughly twice the Compton length. The radii of Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptunus are (.38, .99, .533, 1, 10.6, 8.6, 4.0, 3.9) using Earth radius as unit the value of h_{gr} is by factor 5 larger than for 4 inner planets so that the values are reasonably near to gravitational Compton length or twice it. Does this mean that dark matter associated with Earth and maybe also other planets is in macroscopic quantum state at some level of the hierarchy of space-time sheets? Does this mean that Mother Gaia as conscious entity might make sense. One can of course make same question in the case of Sun. The universal gravitational Compton length in Sun would be 18 per cent of the radius of Sun if v_0 is taken to be the rotational velocity at the surface of Sun. The radius of solar core, where fusion takes place, is 20-25 per cent of solar radius.

6. There are further interesting numerical coincidences. One can for a moment forget the standard hostility of scientist towards horoscopes and ask whether Sun and Moon could have somehow affect our life via astrocopic quantum coherence. The gravitational Compton length for particle-Moon or particle-Sun system multiplied by the natural value of magnetic field is the relevant parameter. For Sun the parameters in question are mass of Sun, and rotational velocity of Earth with respect to Sun, plus magnetic fields of Sun at flux tubes associated with solar magnetic field measured to be about 5 nT at the position of Earth and 100 times stronger than expected from dipole field behavior. This gives that the range of biophoton energies is scaled down with factor of 1/4 in good approximation so that Father Sun might affect terrestrial biology! If one uses for the rotational velocity of particle at surface of Moon as parameter v_0 (particle would be at Moon), biophoton energy scaled scaled up by factor 1.2.

The general proposal discussed above is testable. In particular, a detailed study of molecular energies with those associated with resonances of EEG could be highly rewarding and reveal the speculated spectroscopy of consciousness.

What about $h_{em} = h_{eff}$?

The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone [L13] (`http://tinyurl.com/oyhstc2`) and its complement define this kind of system and TGD inspired identification is as prebiotic life form. I have proposed a TGD inspired model for the fourth phase of water [K58] [L13].

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. The rotating shaft of a molecular motor associated with ATP synthase is proposed to play a key role.

2. What comes in mind is that the rotational velocity v_0 of the shaft appears in the formula for h_{em}. The electric field over the mitochondrial membrane generates charge separation and the product of charges of shaft and its complement should appear in the expression for h_{em}.

3. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The lower bound for the magnitude for h_{em} is same as for h_{gr} associated with Earth-particle system.

Rotating magnetic systems are claimed to exhibit anomalous effects such as spontaneous acceleration and over unity energy production. I have discussed these in [K10].

1. The proposal is that rotating magnetic systems give rise to dark matter at magnetic flux tubes and sheets associated with the system and that the metabolic energy is needed to rotate the motor to generate the dark matter, which in turn makes possible negentropic entanglement characterized the density matrix proportional to unit matrix. This kind of matrix results if

entanglement coefficients form a unitary S-matrix characterizing also quantum computation as unitary process.

2. The parameter v_0 appearing in the general formula for h_{eff} assigned with either em - or gravitational flux tubes is identifiable as the rotation velocity. One has $v_0/c \simeq 3 \times 10^{-8}$.

3. Since these systems are strongly charged, a natural guess is that large h_{em} system is in question.

9.2.3 Gravitational Mother Gaia And Life

Negentropic entanglement (NE) is one of the key notions of TGD inspired quantum biology. For instance, it would seem that NE would look more natural metabolic resource than energy. Nutrients should carry it. NE is however not single particle property but between nutrient and some other system in the recent case. What can one say about this system? Can it be part of nutrient? Could it correspond to oxygen molecules? Or could it be Mother Gaia identified in some sensible manner?

If one believes on the presence of gravimagnetic flux tubes and their role as generator of macroscopic quantum coherence in biology then one is forced to consider seriously also NE between its ends. If this is the case then the view of religions about life might be nearer to truth than that of hard-born materialists.

To make this more concrete, let us first look what the transfer of NE could mean.

1. Suppose that nutrient N has NE with unknown system A which a priori could be part of nutrient. Assume that the transfer of NE of nutrient with A is formed by reconnection of U-shaped flux tubes associated with N (or glucose G produced from it) and A so that two parallel flux tubes connecting N and A are formed.

2. The basic operation allowing transformation of $N - A$ NE to $P - A$ NE is following. The two flux tube portions of U-shaped flux associated with the receiver R are reconnected with the two parallel flux tubes connecting N and A so that two flux tubes connecting R to A are formed. NMP strongly suggests that the entanglement remains negentropic in the process.

3. NE is first transferred to P using this process so that P and A are now NE-connected. After this P attaches to ADP to yield ATP and ATP attaches to B and the transfer process leads to NE between B and A.

   For ATP synthase the h_{em} consisting two elementary charges is of the same order as h_{gr}. This is probably not an accident. Could this mean that this kind of flux tube can reconnect with gravitational flux tube? Could this make possible a reconnection transforming N-Earth NE to P-Earth NE? This looks plausible.

Consider now the identification of A.

1. If one assumes that the negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) corresponds to gravitational flux tubes for N-Earth system then A should be gravitational Mother Gaia, whatever its precise definition might be. N (and glucose) molecules would be alive in the sense that they have NE with Mother Gaia.

2. Could oxygen have some deeper role? For instance, could O_2 molecules serve as analogs of cell membrane receptors for Mother Gaia meaning that gravitational flux tubes go through O_2 molecules? This does not look plausible since metabolism is possible also as fermentation involving no oxygen.

3. In this picture the role of breathing and fermentation would be to make possible the transfer of NE from nutrients to the living system.

This picture allows to imagine about what might happen in biological death. Biological death takes first place only at the highest level of self hierarchy assignable to the our biological body. Cells continue for some time their life even after the last breath. The notion of h_{gr} together with Equivalence Principle suggests that the living biological body has negentropic flux tube connections

to both electromagnetic magnetic body (personal magnetic body) and to gravitational Mother Gaia (MG) representing collective consciousness in the scale of Earth. Also personal magnetic body has flux tube connections to MG. The latter especially during sleep. Also connections to higher levels in hierarchy are possible. At the moment of biological death the negentropic flux tube pairs connecting the personal magnetic body to biological body are split and only those with MG remain or are generated in this process. This would happen later at lower levels of biological self hierarchy such as organ and organelles and eventually for cells and biopolymers. On the other hand, new life forms using the decay products as nutrients would take the available NE to use during the decay process.

The quantum model for metabolism allows to understand life as a process in which negentropic entanglement of gravitational Mother Gaia with nutrients is transformed to that of molecules of biological body with personal magnetic body and further processed and enriched. At the moment of biological death this information returns to the gravitational Mother Gaia. By NMP information is not lost but increases steadily giving rise to "Akashic records". This view conforms with the core ideas of spiritual and religious teachings.

9.3 TGD Inspired Model For The Formation Of Exclusion Zones From Coherence Regions

There is a talk of Mae-Wan Ho (`http://tinyurl.com/ybbyn4pc`) in Conference on the Physics, Chemistry and Biology of Water 2014. It is a very nice representation and I learned new facts highly relevant for my own work.

Some background articles might be helpful. Mae-Wan Ho [I109] has proposed that there exists superconducting liquid crystal water aligned with collage fibres. Giudice *et al* [I59] have proposed that water dynamics is at the root of metamorphosis in living matter: this involves the notion of water coherent region (CD) with size scale of 1 micrometer. I have not considered this notion in TGD framework earlier but TGD strongly suggests that the four Gaussian Mersennes $M_{G,k}$, $k = 151, 157, 164, 167$ with corresponding p-adic length scales coming as $L(k) = 2^{(k-151)/2} times L(151)$, $L(151)$=10 nm are important in biology: $k = 167$ corresponds to 2.5 micrometers. Pollack and *et al* [I143, I123] have introduced the concept of exclusion zone (EZ) with size scale of 200 nm and related notion fourth phase of water. TGD inspired model of EZ involves in essential manner dark protons at magnetic flux tubes assignable to EZ [K70, K74].

The main points of Mae-Wan Ho's talk are following.

1. Protons make water a conductor, maybe even superconductor. In TGD framework the statement would be that dark protons flowing along magnetic flux tubes make this possible. Personally I believe that electronic and even ionic Cooper pairs are are involved and TGD based model of cell membrane [K88] assumes these super-conductivities relying on the notion of dark matter realizes as $h_{eff} = n \times h$ phases.

2. The water associated with collagen networks appears as superconductor and superfluid in nano-scales. Also this is very attractive idea and if the $h_{eff} = h_{gr}$ condition holds as some arguments suggest, then superfluidity allowing macroscopic quantum coherence with gravitational Compton length having no dependence on the mass of particle becomes possible [K70]. This is due to two facts. First, one has $\hbar_{gr} = GMm/v_0$, where M can be identified as dark part of the Earth's mass, m is the mass of the particle and v_0 is velocity parameter. Secondly, Compton length is inversely proportional to the mass. One of the strange effects involved with superfluidity is fountain effect explained elegantly by macroscopic quantum gravitational coherence: water would effectively defy gravitation: this effect might allow testing of the hypothesis.

9.3.1 CDs And EZs

Mae Wan-Ho talked about and compared two notions: CDs (coherent domains of water with size of about micrometer postulated by quantum field theoreticians, in particular Emilio del Giudice) and EZs (exclusion domains with size about 200 micrometers discovered by Gerald Pollack and

collaborators experimentally). Note that in Zero Energy Ontology (ZEO) I talk about causal diamonds (CDs), which are typically much larger than CDs of Giudice *et al.*

1. Inside EZ the water forms layered structure consisting of hexagonal layers and the stoichiometry is $H_{1.5}O$ so that every fourth proton must be outside EZ (proton is not accompanied by electron if charge separation takes place: EZ is indeed negatively charged so that one obtains different pHs inside EZ and in its exterior). This state is experimentally heavier than ordinary water.

2. So called tetrahedral or 4-coordinated water is assigned with CDs. CDs and EZs could correspond to two different p-adic length scales in TGD framework. This state would be less dense than ordinary water. Both CD and EZ contain plasma of almost free electrons. CDs are excited to 12.06 eV just.5 eV below the ionizing potential 12.56 eV..5 eV which is the nominal value of metabolic energy quantum - probably not an accident.

9.3.2 TGD Inspired Model For CDs And EZs

I try my best to summarise some very interesting points of the talk and develop in more detail TGD inspired model for EZs and their formation, and the TGD view of metabolism leading to a prediction of new form of metabolism involving dark UV photons from Sun.

1. The splitting of ordinary water H_2O to $2H^+ + 2e^- + O$ is a key step in photosynthesis. In particular, it produces oxygen without which which we cannot survive. The splitting process involves two ionizations. The ionisation energy of the first electron 12.56 eV and in ultraviolet much above the metabolic energy quantum around.5 eV. How the splitting of water can be achieved at all? This looks like a very real problem!

2. CDs/EZs could be the solution to the problem. Inside CD the energy for the splitting of water is much smaller due to the fact that electrons are almost free as already mentioned: if the splitting energy equals to the so called formation energy, it is about.41 eV for CD: nothing but the metabolic energy quantum! Also at the interace of EZ just above the boundary of EZ the electronic states are excited and only an energy of.51 eV - known as formation energy - is needed for the splitting. This suggests that metabolic energy quanta are used to generate EZs and/or CDs in the fundamental step metabolism. Also irradiation at these energies generates CDs/EZs.

3. My layman logic says that formation energy for EZ must correspond to the energy needed to increase the size of /EZ by a minimum amount. In TGD model this would mean creating one proton-electron pair such that electron remains inside the EZ, whose size thus increases and proton becomes dark proton at dark magnetic flux tube. This step would be also a key step in the splitting of water. Splitting of water and growth of EZ would be essentially the same process. In the case of CD it would seem that charge separation takes place inside CD in the splitting and proton can go outside.

   What comes in mind that the formation of CDs requiring large excitation UV energy of 12.06 eV precedes that of EZs. After the formation of CD and almost free electrons only metabolic energy quantum per proton is required to kick single proton to dark magnetic flux tube. This would conform with the fact that CD radius is about 200 times larger than that of CD meaning that volumes are related by a factor $8 \times 10^6 \simeq 2^{23}$. The formation of EZ would transform tetrahedral water to the hexagonal $H_{1.5}O$ and suck protons to dark protons at magnetic flux tubes. If this picture is correct, the proper identification of formation energy for CD would be as absorption energy for CD equal to 12.06 eV and in UV. Recall that bio-photon spectrum extends to UV and dark photons with this energy could be responsible for the formation of CDs. This would adde dark photons transforming to bio-photons to the picture.

   The formation of EZ can be seen as pulling out one ordinary proton from ordinary water just above the surface of the EZ and making it dark proton at a magnetic flux tube assignable to the EZ and perhaps connecting it to neighboring EZ for form a quantum coherent network. Dark proton would serve as a current carrier and make water a conductor and perhaps even super-conductor. Even superfluidity can be considered.

4. The metabolic energy quantum.5 eV can be also assigned with hydrogen bond. Could the process of generating dark proton and increasing the size of EZ by one electron involve cutting of the hydrogen bond binding the proton to the water outside. If so then the only thing keeping the excited water inside CD as a coherent phase would be the bond energy of hydrogen bonds! Maybe this is too simplistic.

   I have proposed earlier that hydrogen bonds are short magnetic flux flux tubes, which can suffer h_{eff} increasing phase transition. These flux tubes could in turn experience reconnections with U shaped large h_{eff} flux tubes and get connected to the dark web. Mae-Wan Ho also tells that the transfer of proton from covalent OH bond to the middle of hydrogen bond happens with a considerable probability. Could this step precede the increase of h_{eff} and reconnection? This would give a connection with hydrogen bonding about which Mae Wan-Ho also talked about. These naïve models of course cannot be correct in detail but give hopes about fusion of existing chemical thinking and new quantal notions.

5. A process bringing in mind the formation of EZs occurs as one perturbs molecular biosystems - that is feeds energy into it. The system "wakes up" from "winter sleep", the globular proteins, which are in resting state with hydrogen bonds at their surface forming kind of ice layer unfold and protein aggregates are formed. Molecular summer begins and ceases when the energy feed is over. Cellular winter begins again. Maybe cellular summer is just temporary formation of EZ layers around the protein involving melting of hydrogen bonds and generation of dark protons making system conscious!

9.3.3 Is A New Source Of Metabolic Energy Needed?

What remains to be understood is the process generating CDs: where could the UV photons with energy 12.06 eV come? Clearly a new form of metabolism is involved and the only source of energy seems to be the Sun!

1. Solar radiation cannot however provide UV photons as ordinary photons since UV radiation at these wavelengths is absorbed by the atmosphere. In TGD framework a reasonable candidate for dark radiation with energies in UV range is dark cyclotron radiation with energy $E = h_{eff} \times f$: biophotons would be produced in the transformation of dark cyclotron photons to ordinary photons.

2. Could part of solar UV radiation transform to dark UV photons at magnetic flux tubes of even size scales larger than that of Earth predicted by the model of EEG and arrive along them through the atmosphere? The presence of a new source of metabolic energy is in principle a testable prediction: is the energy feed from the visible part of solar radiation really enough to cover the metabolic energy needs? Here one must however take into account the fact that the UV energy would be received by water. The water from which CDs are eliminated would not allow photosynthesis.

To sum up, if the proposed picture is correct photosynthesis involves formation of EZs and cellular respiration the inverse of this process. As discussed earlier, the purpose of metabolic processes would be basically generation and transfer of negentropic entanglement assignable to large h_{eff} states.

9.4 Water Memory And Pre-Biotic Life

Pollack's findings [L13] discussed from TGD view point in [K76, K72] provide new insights to the mechanisms of water memory and homeopathy. Also the attempts to understand the dependence of h_{eff} on parameters of the system involved provide help. This picture also suggests a more detailed vision about prebiotic life forms as analogs of exclusion zones involving charge separation leading to large value of h_{eff}.

9.4.1 Exclusion Zones As Prebiotic Cells

TGD based model model [L13], [K73] for Pollack's findings [L13] provides further guidelines.

1. Pollack *et al* discovered what they call exclusion zones and fourth gel like phase of water. The phenomenon occurs when water is bounded by gel and is irradiated with say visible light. Exclusion zones are negatively charged regions of water with positively charged environment. They act like batteries and have rather exotic properties. For instance, various impurities are repelled from exclusion zone.

2. The observed $H_{1.5}O$ stoichiometry implies that every fourth proton or hydrogen atom is dark and is transferred to the region outside the negatively charged exclusion zone. If only protons are transferred, very high negative charge density is generated. The size of the exclusion zone varies up to 100 μm and is in the range of cell sizes.

3. Dark matter corresponds in TGD Universe to phases with nonstandard value of Planck constant: $h_{eff} = n \times h$ phases at the "magnetic body" of the system (negatively charged region now). Magnetic body corresponds in Maxwell's theory to the magnetic fields generated by the system. Magnetic body consists of flux quanta (flux tubes and sheets).

4. If dark protons with say size scale of atomic size reside at flux tubes, one can assume that they form strings giving rise to dark atomic nuclei. Also ordinary nuclei consist of strings of dark protons and strings of neutrons. Various impurities are transferred from exclusion zone to the exterior suggesting that they become dark particles at magnetic flux tubes.

5. The quantum states of dark protons consist of 3 quarks and a simple model involving rotational symmetry around the axis of dark proton string predicts that the states of dark proton can be arranged into groups which correspond to DNA, RNA, amino-acids and possibly also tRNA molecules. Vertebrate genetic code can be realized as a natural correspondence between DNA/ RNA and amino-acids [L2, K47].

6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive prebiotic life form. The voltage would be the analog of the resting potential. The transformation of dark protons to ordinary ones would liberate metabolic energy so that primitive metabolism and photosynthesis would be realized. One can also consider a more general possibility that cyclotron energies are different at flux tube portions in the interior and exterior of the EZ analogous to cell membrane. This would increase the value of the metabolic energy currency by adding to Josephson energy ZeV the difference of dark cyclotron energies proportional to h_{eff}. One expects that dark counterparts of basic bio-polymers are still present in living matter and play a fundamental role.

9.4.2 TGD View About Homeopathy, Water Memory, And Evolution Of Immune System

The following gives an attempt to build a brief sketch of TGD based model of water memory and homeopathy as it is after the input from Pollack's findings and $h_{eff} = h_{gr} = h_{em}$ hypothesis.

Summary of the basic facts and overall view

A concice summary of the basic qualitative facts about homeopathy [K47] could be following.

1. The manufacture of the homeopathic remedies consists of repeated dilution and agitation of water sample containing the molecules causing the effect which the remedy is intended to heal. This paradoxical looking healing method is based on "Alike likes alike" rule. This rules brings in mind vaccination causing immune system to develop resistance. The procedure seems to somehow store information about the presence of the molecules and this information induces immune response. Usually it is the organisms or molecules causing the disease which induce immune response.

2. The ultra-naïve and simplistic objection of skeptic is that the repeated dilution involved with the preparation of homeopathic remedy implies that the density of molecules is so small that the molecules can have absolutely no effect. Despite the fact that we live in information society, this is still the standard reaction of a typical skeptic.

3. A lot of research is done by starting from the natural idea that the electro-magnetic fields associated with the invader molecules (or more complex objects) represent the needed information and that water somehow gets imprinted by these fields. This could for instance mean that water clusters learn to reproduce radiation at frequencies characterizing the invader molecule. Benveniste is one of the most outstanding pioneers in the field [I61]. Benveniste *et al* [I62] even managed to record the VLF frequency finger print of some bio-active molecules and record them in binary form allowing to to yield the same effect as the real bio-active molecule induced. Benveniste was labelled as a fraud. The procedure used by the journal Nature to decide whether Benveniste is swindler or not brings in mind the times of inquisition. It tells a lot about attitudes of skeptics that magician Randi was one member of the jury!

4. Benveniste's work has been continued and recently HIV Nobelist Montagnier produced what might be regarded as remote replication of DNA using method very similar to that used in manufacturing homeopathic remedy [I86, I87].

The general conclusion is that the em frequencies possibly providing a representation of the molecules are rather low - in VLF region - so that frequencies assignable to molecular transitions are not in question. Cyclotron frequencies assignable to the molecules are the most natural candidates concerning physical interpretation. The corresponding photon energies are extremely low if calculated from $E = hf$ formula of standard quantum mechanics so that quantal effects in the framework of standard quantum theory do not seem to be possible.

My personal interest on water memory was sparked by the work of Cyril Smith [I55]. What I learned was what might be called scaling law of homeopathy [K47]. Somehow low frequency radiation seems to be transformed to high frequency radiation and the ratio $f_h/f_l \simeq 2 \times 10^{11}$ seems to be favored frequency ratio.

These two basic findings suggest what looks now a rather obvious approach to homeopathy in TGD framework. The basic physical objects are the magnetic bodies of the invader molecule and water molecule cluster or whatever it is what mimics the invader molecule. The information about magnetic body is represented by dark cyclotron radiation generated by the invader with frequency f_l. This dark radiation is transformed to ordinary photons with frequency f_h and energy $h_{eff} f_l = h f_h$, which is above thermal energy, most naturally in the range of bio-photon energies so that the radiation can directly induce transitions of bio-molecules. The analogs for the EZs discovered by Pollack are obvious candidates for "water molecule clusters".

The following summarizes this overall picture in more detail.

Dark photon-bio-photon connection

The idea that bio-photons are decay product of dark photons emerged from the model of EEG [K36] in terms of dark photons with energies above thermal energy. Dark photons in question would be emitted as cyclotron radiation by various particles and molecules, perhaps even macromolecules like DNA sequencies. Also cell membrane would emit dark photons with frequencies, which correspond in good approximation to differences of cyclotron energies for large value of $h_{eff} = nh$ [K76, K36].

1. Bio-photons have spectrum in the visible and UV would decay products of dark cyclotron photons. If the h_{eff} of particle is proportional to its mass then the cyclotron energy spectrum is universal and does not depend on the mass of the particle at all. The original model of EEG achieved this by assuming that h_{eff} is proportional to the mass number of the atomic nucleus associated with the ion.

2. The ideas about dark matter involve two threads: $h_{eff} = n \times h$ thread motivated by biology and the thread based on the notion of gravitational Planck constant and inspired by the observation that planetary orbits seem to obey Bohr rules. $\hbar_{gr} = GMm/v_0$ is assigned to the pairs of gravimagnetic flux tubes and massless extremals making possible propagation of

dark gravitons. The realization was the two threads can be combined to single thread: by Equivalence Principle h_{gr} hypothesis is needed only for microscopic objects and in this case $h_{eff} = h_{gr}$ makes sense and predicts that dark photon energies and dark particle Compton lengths do not depend on particle and that bio-photon energy spectrum is universal and in the desired range if one assumes that h_{gr} is associated with particle Earth par with v_0 the rotational velocity at the surface of Earth. Even $h_{eff} = h_{em} = h_{gr}$ hypothesis makes sense. $h_{em} = h_{gr}$ is also very natural assumption for ATP synthase which can be regarded as a molecular motor whose rotation velocity appears in the formula for h_{em}.

3. The prediction would be that any charged system connected to Earth by flux tubes generates cyclotron dark photons decaying to bio-photons. Bio-photons in turn induce transitions in biomolecules because the energy range is in visible and UV. Magnetic bodies can control biochemistry via resonant coupling with bio-photons.

Molecular recognition mechanism as basic building brick of primitive immune system

The reconnection of U-shaped magnetic flux tubes emanating from a system makes possible a recognition mechanism involving besides reconnection also resonant interaction via cyclotron radiation which can induced also biochemical transitions of $h_{eff} = h_{gr}$ hypothesis holds true.

1. Molecules have U-shaped flux tube loops with fluxes going in opposite directions. This makes possible also super-conductivity with members of Cooper pair at the parallel flux tubes carrying magnetic fluxes in opposite direction since magnetic fields now stabilize Cooper pairs rather than tend to destroy them.

2. The flux loops associated with systems - call them A and B - can reconnect and this leads to the formation of 2 parallel flux tubes connecting A and B. Stable reconnection suggests that magnetic field strengths must be same at the flux tube pairs associated with A and B. This implies same cyclotron frequencies and resonant interaction. This would define molecular mechanism of recognition and sensing the presence of invader molecules - even conscious directed attention might be involved.

3. Systems with magnetic body could be constantly varying the thicknesses of at least some of their flux tubes and in order to reconnect with the magnetic body of a possible invader. This activity could be behind the evolution of the immune system.

The question is how the system or its sub-system could stabilize itself so that it would receive signals only from one kind of molecule specified by its cyclotron frequency spectrum.

1. If the flux tubes carry monopole flux (this is possible in TGD framework and requires the flux tube cross section is closed 2-surface), stabilization of the flux tube thickness stabilizes the magnetic field strength. How the stabilization of the thickness of the flux tubes could have been achieved?

   Pollack's negatively charged EZs with dark protons at magnetic flux tubes giving rise to dark nuclei identifiable as dark proton sequences suggests an answer. Maybe the presence of dark proton sequences could stabilize the flux tube thickness. Dark proton sequences have also interpretation as dark DNA/RNA/amino-acid sequences [L2].

A further question is whether the magnetic body of the prebiotic cell identified as EZ could use the information about invader molecule to represent its magnetic body either concretely and perhaps even symbolically and regenerate the concrete representation when needed.

1. The concrete representation could be in terms of dark proteins whose folding would represent the topology of the invader molecule and symbolic representation in terms of dark DNA transcribed to dark protein. If the dark protein has same topology of knotting it could more easily attach to the invader molecule and make it harmless. Note that the invaders are naturally other dark DNAs and proteins jus as in living matter. The higher purpose behind this cold war would be stimulation of mimicry - emulation in computer science - leading to generation of cognitive representations and negentropic entanglement.

2. Not only the representation of the 3-D magnetic body - its behavior - is possible. In ZEO also the representation of the dynamical evolution of magnetic body becomes possible since basic objects are pairs of 3-surfaces at future and past boundaries of causal diamond. The challenge is to represent the topology time development of magnetic body - 2-braiding, first concretely by mimicking it and then symbolically in terms of DNA coding for proteins doing the mimicry. The obvious representation for the behavior of magnetic body of invader molecule would be in terms of folding and unfolding of protein representing it.

3. The question how the symbolic representation could have emerged leads to a vision about how genetic code emerged. The model for living system as topological quantum computer utilizing 2-braiding for string world sheets at 4-D space-time leads to the idea that 3-D coordinate grids formed by flux tubes are central for TQC: each node of grid is characterized by 6 bits telling about the topology of the node concerning 2-braiding. Could the 6 bits of dark DNA code for the local topology of the invader molecule and an the flux tube complex mimicking it?

4. This raises the possibility that DNA strands - one for each coordinate line in say z-direction could code for the 2-braiding of 3-D coordinate grid and in this manner code for the magnetic template of invader molecule and also that of the biological body. Therefore genetic code would code for both the basic building bricks of the biological body and 4-D magnetic body serving as template for the development of biological body.

One can imagine how the biochemical evolution after this stage might have taken place.

1. At the next step the chemical representation of genetic code would have emerged. Dark proteins learned to attach to real proteins and real proteins to other proteins and DNA and bio-catalysis became possible.

2. The transformation of the ordinary photons emitted in the transitions of biomolecules to dark photons made possible the recognition of invader molecules using ordinary photons emitted in their molecular transitions.

3. Magnetic bodies learned to control biochemical reactions by using dark cyclotron radiation transformed to bio-photons.

4. Gradually dark and ordinary proteins developed a rich repertoire of functions relying on reconnection, communication by dark photons, and attachment in invader molecule. Proteins began to serve as building bricks, as bio-catalysts, promote the replication of DNA, responding to stimuli, serve as receptors.

Possible mechanism of water memory and homeopathy

The general vision about prebiotic evolution described above suggests that the mechanisms of water memory and homeopathy are basically the same as those underlying the workings of the immune system.

1. Exclusion zones could define primordial life forms with genetic code. They are able to detect the presence of invader molecule from its cyclotron frequency spectrum.

2. Dark proteins can form concrete memory representations of the invader molecules in terms of dark proton sequences defining dark proteins. The folding of these dark proteins mimics the behavior of the magnetic bodies of the invaders. These dark proteins can attach to the magnetic body of the invader molecule to make it non-dangerous. Even symbolic representations in terms of dark DNA allowing transcription and translation to concrete dark protein representation could be involved. The procedure involved in the manufacture of homeopathic remedy could be seen as a series of "environmental catastrophes" driving the evolution of dark primordial life by feeding in metabolic energy and generating new EZs, which mimic the invader molecules and existing EZs mimicking them.

3. In organism the dark DNA representing the invader molecule would generate ordinary genes coding for ordinary proteins attaching to the invader molecules by the attachment of ordinary DNA nucleotides to them. The attachment would involve h_{eff} reducing phase transition reducing the length of connecting flux tube.

4. Later dark genetic code transformed to chemical genetic code as dark DNA strands were formed around dark double strands and large number of other biological functions emerged besides immune response.

5. The mechanical agitation in the manufacturing of homeopathic remedy generates exclusion zones and new primitive life forms by providing the needed energy. These in turn recognize and memorize invader molecules and their already existing representations as EZs.

9.4.3 Direct Empirical Evidence For Dark DNA?!

Sciencedaily tells about extremely interesting finding related to DNA (`http://tinyurl.com/pbzqx36`. The finding is just what breakthrough discovery should be: it must be something impossible in the existing world view.

What has been found [I94] (`http://tinyurl.com/y9849jkz`) is that knock-out (removing parts of gene to prevent transcription to mRNA) and knock-down of gene (prevent protein translation) seem to have different consequences. Removing parts of gene need not have the expected effect at the level of proteins! Does this mean that somehow DNA as a whole can compensate the effects caused by knock-out but not those by knock-down? This explanation is natural in the standard conceptual framework and is proposed in the article.

Could this be explained by assuming that genome is a hologram as Gariaev *et al* (`http://tinyurl.com/ycosxzen`) [I71, I5] have first suggested? Also TGD leads to a vision about living system as a conscious hologram [K16]. Small local changes of genes could be compensated. Somehow the entire genome would react like brain to a local brain damage: other regions of brain take the duties of the damaged region. Could the idea about DNA double strand as nano-brain having left and right strands instead of hemispheres"help here. Does DNA indeed act as a macroscopic quantum unit? The problem is that transcription is local rather than holistic process. Something very simple should lurk behind the compensation mechanism.

Could transcription transform dark DNA to dark mRNA?

Also the TGD based notion of dark DNA comes in mind [K47, L2] (`http://tinyurl.com/ybp338x5`, `http://tinyurl.com/yag67j4p`). Dark DNA consists of dark proton sequences for which states of single DNA proton correspond to those of DNA, mRNA, aminoacids, and tRNA. Dark DNA is one of the speculative ideas of TGD inspired quantum biology getting support from Pollack's findings (`http://tinyurl.com/oyhstc2` [L13], [K70]). Ordinary biomolecules would only make their dark counterparts visible: dark biomolecules would serve as a template around which ordinary biomolecules such as DNA strands are formed in TGD Universe. All basic biomolecules of genetics would be pairs of ordinary biomolecule and its dark proton analog.

Although ordinary DNA is knocked out of ordinary gene, dark gene would still exist! If dark DNA actually serves as template for the transcription to mRNA, everything is still ok after knockout! Could it be that we do not understand even transcription correctly? Could it actually occur at the level of dark DNA and mRNA?! Dark mRNA would attach to dark DNA after which ordinary mRNA would attach to the dark mRNA. One step more!

Damaged DNA could still do its job! DNA transcription would would have very little to do with bio-chemistry! If this view about DNA transcription is correct, it would suggest a totally new manner to fix DNA damages. These damages could be actually at the level of dark DNA, and the challenge of dark genetic engineering would be to modify dark DNA to achieve a proper functioning.

Could dark genetics help to understand the non-uniqueness of the genetic code?

Also translation could be based on pairing of dark mRNA and dark tRNA. This suggests a fresh perspective to some strange and even ugly looking features of the genetic code. Are DNA and

mRNA always paired with their dark variants? Do also amino-acids and anticodons of tRNA pair in this manner with their dark variants? Could the pairings at dark matter level be universal and determined by the pairing of dark amino-acids with the anticodons of dark RNA? Could the anomalies of the code be reduced to the non-uniqueness of the pairing of dark and ordinary variants of basic bio-molecules (pairings RNA–dark RNA, amino-acid– dark amino-acid, and amino-acid–ordinary amino-acid in tRNA).

1. There are several variants of the genetic code differing slightly from each other: correspondence between DNA/mRNA codons and amino-acids is not always the same. Could dark-dark pairings be universal? Could the variations in dark anticodon - anticodon pairing and dark amino-acid-amino-acid pairing in tRNA molecules explain the variations of the genetic code?

2. For some variants of the genetic code a stop codon can code for amino-acid. The explanation at the level of tRNA seems to be the same as in standard framework. For the standard code the stop codons do not have tRNA representatives. If stop codon codes for amino-acids, the stop codon has tRNA representation. But how the mRNA knows that the stop codon is indeed stop codon if the tRNA associated with it is present in the same cell?

   Could it be that stop codon property is determined already at the level of DNA and mRNA? If the dark variant of genuine stop codon is missing in DNA and therefore also in mRNA the translation stops if it is induced from that at the level of dark mRNA. Could also the splicing of mRNA be due to the splitting of dark DNA and dark mRNA? If so genes would be separated from intronic portions of DNA in that they would pair with dark DNA. Could it be that the intronic regions do not pair with their dark counterparts. They would be specialized to topological quantum computations in the TGD inspired proposal [K2].

   Start codon (usually AUG coding met) serves as a Start codon defining the reading frame (there are 3 possible reading frames). Dark DNA would naturally begin from this codon.

3. Also two additional amino-acids Pyl and Sec appear in Nature. Gariaev *et al* have proposed that the genetic code is context dependent so that the meaning of DNA codon is not always the same. This non-universality could be reduced to the non-uniqueness of dark amino-acid–amino-acid pairing in tRNA if genetic code is universal.

Could dark genetics help to understand wobble base pairing?

Wobble base pairing (`http://tinyurl.com/y73se8vs`) is second not-so-well understood phenomenon. In the standard variant of the code there are 61 mRNAs translated to amino-acids. The number of tRNA anticodons (formed by the pairs of amino-acid and RNA molecules) should be also 61 in order to have 1-1 pairing between tRNA and mRNA. The number of ordinary tRNAs is however smaller than 61 in the sense that the number of RNAs associated with them is smaller than 45. tRNA anticodons must be able to pair with several mRNA codons coding for given amino-acid. This is possible since tRNA anticodons can be chosen to be representative for the mRNA codons coding a given amino-acid in such that all mRNA codons coding for the same amino-acid pair with at least one tRNA anticodon.

1. This looks somewhat confusing but is actually very simple: genetic code can be seen as a composite of two codes: first 64 DNAs/mRNAs to are coded to $N < 45$ anticodons in tRNA, and then these N anticodons are coded to 20 amino-acids. One must select N anticodon representatives for the mRNAs in the 20 sets of mRNA codons coding for a given amino-acid such that each amino-acid has at least one anticodon representative. A large number of choices is possible and the wobble hypothesis of Crick pose reduce the number of options.

2. The wobble hypothesis of Crick states that the nucleotide in the third codon position of RNA codon of tRNA has the needed non-unique base pairing: this is clear from the high symmetries of the third basis. There is exact U-C symmetry and approximate A-G symmetry with respect to the third basis of RNA codon (note that the conjugates of RNA codons are obtained by A$\leftrightarrow$U and C$\leftrightarrow$G permutations).

3. The first two basis in the codon pair in 1-1 manner to the second and third basis of anticodon. The third basis of anticodon corresponds to the third letter of mRNA codon. If it is A or C the correspondence is assumed to be 1-to-1: this gives 32 tRNAs. If the first basis of anticodon is G or U the 2 mRNA basis can pair with it: they would be naturally A for G and C for U by symmetry. One would select A from A-G doublet and C from U-C double. This would give 16 anticodons: 48 anticodons altogether, which is however larger than 45. Furthermore, this would not give quite the correct code since A-G symmetry is not exact.

   Smaller number of tRNAs is however enough since the code has almost symmetry also with respect to A and C exchange not yet utilized. The trick is to replace in some cases the first basis of anticodon with Inosine I, which pairs with 3 mRNA basis. This replacement is possible only for those amino-acids for which the number of RNAs coding the amino-acid is 3 or larger (the amino-acids coded by 4 or 6 codons).

4. It can be shown at least 32 different tRNAs are needed to realize genetic code by using wobble base pairing. Full A-C and G-U symmetry for the third basis of codon would give 16+16=32 codons. One can ask whether tRNA somehow realizes this full symmetry?

How dark variants of could help to understand wobble base pairing? Suppose for a moment that the visible genetics be a shadow of the dark one and fails to represent it completely. Suppose the pairing of ordinary and dark variants of tRNA anticodons *resp.* amino-acids and that translation proceeds at the level of dark mRNA, dark anticodons, and dark amino-acids, and is made visible by its bio-chemical shadow. Could this allow to gain insights about wobble base pairing? Could the peculiarities of tRNA serve for some other - essentially bio-chemical - purposes?

The basic idea would be simple: chemistry does not determine the pairing but it occurs at the level of the dark mRNA codons and dark tRNA anticodons. There would be no need to reduce wobble phenomenon to biochemistry and the only assumption needed would be that chemistry does not prevent the natural dark pairing producing standard genetic code apart from the modifications implied by non-standard dark amino-acid–amino-acid pairing explaining for different codes and the possibility that stop codon can in some situation pair with dark mRNA.

One can consider two options.

1. The number of dark RNAs is 64 and the pairings between dark mRNA and dark anticodons and dark anticodons and dark amino-acids are 1-to-1 and only the pairing between dark RNA codons and anticodons in tRNA is many-to-1.

2. The model of dark genetic code [K47] suggests that there are 40 dark proton states, which could serve as dark analogs of tRNA. This number is larger than 32 needed to realize the genetic code as a composite code. I have cautiously suggested that the proposed universal code could map dark mRNA states of the same total spin (there is breaking of rotational symmetry to that around the axis of dark proton sequences) to dark tRNA/dark amino-acid states with the same total spin projection. The geometric realization would in terms of color flux tubes connecting the dark protons of corresponding dark proton sequences. Also in ordinary nuclei the nucleons are proposed to be connected by color flux tubes so that they form nuclear strings [L2] and dark proton sequences would be essentially dark variants of nuclei.

One should understand the details of the dark mRNA–tRNA anticodon correspondence. One can also ask whether the dark genetic code and the code deduced from the icosahedral model for music harmony [K77] [L11] are mutually consistent. This model implies the decomposition of 60+4 DNA codons to 20+20+20+4 codons, where each "20" corresponds to one particular icosahedral Hamilton's cycle with characteristic icosahedral symmetries. "4" can be assigned to tetrahedron regarded either disjoint from icosahedron or glued to it along one of its faces. This allows to understand both the standard code and the code with two stop codons in which exotic amino-acids Pyl and Sec appear. One should understand the compositeness $64 \to 40 \to 20$ of the dark genetic code and and whether it relates to the icosatetrahedral realization of the code.

I have proposed [K52] (`http://tinyurl.com/ycm48w54`) that dark variants of transcription, translation, etc.. can occur and make possible kind of R&D laboratory so that organisms can test the consequences of variations of DNA. If ordinary translation and transcription are induced

from their dark variants it would not be surprising and if dark biomolecules could also appear as unpaired variants, these processes could occur as purely dark variants. Organisms could indeed do experimentation in the virtual world model of biology and pairing with ordinary bio-molecules would make things real.

There is now evidence for this picture. It has been discovered [J14] (http://tinyurl.com/oec3mff) that brain cells have a mosaic like distribution of genomes (http://tinyurl.com/odwajdq) . In standard framework this mosaic should be created by random mutations. The mechanism of mutation is reported to involve transcription rather than DNA replication. The mutation would take place for DNA when its is copied to RNA after opening of the DNA double strand. The mutations would have occurred during the period when neurons replicate and the mutation history can be read by studying the distributions of changes in the genome.

This brings in mind the finding that removing a part of gene does not affect transcription. In both cases it is dark DNA, which would serve as a template for transcription rather than ordinary DNA. This suggests that the dark DNA is not changed in these modifications and mRNA is determined by the dark DNA, which would serve as a template for transcription rather than ordinary DNA. If this were the case also for neurons, the mutations of neuronal genes should not affect the gene transcription at all, and there would be no negative (or positive) effects on brain function. This seems too conservative. The mutations should have some more active role.

One can consider also different interpretation. The mutations of DNA could be induced by the dark DNA. As dark DNA changes, ordinary DNA associated with it is forced to change too - sooner or later. Especially so when the genome is in a state in which mutations can take place easily. Neurons during to replication stage could have such quantum critical genomes.

Evolution would not be mere selection by a survival of random mutations by external environment in the time scale much longer than lifetime of individual - but a controlled process, which can occur in time scale shorter than lifetime and differently inside parts of say brain. This is what the idea TGD inspired biology suggests. The modified DNA could be dark DNA and and serve as template for transcription and also induce transformation of ordinary DNA associated with it.

Whether this change can be transferred to the germ cells to be transferred to the offspring remains of course an open question. For instance, one can imagine that dark DNA strands (magnetic flux tubes) can penetrate germ cell membranes and replace the earlier dark DNA sections and induce change of ordinary DNA. Or is a more delicate mechanism involving dark photons in question. With inspiration coming from the findings reported by Peter Gariaev [I71] I have proposed a model of remote DNA replication suggesting that DNA can be replicated remotely if the needed nucleotides are present [K104]: the information about DNA could be transferred as dark photons, which can be transformed to ordinary photons identified as bio-photons. Could Lysenko have been at least partially right despite that he was a swindler basing his views on ideology?

In any case, TGD inspired biology allows to imagine a controlled evolution of DNA in analogy to that what occurs in R&D departments of modern technological organizations. The notion of dark DNA suggests that biological systems indeed have a "R&D department" in which new variants of DNA studied as "dark DNA" sequences realised as dark proton sequences - same about dark RNA, and amino-acids and even tRNA. The possibility to transcribe RNA from dark DNA would mean that the testing can be carried in real life situations.

There indeed exists evidence that traumatic - and thus highly emotional - memories may be passed down through generations in genome [J6] (http://tinyurl.com/oja8v94). Could the modifications of brain DNA represent long term memories as the above described experiment suggests? Could the memories be transferred to the germ cells using the mechanism sketched above?

9.4.4 Is Replication Of Magnetic Body Behind Biological Replication?

The vision about exclusion zone (EZ) like regions as primordial life forms and facts about water memory and homeopathy lead to a vision about how primitive immune system might have developed and how the recent genetic code might have emerged.

Magnetic body and dark analogs of bio-polymers should still play key role in living matter. The basic idea is that the time evolution of the magnetic body is the template for the time evolution of the biological body. In [K74] [L12] various pieces of evidence for the role of magnetic body as

"morphogenetic field" are discussed. For instance, the replication of DNA and cell would reduce basically to that for corresponding magnetic bodies.

Replication of magnetic body is analogous to what happens in 3-vertex of Feynman diagram. This occurs in several scales. This would make possible dark DNA (dDNA) replication and copying of dDNA to dDNA+dRNA as well as copying of dRNA to dRNA+dark protein.

Replication process should start from the higher levels of dark matter hierarchy and proceed to shorter scales. The basic constraint from ZEO is that the time evolutions of magnetic bodies at various levels of the hierarchy are highly unique as preferred extremals connecting initial and final 3-surfaces. For the maxima of vacuum functional only preferred pairs of 3-surfaces are possible. This gives rise to what might be called "standard behaviors". Also the replication would be this kind of behavioral pattern. In the context of the positive energy ontology it is extremely difficult to understand why the predictability of cell replication or the development of organism from single cell by repeated cell divisions.

Remote gene replication [K104] might be one application: the model described was actually developed before the idea that the replication of the magnetic body could be the fundamental mechanism. Its reversal could be basic mechanism of bio-catalysis and induce the attachement of bio-molecules together. Also ordinary DNA replication could be induced by the same electromagnetic signal as remote replication.

The sketch about replication of DNA would look roughly like following.

1. Assume that the portion of DNA promoting DNA replication is activated by dark radiation at some frequency and that the promoter region emits radiation with same frequency. This activates further promoter regions -also in other cell nuclei. The replication process is amplified exponentially. The negative feedback is necessary in the general case and is provided by attachment of the produced proteins (basically dark proteins) to the genes making them inactive.

2. This might occur during cell division which might involve irradiation by dark analog of white noise exciting all promoter regions. Certainly the coherence of this process is essential and here the higher levels of the dark matter hierarchy would be essential.

3. Remote replication becomes possible if the dark radiation exciting promoter region can leak to other cells or even other organisms. Large h_{eff} might make this possible.

4. Also remote transcription is possible by the same mechanism. Actually remote variants of very many basic processes seem to be possible.

5. The observations of Peter Gariaev's group about effects of laser light on genes [I73, I102] support this view as also the findings of group of HIV Nobelist Montagnier [I86, I87].

9.4.5 Quantum Model For Metabolism

First it is good to list some basic facts about energy metabolism.

1. ADP$\rightarrow$ ATP meaning the addition of phosphate to ADP is believed to be the fundamental step of metabolism. The process occurs when protons flow through the ATP synthase, which can be regarded as a nano-motor with a rotating shaft. During single turn three ADPs are phosphorylated and 3 protons flow through the "turbine" of the nano-motor and give up their Coulombic and chemical energy parameterized in terms of chemical potential difference. There is clearly a strong analogy with power plant. High energy phosphate bond is believed to receive the metabolic energy transferred from the flow of protons through the mitochondrial membrane.

2. The nominal value of metabolic energy quantum about.5 eV. The Coulomb energy associated with the mitochondrial membrane is 50-80 meV and by almost order of magnitude too small. The large chemical potential difference is believed to explain the large metabolic energy gain. This requires that the process is regarded as purely thermodynamical. This is a questionable assumption even in standard physics context and does not conform with the TGD based idea that transmembrane proteins such as ATP synthase act as large h_{eff} Josephson junctions.

The square root of thermodynamics forced by zero energy ontology suggests itself as a proper description of cell membrane as macroscopically quantum coherent system.

3. The notion of high energy phosphate bond is not well understood. The storage of energy dark cyclotron energy at the magnetic body of phosphate suggests itself as TGD based description.

How to understand the value of $heff$?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

1. The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [K7].

   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 [K36, K76]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_AC$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC})$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_C$. Note that correct sign requires $\Delta f_C - f_{AC} > 0$.

2. The conjecture $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

   following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

3. $h_{eff} = h_{em} = Z_1 Z_2 e^2/v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory is in powers of $1/h_{eff}$) possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n-branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.

4. Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K52] when one requires internal consistency.

How metabolic energy is transferred?

The basic question concerns the mechanism of energy transfer from nutrients. It should be however emphasized that the transfer might not be the really important aspect. The transfer of negentropic entanglement from nutrient to the organism might be of equal importance.

1. Zero energy ontology (ZEO) suggests that magnetic bodies are carriers of the metabolic energy. What does this mean is not quite clear but cyclotron energies or ions or Cooper pairs of them proportional to h_{eff} are obvious candidates concerning energy storage. The value of $h_{eff} \simeq 10^{14}$ guaranteeing the energies of dark EEG photons are in the range of bio-photon energies would mean that storage as cyclotron energies is very effective and the liberated energy quanta can directly induce molecular transitions essential for bio-chemical reactions.

2. The liberation of metabolic energy could take place in a phase transition in which p-adic length scale increases and h_{eff} is reduced in such a way that the length of flux tubes is not changed. This induces a coherent quantum transition in the sense that large number of particles can liberate cyclotron energy as cyclotron energy scale is reduced in the reduction of magnetic field strength. As protons flow from thinner flux tube with smaller h_{eff} to thicker one, similar reduction of cyclotron energy takes place and the energy is liberated, and would be received by ATP synthase to form ATP from ADP. This mechanism could be universal and at work also in other situations.

3. At quantitative level the identification $h_{eff} = h_{gr}$ of gravitational Planck constant with $h_{eff} = n \times h$ at microscopic level at least is an attractive hypothesis [K90, K76]. Gravitational Planck constant can be expressed as $\hbar_{gr} = GMm/v_0$, where v_0 is taken to be the rotational velocity of Earth. Assuming this for Cooper pairs of rotating super-conductor explains the gravimagnetic anomaly claimed by Tajmar et al [E11, E16]. It also predicts a universal energy spectrum of dark cyclotron photons in the range of bio-photon energies and gives thus support for the hypothesis that dark EEG photons decay to bio-photons. The metabolic energy quantum for proton of order.5 eV is consistent with the identification as cyclotron energy difference for proton over mitochondrial membrane. The hypothesis $h_{em} = h_{eff} = h_{gr}$ makes also sense for the nano-motor defined by ATP synthase transforming ADP to ATP.The interpretation would be that this condition makes possible the reconnection of electromagnetic and gravitational flux tubes.

One can imagine also different scenario involving phase transition changing the value of h_{eff} assignable to atoms. TGD indeed predicts also small values of h_{eff}. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems with nonstandard value of h_{eff}.

1. For dark atoms the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K29, K30, K31, K32]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

2. Phosphorylation and de-phosphorylation could be interpreted in terms of reconnection of flux tubes so that the dark proton associated with phosphate is transferred to the acceptor molecule. I have proposed that the deeper meaning of metabolism is transfer of negentropic entanglement (NE). The reconnection of flux tubes would transfer NE between ATP and third party to NE between acceptor molecule and third party. There is a large number of alternative identifications for NE. It could be short range entanglement associated with $h_{eff} = h_{em}$ assignable to electron and nucleus of dark atoms, to pairs of atoms or molecules, or very long range entanglement between molecule and large scale structure with size scale of Earth or even galaxy and associated with $h_{eff} = h_{gr}$. Both forms of NE might be involved and distinguish between two evolutionary levels.

3. Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K29, K30, K31, K32]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. The dark atoms in nutrients transforming to

ordinary atoms could provide the metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the NE or be accompanied by dark magnetic flux tube. The transfer of NE would mean its disappearance followed by reappearance and it could happen that $h_{eff}/h = n$ is reduced in the process.

4. The simplest view about photosynthesis would be that the absorption of solar photons excites some atoms to dark states and that nutrients contain these dark atoms as stable enough entities. The contamination of nutrients could mean the decay of these dark atoms to the normal states.

Exclusion zones as prebiotic cells

TGD based model model [L13], [K73] for Pollack's findings [L13] provides further guidelines.

1. Pollack *et al* discovered what they call exclusion zones and fourth gel like phase of water. The phenomenon occurs when water is bounded by gel and is irradiated with say visible light. Exclusion zones are negatively charged regions of water with positively charged environment. They act like batteries and have rather exotic properties. For instance, various impurities are repelled from exclusion zone.

2. The observed $H_{1.5}O$ stoichiometry implies that every fourth proton or hydrogen atom is dark and is transferred to the region outside the negatively charged exclusion zone. If only protons are transferred, very high negative charge density is generated. The size of the exclusion zone varies up to 100 μm and is in the range of cell sizes.

3. Dark matter corresponds in TGD Universe to phases with nonstandard value of Planck constant: $h_{eff} = n \times h$ phases at the "magnetic body" of the system (negatively charged region now). Magnetic body corresponds in Maxwell's theory to the magnetic fields generated by the system. Magnetic body consists of flux quanta (flux tubes and sheets).

4. If dark protons with say size scale of atomic size reside at flux tubes, one can assume that they form strings giving rise to dark atomic nuclei. Also ordinary nuclei consist of strings of dark protons and strings of neutrons. Various impurities are transferred from exclusion zone to the exterior suggesting that they become dark particles at magnetic flux tubes.

5. The quantum states of dark protons consist of 3 quarks and a simple model involving rotational symmetry around the axis of dark proton string predicts that the states of dark proton can be arranged into groups which correspond to DNA, RNA, amino-acids and possibly also tRNA molecules. Vertebrate genetic code can be realized as a natural correspondence between DNA/ RNA and amino-acids [L2, K47].

6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive prebiotic life form. The voltage would be the analog of the resting potential. The transformation of dark protons to ordinary ones would liberate metabolic energy so that primitive metabolism and photosynthesis would be realized. One can also consider a more general possibility that cyclotron energies are different at flux tube portions in the interior and exterior of the EZ analogous to cell membrane. This would increase the value of the metabolic energy currency by adding to Josephson energy ZeV the difference of dark cyclotron energies proportional to h_{eff}. One expects that dark counterparts of basic bio-polymers are still present in living matter and play a fundamental role.

What might happen in ADP$\rightarrow$ ATP process?

The identification of the exclusion zone with magnetic body as a basic structure allows to speculate about what might happen in ADP $\rightarrow$ ATP process and how ATP might store metabolic energy.

1. The strings of dark protons [K47] would be analogous to basic bio-polymers serving as the basic fuel of metabolics hydrolysed in metabolism. Basic biopolymers tend to be negatively charged and could therefore be accompanied by dark proton strings and the liberated metabolic energy might be stored by these strings as cyclotron energy and as Coulomb energy.

2. The simplest guess is that metabolism has developed from the transformation of dark protons to ordinary ones as the analog of EZ transforms back to ordinary water and potential potential difference disappears. One cana also consider generalizations of this picture. A phase transition reducing h_{eff} and increasing p-adic scale such that the size scale of the flux tube remains fixed but cyclotron energy is reduced. This phase transition could also effectively accompany the flow of protons through the boundary of EZ if h_{eff} is smaller and p-adic scale longer at the other side. This mechanism could be stilla at work at the level of mitochondria for dark protons.

3. The notion of high energy phosphate bond is somewhat mysterious. ATP is negatively charged and one can wonder whether it could be accompanied by EZ assignable to the negatively charged phosphates. Also DNA strands and many other biomolecules carry negative charge due to the phosphates. Could the metabolic energy be stored to the magneti body of ATP or of phosphate and eventually liberated by flow of protons to flux tubes with weaker magnetic field?

One can ask why the rotation of ATP synthase motor is necessary. Could the centrifugal acceleration drive dark particles to the magnetic body or keep them there thus stabilizing the dark phase? The dark protons at the magnetic body rotating with the system would remain to magnetic body and would avoid transition to ordinary protons if it is induced by the vicinity of ordinary protons serving as seeds for phase transition. If this interpretation is in the right direction, the rotating magnetic systems might provide a way to create dark matter [K10].

Energy metabolism as transfer of negentropic entanglement?

Negentropic entanglement (NE, see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) is 2-particle property (or more generally $n > 1$-particle property). One can argue that this is not consistent with the naïve idea about systems carrying NE as a resource analogous to metabolic energy. If negentropy transfer is behind metabolism and if one accepts this objection, one must ask whether metabolism actually corresponds to a transfer of NE between nutrient A and some fixed system B so that NE transforms to that between receiver R and same fixed system B? If so, could this could B correspond some higher collective level of consciousness perhaps identifiable as gravitational Mother Gaia (MG) as suggested by the success of $h_{gr} = h_{eff}$ hypothesis at microscopic level?

1. Negentropic entanglement (NE) would be transferred. Nutrients would be negentropically entangled with something very crucial for life. MG is a good candidate in this respect. Even Sun can be considered. Gravitational NE with MG would make possible dark EEG, etc... Basic formula is $\hbar_{gr} = GMm/v_0$, v_0 the rotational velocity at surface at the surface of Earth.

2. Formula generalizes to em case: $h_{em} = Z_1 Z_2 e^2/v_0$ and would apply to ATP synthase being consistent with $h_{gr} = h_{em} = h_{eff}$. Em flux tubes could reconnect with gravitational flux tubes for $h_{gr} = h_{em}$.

3. Nutrient-MG NE can be transformed to molecule-MG NE by the sequence N-MG $\rightarrow$ P-MG $\rightarrow$ ATP-MG $\rightarrow$ R-MG (N for nutrient, R for receiver).

4. The basic mechanism would be the reconnection of magnetic U-shaped loops associated with various molecules serving as kind of tentacles: N/P/ADP/R would have this kind of loops.

One can represent a critical comment. The notion of personal magnetic body (PMB) controlling biological body (BB) is central for TGD inspired theory of consciousness. The above argument does not involve it at all. Can the notion of PMB be therefore consistent with MG hypothesis? Or is PMB in some sense part of the magnetic body of MG - say in the sense that the flux tubes of PMB could be inside flux tubes of MG? Mystics would perhaps equate MG with PMB but this leads to paradoxes.

1. An attractive guess is that $h_{em} = h_{gr}$ holds true for PMB so that it can interact with MG by forming reconnections. Nutrients are dead but have NE with MG so that metabolism allows BB to have NE with MG.

2. How PMB could generate NE with BB? Could it reconnect with the flux tube pairs connecting MG with BB? Do both MG and PMB have NE with BB during life-time. What happens in biological death?: does the NE between PMB and BB transform to that between BB and MG again and only the NE between PMB and MG remains? This would conform with what spiritual teachings say.

3. If the answers to these questions are "yes", the basic purpose of metabolism would be the transformation of gravitational NE between MG and nutrients to that between MG and biomolecules. Magnetic bodies would "steal" part of this NE by reconnecting between MG and BB to that between PMB and BB: note that this process would be something new besides molecular metabolism and could be interpreted as a higher level metabolism. All this would be basically transfer of information from collective level of consciousness to lower levels to be processed and further enriched and to be returned back to MG in biological death: nothing would lost! Biological death itself would be reconnection transforming flux tube bonds to PMB to bonds to MG.

Could electrons serve as nutrients?

The New Scientist article (see `http://tinyurl.com/ybd4g2kl`) about bacteria using electrons as nutrients is very interesting reading since the reported phenomenon might serve as a test for the TGD inspired idea about metabolism as a transfer of negentropic entanglement (NE, see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) at fundamental level discussed in [K76] (see `http://tinyurl.com/yat9bx9j`).

1. NE is always between two systems: nutrient and something, call it X. The proposal inspired by a numerical coincidence was that X could be what I have called Mother Gaia. X could be also something else, say personal magnetic body. The starting point was the claim that the anomalously high mass of electronic Cooper pair in rotating supercounductor (slightly larger than the sum of electron masses!) could be due to a gravimagnetic effects which is however too strong by a factor 10^{28}. This claim was made by a respected group of scientists. Since the effect is proportional to the gravimagnetic Thomson field proportional to the square of Planck constant, the obvious TGD inspired explanation would be $h_{eff} \simeq 10^{14}$ (see `http://tinyurl.com/yb7rsct5` and `http://tinyurl.com/yat9bx9`).

2. Gravitational Planck constant $\hbar_{gr} = GMm/v_0$, v_0 typical velocity in system consisting of masses $M >> m$ and m was introduced originally by Nottale and I proposed that it is genuine Planck constant assignable to flux tubes mediating gravitational interaction between M and m. In the recent case v_0 could be the rotating velocity of Earth around its axis at the surface of Earth.

3. For electron, ions, molecules, .. the value of h_{gr} would of the order of 10^{14} required by the gravimagnetic anomaly and is also of the same order as $h_{eff} = n \times h$ needed by the hypothesis that cyclotron energies for these particles are universal (no mass dependence) and in the visible and UV range assigned to biophotons. Biophotons would result from dark photons via phase transition. This leads to the hypothesis $h_{eff} = h_{gr}$ unifying the two proposals for the hierarchy of Planck constants at least in microscopic scales.

   Thanks to Equivalence Principle implying that gravitational Compton length does not depend on particle's mass, Nottale's findings can be understood if h_{gr} hypothesis holds true only in microscopic scales. This would mean that gravitation in planetery system is mediated by flux tubes attached to particles. One non-trivial implication is that graviton radiation is dark so that single graviton carries much larger energy than in GRT based theory. The decay of dark gravitons to ordinary gravitons would produce bunches of ordinary gravitons rather than continuous stream: maybe this could serve as an experimental signature. Gravitational radiation from pulsars is just at the verge of detection if it is what GRT predicts. TGD

would predict pulsed character and this might prevent its identification if based on GRT based belief system.

4. In the recent case the model would say that the electrons serving as nutrients have this kind of negentropic entanglement with Mother Gaia. $h_{gr} = h_{eff}$ would be of order 10^8. Also in nutrients electrons would be the negentropically entangled entities. If the model is correct, nutrient electrons would be dark and could also form Cooper pairs. This might serve as the eventual test.

This is not the only model that one can imagine. TGD predicts also small values of h_{eff}. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems. At this moment one cannot exclude the possibility that only short range NE is involved with living matter.

Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K29, K30, K31, K32]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

Electrons are certainly fundamental for living matter in TGD Universe.

1. Cell membrane is high T_c electronic super-conductor [K76]. Members of Cooper pairs are at flux tubes carrying opposite magnetic fields so that the magnetic interaction energy produces very large binding energy for the large values of h_{eff} involved: of the order of electron volts! This is also the TGD based general mechanism of high T_c superconductivity: it is now accepted that anti ferromagnetism is crucial and flux tubes carrying fluxes at opposite directions is indeed very antiferromagnetic kind of thing.

2. Josephson energy is proportional to membrane voltage ($E_J = 2eV$) is just above the thermal energy at room temperature meaning minimal metabolic costs.

3. Electron's secondary p-adic time scale is.1 seconds, the fundamental biorhythm which corresponds to 10 Hz alpha resonance.

9.4.6 Humble Origins Of DNA As Nutrient - Really Humble?

I received an interesting link (`http://tinyurl.com/ybv8xu9uDNA_May_Have_Had_Humble_Beginnings_As_Nutrient_Carrier_999.html`) about the indications that DNA may have had rather humble beginnings: it would have served as a nutrient carrier [I97]. Each nucleotide in the phosphate-deoxiribose backbone corresponds to a phosphate and nutrient refers to phosphate assumed to carry metabolic energy in high energy phosphate bond.

In AXP, X=M, D, T the number of phosphates is 1, 2, 3. When ATP transforms to ADP, it gives away one phosphate to the acceptor molecule which receives thus metabolic energy. For DNA there is one phosphate per nucleotide and besides A also T, G, and C are possible.

The attribute "humble" reflects of course the recent view about the role of nutrients and metabolic energy. It is just ordered energy what they are carrying. TGD view about life suggest that "humble" is quite too humble an attribute.

1. The basic notion is potentially conscious information. This is realized as negentropic entanglement for which entanglement probabilities must be rational numbers (or possibly also algebraic numbers in some algebraic extension of rationals) so that their p-adic norms make sense. The entanglement entropy associated with the density matrix characterizing entanglement is defined by a modification of Shannon formula by replacing the probabilities in the argument of the logarithm with their p-adic norms and finding the prime for which the entropy is smallest. The entanglement entropy defined in this manner can be and is negative

unlike the usual Shannon entropy. The interpretation is as information associated with entanglement. Second law is not violated since the information is 2-particle property whereas as Shannon entropy is single particle property characterizing average particle.

The interpretation of negentropic entanglement is as potentially conscious information: the superposition of pairs of states would represent abstraction or rule whose instances would be the pairs of states. The large the number of pairs, the higher the abstraction level.

2. The consistency with standard quantum measurement theory gives strong constraints on the form of the negentropic entanglement. The key notion is that if density matrix is proportional to unit matrix, standard measurement theory says nothing about the outcome of measurement and entanglement can be preserved. Otherwise the reduction occurs to one of the states involved. This situation could correspond to negentropic 2-particle entanglement. For several subsystems each subsystem-complement pair would have similar density matrix. There is also a connection with dark matter identified as phases with non-standard value $h_{eff} = n \times h$ of Planck constant. n defines the dimension of the density matrix. Thus dark matter at magnetic flux quanta would make living matter living.

   In 2-particle case the entanglement coefficients form a unitary matrix typically involved with quantum computing systems. DNA-cell membrane system is indeed assumed to form a topological quantum computer in TGD framework. The braiding of magnetic flux tubes connecting nucleotides with lipids of the cell membrane defines topological quantum computer program and its time evolution is induced by the flow of lipids forming a 2-D liquid crystal. This flow can be induced by nearby events and also by nerve pulses.

   Side-step: Actually pairs of flux tubes are involved to make high temperature superconductivity possible with members of Cooper pairs at flux tubes with same or opposite directions of spins depending on the direction of magnetic field and thus in spin $S = 0$ or $S = 1$ state. For large value of Planck constant $h_{eff} = n \times h$ the spin-spin interaction energy is large and could correspond in living matter to energies of visible light.

3. Negentropy Maximization Principle (NMP, [K60]) is the basic variational principle of TGD inspired theory of consciousness. NMP states that the gain of negentropic entanglement is maximal in state function reduction so that negentropic entanglement can be stable.

4. NMP guarantees that during evolution by quantum jumps recreating the Universe (and sub-Universes assignable to causal diamonds (CDs)) the information resources of Universe increase. Just to irritate skeptics and also to give respect for the ancient thinkers I have spoken about "Akashic records". Akashic records can be said to form books in a universal library and could be read by interaction free quantum measurement preserving entanglement but generating secondary state function reductions providing conscious information about Akashic records defining also a model of self.

   Side-step: Self can be identified as a sequence of state function for which only first quantum is non-trivial at second boundary of CD whereas other quantum jumps induce change of superposition of CDs at the opposite boundary and states at them). Essentially a discretized counterpart of unitary time development would be in question. This allows to understand how the arrow of psychological time emerges and why the contents of sensory experience is about so narrow a time interval. Act of free will corresponds to the first state function reduction at opposite boundary and thus involves change of the arrow of psychological time at some level of self hierarchy: this prediction is consistent with the Libet's findings that conscious decision implies neural activity initiated before the decision ("before" with respect to geometric time, not subjective time).

In this framework the phosphates could be seen as ends of magnetic flux tubes connecting DNA to cell membrane and mediating negentropic entanglement with the cell membrane. DNA as topological quantum computer vision conforms with the interpretation DNA-cell membrane system as "Akaschic records". This role of DNA-cell membrane system would have emerged already before the metabolic machinery, whose function would be to transfer the entanglement of nutrient molecules with some bigger system X to that between biomolecules and X. Some intriguing

numerical coincidences suggest that X could be gravitational Mother Gaia and flux tubes mediating gravitational interaction with nutrient molecules and gravitational Mother Gaia could be in question [K70]. This brings in mind Penrose's proposal about the role of quantum gravity. TGD is indeed a theory of quantum gravity predicting that gravitation is quantal in astroscopic length scales.

9.5 A model of protocell based on Pollack effect

I learned about extremely interesting Quanta Magazine article (`http://tinyurl.com/y34o784j`) telling about findings related to water droplets as protocells able to perform chemical metabolism as a transfer of molecules to exterior and back. See

The work is carried out by David Zwicker and collaborators at the Max Planck Institute for the Physics of Complex Systems and the Max Planck Institute of Molecular Cell Biology and Genetics, both in Dresden. The report about the work is published in Nature Physics.

In a simplified model for the droplets (P-granules in C-elegans cell is the real life example) the proteins in droplet can be in two states: in state A the stay in droplet and do not get out but can enter to the droplet from outside. In state B they can get out from droplet. To get into state B energy such as sunlight would be required.

TGD suggests a concrete counterpart for the droplet as exclusion zones (EZs) induced by energy feed such as radiation in water in Pollack effect. EZs are able remove inpurities from interior in conflict with second law. TGD based explanation of the mystery is change of the arrow of time induced by TGD counterpart of ordinary state function reduction in zero energy ontology (ZEO): self-organization would be dissipation with reversed arrow of time at at the magnetic body (MB) of system acting as master and forcing time reversed evolution at the level of ordinary bio-matter serving as a slave.

9.5.1 TGD based model

TGD suggests for the model of protocell as droplet a realization as exclusion zone (EZ) generated in Pollack effect.

1. The exclusion zones (EZs) discovered by Pollack [I143, I123, I32, I100, L13] (`http://tinyurl.com/oyhstc2`) behave just like this. TGD allows to build a model of the Pollack effect [L13] (`http://tinyurl.com/gwasd8o`). The formation of EZs requires water bounded by a gel phase and they are negatively charged. Their really strange feature is that they throw out impurities just like state B in the model: this seems to defy second law telling that gradients tend to disappear. This makes possible primitive chemical metabolism involving exchange of chemicals between droplet and exterior. Light signal initiating the transfer by providing the metabolic energy needed. Transfer would stop as light signal stops.

   In TGD inspired quantum biology EZs are in crucial role. For instance, cell is negatively charged as also DNA double strand. Interpretation as EZs is natural.

2. The explanation for the negative charge of EZ is that part of protons and possibly other ions go to magnetic flux tubes forming the magnetic body (MB) of the system [L47, L68] (`http://tinyurl.com/yyyk6fu8` and `http://tinyurl.com/yjhx9xp7`). Dark ions form phases with nonstandard value $h_{eff} = n \times h_0 > h$ of effective Planck constant as cyclotron Bose-Einstein condensates. This system has long length scale quantum coherence and serves as a master controlling bio-chemistry, which is in the role of slave. This forces the mysterious coherence of the ordinary bio-matter impossible in life-as-mere-chemistry approach.

3. MB could control chemical metabolism of the droplet by sending dark photons to the droplet transforming to bio-photons and generating EZ state in the droplet and initiating transfer of molecules to the outside. The transition reducing the value of h_{eff} at MB would bring protons back to EZ droplet and it would become normal again. Secpnd law would force the molecules from outside to diffuse back to the droplet.

4. There is still one hard problem to be solved. What causes the mysterious removal of impurities from EZ challenging second law? Here zero energy ontology (ZEO) comes in rescue [L69] (`http://tinyurl.com/wd7sszo`). In ZEO macroscopic quantum jump corresponding to ordinary state function reduction changes the arrow of time . This would occur to MB as EZ is formed. Second law holds still true but in reverse time direction. MB is the boss and forces time reversal also at the level of ordinary bio-matter. The usual diffusion of molecules to cell occurs but with reverse arrow of time and explains the mysterious removal of impurities observed by Pollack for EZs.

All biological self-assembly processes would use this mechanism. In fact, self-organization quite generally would be dissipation in reverse direction of time: this would explain self-assembly aspect of self-organization. The big quantum jumps would inducing change of the arrow of time would tend to increase of h_{eff} in statistical sense (h_{eff} is identifiable number theoretically essentially as the dimension of extension of rationals and bound to increase in statistical sense). This would correspond to the evolutionary aspect of self-organization [L35, L47]. The increase of h_{eff} requires energy since the energy of state increases with h_{eff} with other parameters kept constant. Energy feed is therefore needed. Dark matter n TGD sense would make itself visible in everyday life.

9.6 Was Ribosome The First Self-Replicator?

I encountered a link to apopular article (see `http://tinyurl.com/nl2wybc`) describing a highly interesting work [I128] by M. Root-Bernstein and R. Root-Bernstein (daughter and father). The title of the popular article "Forget the selfish gene: Evolution of life is driven by the selfish ribosome, research suggests". As a matter of fact, the article itself is not selling anything of type "selfish X", a dogma which to my opinion is more or less dead: synergy and quantum coherence are much more promising notions relevant to biomatter. "Selfish X" is a paradigm, which suits much better to the description of cancer. The title of the article "The ribosome as a missing link in the evolution of life" would have been much more appropriate also for the popular article.

First a summary of motivations by authors. The basic problem relates to the emergence of life and there are many theories. The models can be divided to "genetics first" and "metabolism first" type models.

1. RNA world is basic example of "genetics first" models. The problem of the "genetics first models" is that it is difficult to understand how prebiotic life could have coped before the complex molecular machinery of metabolism. The second problem of RNA world is that polynucleotides and proteins almost certainly co-evolved. So called compositional replication models start from this assumption but have difficulties in explain replication schemes. Both approaches fail to explain how complex cells emerged from molecular evolution. It is however known that lipid layers of cell membrane are emergent structures not coded by genes (soap films).

2. Second class of models try to proceed from complexity to simplicity by assuming the first replicator (pro-cell typically) but are not able to answer the question "What before this?". The natural assumption is that simple bio-molecules gradually evolved to polymers and polymer aggregates and eventually cell membrane emerged.

According to authors, the challenge is to bridge the gap between self-replicating polymers and fully functional cell by identifying intermediate structures able to replicate, restore and replicate information, capture metabolic components and energy, and transform all these into biochemical networks.

9.6.1 Trying To Catch The Idea

The basic idea of the authors is simple and brilliant. Ribosome is the transcription machinery transforming DNA to proteins. Also the first replicator must have contained the transcription machinery. Perhaps the first replicator was minimal and contained just this machinery! Perhaps

ribosome or its precedessor ("pre-ribosome") indeed was the first self-replicator. One would have beautiful self-reference: ribosome would be the recipe for making a copy about the recipe! Brings in mind Gödel-Escher-Bach!

This assumption is highly non-trivial. In the following I try to sketch for myself what this could mean. In the following I drop "pre"or notational convenience with understanding that ribosome, RNA, amino-acid etc. means "pre-ribosome", "pre-RNA", "pre-amino-acid", "pre-tRNA" etc.. In TGD framework pre-ribosome could be of non-biochemical nature and realized at the level of dark matter.

1. It seems natural to assume that the basic raw material consisted of RNA and amino-acid molecules in the environment. Ribosome could use them to build copies of itself. The question how these were generated will not be considered now.

2. Ribosome consists of rRNA and proteins and uses tRNA to associated to mRNA sequence amino-acid sequence. If ribosome was the first replicator realizing genetic code as mRNA-amino-acid correspondence it had to use its own rRNA as a template for the translation to a corresponding protein.

   If nothing has changed after the emergence of the recent replication mechanisms, the testable prediction is that ribosome amino-acids are images of rRNA sequences under genetic code. One of course expects that the stricture of ribosome has not conserved in precise sense so that this prediction could be too strong.

3. tRNA is a molecule of form RNA-X-amino-acid and rRNA should have contained the genetic information allowing to transcribe and translate the RNA and amino-acid polymers appearing in tRNA.

According to [I128] these predictions are indeed tested in the work considered for Escheria Coli bacterium and it is found that the findings are consistent with the hypothesis.

On basis of these observations one can try to imagine how the ribosome or its precedessor "pre-ribosome" might have replicated.

1. Both the basic units of RNA sequences and corresponding amino-acid polymers of rRNA had to replicate. The most economic assumption is that this occurred simultaneously.

2. One can imagine that rRNA "gene" and the protein coded by it arranged themselves so that they were parallel. The amino-acid coded by rRNA codon acted as a catalyzer for the attachment of a conjugate of rRNA codon to the growing rRNA sequence just as in DNA replication promoter catalyzes the replication. rRNA codon in turm acted as a catalyzer for the addition of new amino-acid to the growing protein. tRNA molecules of form RNA-X-amino-acid from the environment provided the needed RNA codon and amino-acid.

   Remark: I have already earlier considered an RNA world scenario in which amino-acids of tRNA catalyzed the replication of RNA sequences [K39, K40]. When DNA emerged, the roles would have changed and amino-acid sequence was formed instead of the replication of RNA.

   This replication differs from ordinary transcription. In transcription incoming mRNA sequences produce amino-acid sequences as tRNAs attach to the mRNA codons of mRNA attached to the ribosome. tRNA looses its amino-acid but keeps RNA. Now tRNA loses both amino-acid and RNA codon and only the unit X in tRNA? RNA-X-amino-acid remains.

   At some step of evolution the replication of rRNA would have ceased to occur and tRNA would have kept its RNA in the double translation process. Is this possibly biologically?

3. Concerning tRNA there are many possibilities. One can imagine that ribosome and Xs could have served as co-replicators. The reaction $X \to RNA - X - amino - acid$ and its inverse could have occurred spontaneously. The resulting complex would have attached to the end of RNA-amino-acid sequence associated with some portion of mRNA just as it does in ordinary translation. In the replication or ribosome RNA-X-amino-acid would have attached to ribosome and X: s would have been produced in the replication of X forming a part of ribosome. In the environment the attachment of RNA and corresponding amino-acid to X would have taken place.

A possible objection is based on ontogenesis-recapitulates-phylogeny vision (ORP). The replicating pre-ribosomes should be still there but they are not. There should be some very simple mechanism preventing the replication but still one can ask whether the ribosomal replication could not occur in special circumstances.

9.6.2 How The Pre-Ribosome As First Replicator Relates To TGD Approach?

TGD framework predicts that replication as a splitting of 3-surfaces to two copies is a fundamental mechanism of quantum TGD analogous to the $1 \to 2$ decay of elementary particle and the replication of DNA, cells, etc... should reduce to a hierarchy of replications starting from long length scales and proceeding as replications at shorter length scales with master slave relationship between the subsequent levels of the scale hierarchy.

This identification of replication as a mere splitting of 3-surfaces saying nothing about what happens for the quantum states associated with them is too general to allow to talk about unique primary replicator. If one however restricts the consideration to systems consisting of RNA and amino-acid sequences the idea about ribosome as primary replicator becomes highly non-trivial.

In TGD framework it is possible that pre-biopolymers were not bio-polymers but their dark counterparts formed from dark protons sequences at magnetic flux tubes with states of dark proton in 1-1 corresponds with DNA, RNA, amino-acids and tRNA. If so pre-ribosome was realized at the level of dark matter as dark ribosome - a complex formed by dark analogs of bio-polymers.

If so, then pre-ribosome consisting of dark matter at flux quanta could be the primary replicator and the formation of its bio-molecular counterpart would be induced from that of dark pre-ribosome like the dynamics of slave in master slave hierarchy.

This raises questions. How does this replication proceed? Does ribosome still replicate as all other biological structures do and induce replication of low ever level structures in the dark matter hierarchy? Does the ordinary biomatter induced at the lowest level of hierarchy would only make visible this replication?

In the following I briefly summarize the basic TGD based notions involved in attempt to answer these questions.

4-D self-organization and magnetic body

One class of questions concerns the roles of self-organization and genetices. Even the definition of the notion of self-organization is poorly defined. In TGD zero energy ontology (ZEO) forms the basic framework of both quantum TGD proper and its applications to consciousness and biology. In zero energy ontology (ZEO) self-organization is replaced with self-organization by quantum jump sequence leading to the emergence of not only 3-D spatial patterns but also of 4-D behavioral patterns: one can say that living system is 4-dimensional and also its geometric past changes in quantum jumps (Libet's findings).

1. Various motor actions of magnetic body appear as basic processes of the quantum self-organization. This includes braiding and knotting, h_{eff} changing phase transitions changing the lengths fo flux tubes, reconnections allowing to build connections between different system consisting of flux tube pairs, and also replication. Also signalling by dark photons is an essential part of the picture and the general hypothesis is that dark photons have same universal energy spectrum as bio-photons and thus in the energy range of molecular transition energies.

2. Replication in TGD framework occurs at the fundamental level as a replications of 3-surface and is completely analogous to $1 \to 2$ decay for point elementary particle. This replication could take place for the magnetic flux quanta representing various biopolymers and higher level structures and induced the replication at the level of visible matter. As noticed, this replication is not enough in biology and must be accompanied by the replication of the quantum states associated with 3-surfaces.

3. One key question is how the bio-molecular processes arranged into a functional network. Here the hypothesis that magnetic flux tubes form a 3-D grid analogous to coordinate grid

with points of grid at intersections of 3 flux tubes and flux tubes as coordinate lines is very attractive. This Indra's web would be behind the gel like structure of cellular water and make it single coherent unit. Behavioral modes would be time evolutions of this grid: motor actions of the magnetic body - or hierarchy of them.

Does dark matter induced the dynamics of visible biomatter?

The idea that dark matter induces the dynamics of biomatter is extremely attractive since the enormous complexity of biochemistry would be only adaptation to the dynamics of the much simple almost topological dynamics of the master represented as flux tubes carrying dark matter.

1. In TGD framework there are good reasons to believe that water contained the prebiotic life forms as dark analogs of various biomolecules consisting of dark proton sequences at magnetic flux tubes with the states of dark proton in 1-1 correspondence with various bio-polymers (DNA, RNA, amino-acids, tRNA). These string like objects would be dark nuclei but with a large value of Planck $h_{eff} = n \times h$ constant and with same size scale as biopolymers. The proposal is that they are present also in living matter and that is interaction between various levels based on dark photons which give bio-photons as decay products.

2. All the basic processes such as transcription, translation, and replication would be realized already at this level. The analogs of these processes assigning to dark analogs of biopolymers the biopolymers themselves would have evolved later. (ORP) suggests that ordinary biopolymers are accompanied by parallel flux tubes carrying dark protons sequences representing them. Ordinary manner would condense around dark matter.

   The strongest assumption is that dark processes induce their bio-chemical counterparts as biomolecules attach to the magnetic flux tubes for which they form images at the level of visible matter. This might explain why strong dehydration leads to denaturation of biomolecules and why denatured biomolecules are not biologically active. Dark DNA would represent the "soul" of DNA not present in denatured DNA! Same of course would apply to other biopolymers: the loss of dark matter would induce the in vivo $\rightarrow$ in vitro transformation.

   I have proposed the identification of dark counterparts of RNAs and amino-acids as complex braided and knotted structures with braiding carrying information making possible topological quantum computation like processes and topological realization of memory. DNA would provide a symbolic representation coding also the braiding characteristics of the dark amino-acid sequence. Dark amino-acid sequence would represent the braiding physically ad dark DNA as a sequence of symbols.

   Cyclotron frequencies are crucial for communication and the strength of magnetic field on flux tubes emanating transversally from dark amino-acid sequence would be determined by the state of dark proton. The correspondence between dark RNA and amino-acid would be determined by the condition that cyclotron frequencies are identical for the corresponding dark proton states (DNA and mRNA, RNA and amino-acid) so that resonant interaction is possible.

3. This picture conforms with the chemical properties of DNA, RNA and proteins.

   (a) RNA does not appear as double strands and in unfolded form is much less stable than DNA. This conforms with the fact that DNA serves as an information storage providing symbolic representation of RNA and amino-acids including their folding or at least braiding. RNA in turn would provide the concrete representation for braiding and folding.

   (b) DNA double strand is stable against hydrolysis but only inside cell - this could be due to the fact that the phase of water is ordered and ice-like so that it cannot induce hydrolysis by providing water molecules - perhaps the fourth phase of water discovered by Pollack and leading to the formation of dark proton sequences in TGD framework is in question.

(c) The braiding structure of DNA is repetitive and carries no information. This conforms with the idea that DNA and its dark variant provide a purely symbolic representations in terms of genetic code for the corresponding amino-acid- and RNA polymers including also their braiding.

4. One can invent objections against the hypothesis that the dynamics of biopolymers is induced from that for their dark variants.

   (a) RNA is not stable against hydrolysis but it can gain stability by folding. Thus the shape of RNA molecule would not be determined by its dark variant in conflict with induction hypothesis. One can however consider the much weaker possibility that dark sector determines only topological dynamics. Only the braiding of the fold RNA molecules would determined by the braiding of dark variant.

   (b) DNA double strand is stable and braided in repetitive and very simple manner. If chemistry determines the stability of the DNA double strand then DNA double strand would induce the braiding of dark DNA strand rather than vice versa. Now one can argue that if dark DNA appears as double strand this forces the repetitive braiding.

To how high level can one continue this parallelism. For instance, does it make sense to talk about dark variants of cell and cell membrane? Can one tell whether it was pro-cell or biomolecules that emerged first? It seems that all these structures could have emerged simultaneously. What emerged was dark matter and its emergence involved the emergence of all the others. Hens and eggs emerged simultaneously.

1. Here the findings of Pollack about the generation of exclusion zones, which are negatively charged regions of water obeying exotic stoichiometry $H_{1.5}O$, are suggestive. The TGD based model assumes that a phase transition generating dark protons sequences at flux tubes of magnetic body outside the EZ takes place. The self-organization at the level of ordinary matter would generate dark matter at quantum criticality - a basic aspect of self-organization process leading to higher hierarchy levels taking the role of master. Dark matter would be the master or rather - there would be entire hierarchy of masters labelled by the values of h_{eff}. I have also considered the possibility that the generation of large h_{eff} phases happens at criticality quite universally so that life would be universal phenomenon rather than random thermodynamical fluctuation.

2. EZs with sizes about 200 microns (size of cell) could have been the prebiotic cells. There is also evidence that EZs consist of structures with size of order micron called coherent regions (CDs to be not confused with Causal Diamonds!). Could they have been the precedessors of the cell nuclei inside which dark DNA would be stable? The TGD model for the formation of EZs assumes that they are formed from CDs under irradiation.

   This picture leads also to a view about metabolism predict that UV radiation with energies about 12.6 eV must play a key role in metabolism. The proposal is that this radiation arrives as dark photons along magnetic flux tubes of the magnetic body and excites water molecules inside CDs so that they are energetically at distance of about.5 eV from the splitting of OH bond. The excitation of water molecules inside CDs by metabolic energy quantum of nominal value.5 eV transforms this phase to EZs of Pollack.

Emergence of life as emergence of dark matter?

Many basic questions of biology seem to be hen-egg questions such as "genetics or metabolism?", "cell membrane or biomolecules?", "DNA or RNA?", "RNA or amino-acids?", etc.. This suggests that there exists a deeper level and emergence at this level induced the emergence at the level of biochemistry and cell biology.

In TGD the emergence of living systems would reduce to the emergence of dark matter as large h_{eff} phases of ordinary matter taking place at quantum critical and perhaps even critical systems [K29, K30, K31, K32].

1. The question whether genetics or metabolism emerged first ceases to be relevant in this framework, where basic physics provides candidates for the fundamental mechanisms of metabolism (for instance liberation of zero point kinetic energy when the p-adic length scale of space-time sheet (magnetic flux tube) increases).

   Also genetic code would have been realized already before biochemistry if dark proton sequences provided the counterparts for the fundamental biomolecules. The dark biology as dark nuclear physics would make itself visible via biochemistry induced by it. We would see directly the dynamics of dark matter just by looking living systems!

2. If one takes this picture seriously, then also pre-RNA and various other pre-biopolymers could have been realized in terms dark proton sequences associated with dark magnetic flux tubes. The dark replication process could have been the arrangement of RNA and amino-acid flux tube portions in parallel and replication of the dark proton sequences with the help of the analog of tRNA attaching to the corresponding amino-acid. In this framework the notion of dark ribosome makes sense. It would however replicate only in cell replication.

3. In the biochemical scenarios also the emergence of DNA looks like mystery. In TGD framework dark DNA could have emerged at the same time as dark RNA and dark amino-acids as CDs and EZs emerged and make the stable presence of also ordinary DNA inside CDs and EZs. All basic biomolecules and prebiotic cell and metabolism would have accompanied the emergence of CDs and EZs under the irradiation of water feeding metabolic energy and giving rise to prebiotic photosynthesis (note that the negative net charge of DNAs could be due to the fact that part of protons is at dark flux tubes). Dark DNA could be interpreted as an information storage representing the braiding patterns of dark RNA and dark amino-acids symbolically.

4. In this framework the basic step of the replication is the generation of flux tube parallel to the flux tube from which one forms copy or map (say in DNA replicationandtranscription). How this happens?

   A possible answer to the question relies on the earlier proposal that living system involves kind of coordinate grid formed from magnetic flux tubes serving as coordinate lines and meeting each other at the points of the grid . [K74]. The replication process would involved translation of nearby flux parallel flux tube of the grid near to a given flux tube assignable to say DNA strand as a first step - maybe by h_{eff} reducing phase transition for flux tubes orthogonal the flux tube. After this the building bricks of the new biomolecule would be brought along either of the remaining locally orthogonal flux tubes - perhaps by h_{eff} reducing phase transition. The basic structure would be this Indras web containing visible matter at its nodes with dynamics consisting of magnetic motor actions.

This vision involves of course considerable challenges. One should model the dark ribosome counterparts of the replication process for dark DNA, transcription of dark DNA to dark mRNA, translation of dark mRNA to dark amino-acids, and also possible self-replication of dark ribosome.

9.7 Potential "missing link" in chemistry that led to life on Earth discovered?

In the attempts to understand pre-biology the basic challenge is to understand how the needed short RNA, DNA, and amino-acid sequences managed to form. Phosphorylation (see `http://tinyurl.com/y732fsd3`) is known to be crucial for this process and means energization in standard bio-chemistry. Organic phosphate (see `http://tinyurl.com/cx9ukv9`) possesses somewhat mysterious high energy phosphate bond, which stores energy and makes possible metabolism: in metabolic ATP with three phosphates transforms to ADP with two phosphates by giving one phosphate with high energy phosphate bond to the acceptor molecule, which is therefore phosphorylated.

In the recent biology phosphorylation of various biomolecules such as DNA, RNA, amino-acid sequences is catalyzed by proteins known as enzymes known as phosphorylases. Kinase is one

particular enzyme transferring phosphate from ATP to the acceptor molecule. Proteins consist of amino-acids and would not be present in RNA world, which serves almost as a standard model for the prebiotic period. Ribozymes are catalysts formed from RNA but they catalyze typically only the reversal of phosphorylation.

9.7.1 The problem and its possible solution

The phosphorylation of short nucleotide sequences and amino-acid sequences, and also lipids making possible formation of small cell membrane like structures is necessary for the formation of larger structures from their building bricks. As noticed, ribozymes catalyze only dephosphorylation. How RNA was phosphorylated during RNA era or were the amino-acid present all the time?

The popular article with the title "*Potential 'missing link' in chemistry that led to life on Earth discovered*" (see `http://tinyurl.com/y9s56xnx`) tells about a mechanism allowing phosphorylation during RNA era in absence of enzymes. The discovery [I75] (see `http://tinyurl.com/y9kvgl24`) is that an organic molecule known as diamidophosphate (DAP) (see `http://tinyurl.com/y88vecs2`) having chemical formula $PO_2(NH_2)_2^{-1}$ could do the job in presence of water and imidazol. Imidazol (see `http://tinyurl.com/y8vgfr42`) has chemical formula$C_3N_2H_4$ and is a molecule possessing aromatic hetero-cycle consisting of 3 C atoms and 2 N atoms.

Remark: Pyrimidine (see `http://tinyurl.com/k3vxl9b`) in turn is aromatic hetero-6-cycle consisting of 4 C atoms and 2 N atoms and having formula $C_4N_2H_4$. DNA (see `http://tinyurl.com/cpndtse`) has as basic building bricks phosphates PO_4^- having valence bonds with deoxy-ribose (see `http://tinyurl.com/qxv9kg8`) molecules (containing 5-rings with 4 C atoms and one O). Each sugar has valence bond with N of nucleoside C, T, A or G. C and T are pyrimidines with single aromatic 6-ring and A and G are purines obtained by fusing imidazol 5-ring and pyrimidine 6-ring to obtain purine double ring. By replacing one OH of de-oxyribose of DNA with H one obtains RNA.

DAP could solve several problems simultaneously: how the short sequences of RNA (later DNA) and amino-acids were formed, and how the precedessors of cell membranes emerged. It is not however clear to me whether this process could have been fast enough or whether the slowness only made the first step painful.

9.7.2 How could the discovery relate to TGD inspired quantum biology?

It is interesting to interpret the discovery in TGD framework. The basic question is whether the presence of dark atoms and electrons in bio-molecule distinguish between atomic physics, in-organic chemistry, and organic chemistry. Usually organic chemistry is defined to be chemistry of carbon compounds, typically hydrocarbons. Could it be that the formation of hydrocarbons involves dark variants of proton and electron identified as $h_{eff} = n \times h$ variants of ordinary proton and electron?

From atomic physics to chemistry

How could one proceed from atomic physics to atomic physics to chemistry in TGD framework. The basic question is how to understand valence bond: it is not at all clear whether mere Schrödinger equation allows to understand it. Could the emergence of dark electrons allow their delocalization and formation of valence bonds? It has been known for decades that the heating of rare-earth metals leads to a mysterious loss of some valence electrons and the explanation would be the energy provided by heating kicks them to higher energy states by making some valence electrons dark [L33]. The explanation would be in terms of dark electron orbitals for valence electrons which have radii scaled up by factor n^2 and are analogous to Rydberg states identified as orbitals with large value of principal quantum number and having very large radius.

The dark variants of atoms have binding energy scale reduced by factor $1/n^2$ so that their formation requires energy feed (perhaps radiation at required frequencies). One or more valence electrons of ordinary atom could be dark so that the size of the orbital is scaled up by factor n^2. The valence bond central for chemistry in general and in particular for basic biopolymers could contain dark electrons delocalized because of larger value of n than for the non-valence electrons. Note that one could be $n = n_0 > 1$ for ordinary atoms making in principle possible atoms with

$n < n_0$ with anomalous large binding energy also for the filled shells as the findings of Randel Mills indeed suggest [L24].

Surprisingly, dark electrons would be essential in ordinary chemistry thought to reduce to standard model physics! The increase of n reduces binding energy scale and requires energy feed. This would allow to understand why anabolism (see `http://tinyurl.com/c8x8avz`) - that is generation of biopolymers from their building blocks by generating valence bonds - requires energy feed and why catabolism (see `http://tinyurl.com/cbx99fv`) - the splitting of biopolymers to their building blocks by splitting the valence bonds liberates energy.

The valence bonds would be classified by the value of n and it is quite possible that in organic chemistry the values of n are larger than in in-organic chemistry. Could this mean that valence bonds H and C and N and O have higher values in bio-chemistry? Also the valence bonds between O and H in water could have larger value of n.

To sum up, the transition from atomic physics to ordinary chemistry involved generation of dark electrons associated with valence bonds. The value of n for dark electrons can vary and allow hierarchy of evolutionary steps with increasingly delocalized valence electrons.

From chemistry to bio-chemistry

What about the step leading to a genuine bio-chemistry involving genetic code? Magnetic body (MB) is the basic aspect of biochemistry according to TGD. Pollack effect [L13] (see `http://tinyurl.com/y8uxocch`) leading to the formation of negatively charged regions - exclusion zones (EZs) - would involve generation of dark protons at magnetic flux tubes of MB with electrons left to the EZ - possible as ordinary particles [L13]. Also Pollack effect requires feeding of energy, say as irradiation by photons.

DNA is stable against spontaneous hydration only inside cell membrane. This suggests that the EZs of Pollack containing partially dark water molecules satisfying effectively the stoichiometry $H_{3/2}O$ allowed to stabilize DNA. Therefore EZs are excellent candidates for the precedessors of cell.

The TGD inspired proposal is that DNA strand for which each phosphate has negative unit charge is companied by dark analog of DNA consisting of dark protons such that the states of 3-proton units are in one-one correspondence with DNA, RNA, tRNA and amino-acids and the degeneracies of the vertebrate genetic code (number of codons coding for given amino-acid) come out correctly [L20] (see `http://tinyurl.com/jgfjlbe`). A more general picture is that ordinary chemistry is kind of shadow for the dynamics of dark matter at magnetic flux tubes doing its best to emulate it. This would explain also why genetic code has also other variants.

It would be the emergence of dark protons with large enough value of n, which would distinguish between ordinary chemistry and bio-chemistry. Water is basic element of life and hydrogen bonding is responsible for the formation of water clusters - certainly one of the key aspects of bio-chemistry. Hydrogen bonds (see `http://tinyurl.com/bntn28n`) appear between highly electronegative (see `http://tinyurl.com/pbh6r6c`) atoms such as O, N, and F (electronegativity is roughly the tendency to attract electrons). What distinguishes hydrogen bond from valence bond is that it is proton rather than electron, which is delocalized. This suggests that the delocalized proton is dark proton at magnetic flux tube connecting the hydrogen bonded molecules.

The emergence of metabolism

In the proposed framework the first basic aspect of life would be the generation of dark electrons and protons using energy feed and their transfer between molecules and their generation by providing the needed energy.

1. Metabolism (anabolism) would provide the energy needed to transform ordinary atom (that is electron bound to it) to a dark atom with large value of $h_{eff}/h = n$. This requires energy since the binding energy is proportional to $1/n^2$ and reduced in the process. This is quite generally true for all dark variants of quantum states. One can say that the increase of the complexity of the system by increasing n characterizing its "IQ" requires metabolic energy (in adelic physics [L34, L35] "IQ" has a concrete interpretation as cognitive resources). Therefore the first steps of prebiotic life was the emergence of energy feed mechanism making possible the increase of n.

2. I have considered the possibility that the period of prebiotic life preceding the emergence of chemical storage of energy used dark nucleosynthesis [L30] (see `http://tinyurl.com/y7u5v7j4`) as the source of metabolic energy. The recently discovered life-like properties [I99] in a very simple system consisting of negatively charged plastic balls in the plasma of Ar^+ ions allows to develop rather detailed ideas about this phase of life [L32] (see `http://tinyurl.com/yassnhzb`).

3. A fundamental question is about the step leading to the chemical storage of metabolic energy to valence bonds with non-standard value of n. Solar radiation could have generated both negatively charged EZs identifiable as possible precedessors of cell membrane and valence bonded molecules storing metabolic energy.

About bio-catalysis

Without bio-catalysis biochemical reactions leading to the formation of biopolymers and cell membrane would be quite too slow. Here phosphorylation enters the game.

1. The TGD based model for bio-catalysis relies on the temporary reduction of $h_{eff} = n \times h$ liberating energy kicking the reactants over potential wall. After this step the catalyst - at least in the ideal situation - receives the energy and the atom becomes dark again.

2. Acid catalyst gives a proton and base catalyst gives an electron. Most bio-catalysts are acid catalysts. The TGD based interpretation should rely on the possibility of dark valence electrons and dark protons at flux tubes. Since base catalysts are associated with non-organic chemistry, the identification of the electron given by base catalyst as dark electron looks natural. Acid catalysts would give dark proton.

Bio-catalysts are usually activated by phosphorylation and de-activated by de-phosphorylation but there are exceptions to this rule. This can be understood if the catalyst activates a molecule acting as a switch for a reaction. Catalysts related to phosphorylation are known as phosphotransferasess (see `http://tinyurl.com/y87crqad`) and contain kinases transferring phosphate from ATP to the acceptor molecules.

Phosphatases (see `http://tinyurl.com/ybf9onba`) remove phosphate from the target molecule: they are hydrolases (see `http://tinyurl.com/y88zayj7`) and use water to remove the phosphate and to hydrate the molecule.

The difference between organic and inorganic phosphates

Phosphate appears as too variants: organic and inorganic.

1. Organic phosphates bound to biomolecules have charge -1. Some electrons of organic phosphate ion have transformed to valence electrons and are therefore dark. Also some protons - one dark proton per dark electron to not affect the observed charge in short scales - would be dark and at the magnetic body of the organic phosphate. Both dark protons and dark electrons would be present and give rise to somewhat mysterious high energy phosphate bond.

2. Free phosphate in water environment appears in ionized variants $H_nPO_4^{n-4}$ and is regarded as in-organic and have negative charge 4-n. In inorganic phosphate some dark protons and ordinary electrons giving rise to the negative charge have combined to hydrogen atoms. The larger the number of hydrogens is, the higher the level of inorganicity is.

   The fractions of variants of free phosphate in water depend on pH characterizing the density of protons present. Could pH in fact characterize the fraction of dark protons at magnetic flux tubes? Or could it also characterize the fraction of dark hydrogen atoms present. Similar question applies to the counterparts of pH for other biologically important ions.

About phosphorylation and the interpretation of DAP

At chemical level phosphorylation attaches phosphate ion to the hydroxyl group (R-OH) of the acceptor molecule. At deeper level phosphorylation would give dark electron to the acceptor molecule and dark proton to its MB. Phosphorylation would increase the quantum coherence length: the formation of short RNA, amino-acid sequences and of cell membrane like structures would be a basic example of this.

What about the interpretation of the role of DAP in this framework? DAP has charge -1 as also the phosphate bound to DNA and RNA have (in ATP the outermost phosphate has charge -2). DAP is very similar to the phosphate in DNA and RNA and expected to carry high energy phosphate bond. In TGD framework it would possess both dark valence electrons and dark protons at magnetic flux tubes with only one ordinary electron responsible for the charge of DAP. Due to the properties of phosphatase the phosphorylation would be very simple process at the level of dark electron and proton. Hence DAP and imidazole could make possible the phosphorylation.

About dephosphorylation and phosphoryl transfer

The scanning of web shows that some sources talk of dephosphorylation and some sources about phosphoryl transfer reactions and it remained unclear to me whether the two terms really have the same meaning. In any case, in TGD framework one can distinguish between these notion. Dephosphorylation could mean either phosphoryl transfer (transfer of phosphate between donor and acceptor molecules) or "dropping" of organic phosphate to water environment and giving it negative additional negative charge (the transfer would be now to water environment) and making it inorganic.

1. Phosphoryl would transfer removes PO_4^- group and presumably also the associated dark proton from the target and transfers them to the acceptor molecule and its MB. I have proposed that reconnection of flux tubes transforms the flux tubes entering to the donor molecule to that associated with the acceptor molecule so that dark proton is automatically transferred. In ATP-ADP process the phosphate group and presumably also the dark proton and electron would be transferred to the acceptor molecule from ATP. ADP is dephosphorylated and acceptor phosphorylated.

2. In "dropping" the outcome would be in-organic phosphate denoted by P_i, which is a mixture of HPO_4^{-2} and $H_2PO_4^{-1}$. One interpretation is that 1 or 2 dark protons from magnetic flux tubes have transformed to ordinary protons and combined with electrons to form hydrogen atoms. This operation would reduce the number of dark particle and thus the "evolutionary level" of the system.

Dephosphorylation is known to lead to a decomposition of the donor molecule to smaller structures, indicating the reduction of h_{eff}/h and thus of quantum coherence length. In RNA world dephosphorylation would be catalyzed by ribozymes and in some important cases also in the recent biology. Dephosphorylation would reduce quantum coherence length and lead to the decomposition of structures to smaller ones: mRNA splicing is one example of this. Catabolism of nutrients and the decay process of dead organic matter provide further basic examples.

Catabolism (see `http://tinyurl.com/cbx99fv`) of nutrients and the decay process of dead organic matter suggest what happens. In the first preliminary step of catabolism catalysts are involved. At the second step of catabolism inorganic phosphate is formed, which suggests that the number of dark protons is reduced in the process. This conforms with the reduction of the value of $h_{eff}/h = n$.

9.8 Life in Venus? What says TGD?

Evidence for life in a rather unexpected place - Venus - has emerged [I76]: see the popular article in Scientic American (`https://cutt.ly/qfD973w`). The atmosphere of Venus shows signs of phosphine PH_3 - the analog of ammonium NH_3 -, which cannot be produced by inorganic processes. There are small amounts of phosphine in the Earth's atmosphere and has an organic origin.

Same might be true in the case of Venus. Perhaps simple bacterial life is in question. Is it in the atmosphere or somewhere deeper in an open question.

One can find from Wikipedia that phosphine has the chemical formula PH_3. In inorganic chemistry it is very difficult to form phosphine from phosphate $(PO_4)^{-3}$ which is central in living matter. Somehow reduction must occur: the double valence bonds O=P of phosphates must in the final situation ordinary valence bonds in PH_3.

TGD predicts that all planets have life in their interior. This would solve the Fermi paradox. Also Earth's life would have evolved in the interior and emerged to the surface in the Cambrian Explosion when a large number of multicellulars emerged as if nowhere. The reason would have been a rather fast increase of Earth radius by factor 2: in TGD cosmology continuous expansion for astrophysical objects is replaced by a sequence of fast expansions followed by steady non-expanding states [L46, L45]. Whether the phosphine could emerge from the interior of Venus is an interesting question.

TGD also predicts a new kind of chemistry involving the notions of magnetic body (MB) carrying dark matter identified as phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$ ($h = 6h_0$), which can have very large values. Also the notions of acid resp. base and reduction and oxidation would involve dark protons resp. Dark valence electrons but in biosystems these notions would become fundamental. For instance, in Pollack effect exclusion zones as regions in which every fourth proton goes to a magnetic flux tube as a dark proton would be formed. For pH = 7 the fraction 10^{-7} of protons would be dark! In biology dark protons, electrons, and also dark ions would be fundamental.

MB would be the "boss" controlling the ordinary biomatter using dark cyclotron photon signals and resonance as a control tool. This new chemistry relying on what I call number theoretical (or adelic) physics would be central for the basic biomolecules such as DNA, RNA, tRNA, and amino acids having dark analogs accompanying them. The phosphates of DNA nucleotides with negative charges would be neutralized by dark protons and dark proton triplets would define a fundamental realization of the genetic code. Also amino-acids would be accompanied by dark proton (actually dark hydrogen) triplets.

Transforming protons to dark protons in Pollack effect requires an energy feed: IR photons do the job best. This means that dark protons carry metabolic energy and in ATP there could be 3 dark protons neutralizing the negative charges of phosphates. Together with dark electrons associated with valence bonds this would explain the questionable notion of high energy phosphate bond. ATP $\rightarrow$ ADP would transform one dark proton to ordinary one and break a valence bond, which for a dark electron has an abnormally high energy. Both of them would give energy.

If there is life in Venus, one might expect that both these new phenomena predicted by TGD are involved. TGD based vision about quantum biology suggests the possibility of sulphuric life in which the replacement $O \rightarrow S$ occurs in the basic bio-molecules- DNA, RNA,tRNA, and amino acids. This would leave cell membrane as such. A less plausible replacement (O,N,P) $\rightarrow$ (S,P,As) shifting life downwards along the Periodic Table is also discussed.

9.8.1 Could there be sulfuric life in Venus?

One can find an article (`https://cutt.ly/QfGhpoV`) about the chemistry involved with phosphine. Not only there exists no known in-organic ways to produce phosphine in Venusian atmosphere but also the biological pathways for the production of phosphine in the Earth's atmosphere by bacteria are unknown. Note that these bacteria are non-aerobial: I do not know whether S replaces O in their metabolism.

Could the new chemistry predicted by TGD and based on dark protons and dark electrons be involved? Dark protons carry metabolic energy - Pollack effect producing dark protons indeed requires energy feed - and the transformation of one of 3 dark protons in ATP $\rightarrow$ ADP would liberate metabolic energy. Could an analog of this metabolic mechanism help the formation of phosphine?

Basic fact about Venus and Venusian atmosphere

One learns from Wikipedia (`https://cutt.ly/DfGhuid`) basic facts about Venus.

1. Venus is one of the four terestral planes meaning that it has a rocky body like Earth. Surface gravity is .904 g, surface pressure is 91 atm, and surface temperature corresponding to .0740 eV (eV = 10^4 K), which happens to be rather near to cell membrane potential.

   In clouds at heights 50-60 km from Venusian surface, the temperature is between 0 and 50 ^{circ}C. The assumption that these regions contain the PH_3 is theoretically justified if the life in question is similar to that in Earth.

2. Venusian atmosphere 95 per cent CO_2. There is 3.5 per cent N, 150 ppm SO_2, 70 ppm Ar, 20 ppm waer wapr, 17 ppm CO_2, 12 pp, He, 7 ppm Ne, .1-.6 ppm HCl, 0.01 - 0.05 HF.

Some data items about the role of sulfur in terrestrial biology

There is a nice article "Sulfur: Fountainhead of life in the Universe?" by Benton Clark at the page of Nasa [I50] (`https://cutt.ly/qfGsIST`) giving a summary about sulfur and - as the title suggests - implicitly proposing that sulfur based life might have preceded the recent life.

1. Table 1 gives an overview about the cosmochemisty of sulfur. Note that in Sun S/Si ratio is .5.

   Remark: Even Sun has been proposed as a possible seat of life. The general vision about dark matter as a master controlling ordinary matter and dark proton sequences at magnetic flux tubes providing a universal realization of genetic code allows to consider the possibility of life at temperatures much higher than at Earth.

2. The role of sulfur in planetary evolution is discussed. The abundance of S is as high as 15 per cent in the Earth's core. Earth's crust contains 500 ppm of S and volcanic emissions are rich in sulphur. Sea water is rich in sulfate (SO_4) ions. Table 2 two lists various sulfur compounds in volcanic emissions.

3. Sulfur compounds are discussed. Sulfur can have several valence states including oxidation numbers -2,0+2,+4,+6 and sulfur can appear in compounds with several valence numbers. By this transversality sulphur could have an important role in autotrophic metabolism involving only chemical energy sources.

   Remark: The valence of given atom in molecule (`https://cutt.ly/QfGhaCL`) is the number of valence electrons, which the atom has. For instance, the double bond corresponds to 2 units of valence. Atomic valences characterize the topology of the valence bond network assigned with the molecule. Oxidation state, which can be negative, is a more precise measure telling how many valence electrons the atom has gained or lost. In the TGD framework the valence bond network would correspond to a flux tube network.

4. The role of sulfur in biochemistry is central. Sulfur plays major roles in energy transduction, enzyme action, and as a necessary constituent in certain biochemicals. The latter include important vitamins (biotin, thiamine), cofactors (CoA, CoM, glutathione), and hormones. Table 4 given also here summarizes the biological utilization of sulfur compounds.

   - Energy source (sulfate reduction, sulfide oxidation)
   - Photosynthesis (non-O2 -evolving)
   - Amino acids (met, cys):
   - Protein conformation (disulfide bridges)
   - Energy storage (APS, PAPS)

     These are analogous to AMP and ADP. Could one think of generalization of the TGD view for ATP $\rightarrow$ ADP to PAPS $\rightarrow$ APS as a basic metabolic mechanism? It might be that APS and PAPS do not survive in the Venusian atmosphere.

   - Enzyme Prosthetic group, (Fe-S proteins)

- Unique biochemicals (CoA, CoM, glutathione, biotin, thiamine, thiocyanate, penicillin, vasopressin, insulin).

5. The role of sulfur in the biogeochemical cycle is illustrated in Figure 1. In autotrophic energy metabolism, which does not have organic compounds as sources of energy, sulfur compounds are involved. One can distinguish between sulfur bacteria, sulfate reducers, and sulfur oxidizers. For sulfur bacteria the photosynthesis proceeds - not by splitting H_2O as in the case of green plants and algae - but by splitting H_2S to obtain H atoms: H_2S replaces water. Sulfate (SO_4) reducers liberate energy by increasing the oxidation numbers of S and O ($Na_2SO_4 \rightarrow Na_2S+4H_2O$). Sulfur oxidizers ($H_2S + 2(O2)_2 \rightarrow H_2SO_4$)) reduce the oxidation number of S.

6. SH-group is important for the catalytic function of many enzymes. -S-S link stabilizing systeine is important in establishing the tertiary structure of proteins. Fe-S appear as a prosthetic group (non-peptide group) in enzymes known as iron-sulfur proteins.

7. The presence ecosystems at the mouths of active hydrothermal submarine vents not depending on photosynthesis suggests a chemosynthetic energy source. These communities however require oxidesres and thus photosynthesis in the surface layers. Table 6 lists sulfur based energy sources for biological systems.

The minimal option for a sulphur based life in Venus

Before speculating it is good to summarize the basic facts. Venus has a lot of H_2S - analog of water H_2O in its atmosphere. Also CO_2 is present as also nitrogen N. There is a could layer rich in H_2S and having temperature and pressure very much like at Earth. The environment is extremely acidic and this is a real challenge for terrestrial life forms. There exists however extreme terrestrial extremal acidophiles. They are bacteria.

The idea is to replace O with S in some basic molecules of life and processes to overcome the acidity problem. What are these molecules and processes?

1. Could other biomolecules remain as such and could the cell membrane shield the DNA and proteins inside it against sulphur acid? The outer ends of lipids are hydrophobic: could they be also H_2S-phobic?

2. Could H_2S replace water in some sense in Venusian life? Could water as an environment of the cell be replaced with H_2S?

   What could the replacement of the water environment with H_2S mean?

1. Could photosynthesis rely on the splitting of H_2S rather than H_2O? Ordinary photosynthesis takes place inside the cell interior and involves ordinary proteins in enzymes and sugars as products. This would however require the presence of H_2S is in the cell interior. This does not look a plausible option without a profound change of the chemistry inside the cell replacing perhaps O with S in basic biomolecules such as DNA, RNA and proteins? This suggests that the photosynthesis inside Venusian bacterial cells occurs in the usual manner.

2. The TGD based quantum biology also involves the notion of magnetic body (MB) as a controller of the biological body. Could H_2S have the same role in Venusian prebiotic life as H_2O in the terrestrial prebiotic life?

   In the terrestrial life according to the TGD magnetic body (MB) of the water with hydrogen bonds is accompanied by flux tubes appearing with various values of $h_{eff} > h$ for dark protons. This would make water a multiphase system providing water with its very special thermo-dynamical properties at the temperature range 0-100 C.

   The flux tubes carrying dark protons sequences generated in the Pollack effect creating negatively charged exclusion zones (EZs) would realize the dark analog of genetic code: the negatively charged cell is an example of this kind of EZ.

   Water memory and the entire immune system would basically rely on these flux tube structures. DNA would be accompanied by parallel dark analog and the same would be true

for RNA, tRNA, and amino acids. Water would be living even before the emergence of the chemical life and MB would control the chemical life.

Could also H_2S allow dark hydrogen bonds and Pollack effect? Could the basic difference with respect to terrestrial life be that cells live in H_2S rather than in H_2O?

The separation of O *resp.* S to proto cell interior *resp.* exterior is required for the most conservative option. This requires a formation of lipid membrane like structures consisting of hydrocarbons isolating the interior from exterior and taking care of the separation. This requires charge separation by Pollack effect and solar radiation could provide this energy. H_2S must be replaced with H_2O in the proto cell interior. As a physicist I can only speculate about the possible chemistry of the process. For sulfur and its chemistry see the Wikipedia article (`https://en.wikipedia.org/wiki/Sulfur`). The following proposal is by a non-professional and very probably not correct as such. The basic challenge is however obvious: generate proto cell membrane and transform H_2S to H_2O inside it by reaction which in the optimal situation do not require catalyst but might require energy feed as solar radiation.

1. How the double lipid layer of the proto cell membrane separating S- and O-worlds could have formed? The formation of hydrocarbons of form C_nH_{2n} appearing as building blocks of lipids had to take place - perhaps only from CO_2 and H_2S. Note that SO_2 is the third most significant atmospheric gas in Venus and could have been be produced in this process and participate it. SO_2 has been detected also in volcanoes and one can consider the possibility that the mono-cellular life in volcanoes could have evolved by the same mechanism as in Venus clouds.

   Did something like $CO_2 + H_2S \to CH_2 + SO_2$ necessarily accompanied by a polymerization of CH_2 to C_nH_{2n} occur? Also in the proto cell interior hydrocarbons could have formed by this mechanism. The consumption of CO_2 in the proto cell interior would have induced a further flow of CO_2 from the proto cell exterior and generated more SO_2 which could have flown out or been used for other processes.

2. How was the H_2S inside the proto cell membrane replaced with H_2O? Assume that sulphur dioxide SO_2 is generated in the formation of hydrocarbons. Is the reaction $SO_2 + 2H_2S \to 2H_2O + 2S$ favoured by $T\Delta S$ or $SO_2 + 2H_2S \to 2H_2O + S_2$ favoured by ΔE in $\Delta G = \Delta E - T\Delta S$ a plausible option? Note that elemental S is hydrophobic and some bacteria generate pieces of sulfur inside them. One can also consider the possibility that the sulphur in the final state forms S_8 units: the valence bonds in S_8 make the reaction energetically more favored but entropically less favored.

3. What about oxygen? Ordinary photosynthesis could have produced O_2 by the splitting of the water. One can also ask whether the reaction $X + CO_2 \to CS_2 + O_2$ with $X = 2S$ or $X = S_2$ have generated molecular oxygen O_2 in the proto cell interior and whether carbon di-sulfide CS_2 as the analog of CO_2 could have flown outside the proto cell membrane?

4. How to overcome the possible activation energy barriers for various reactions involved? Suppose that solar radiation indeed generates dark protons from H_2S by a generalization of Pollack effect [L13, I123] by creating fourth phase of H_2S having stoichiometry $H_{1.5}S$ - as Pollack might put it. As the dark protons transform to ordinary protons, they liberate energy and this energy could make possible to overcome the activation energy barrier. This would not be new in TGD framework: in biochemistry according to TGD the energy liberated by ATP$\to$ ADP would transform one of the 3 dark protons of ATP to ordinary proton and liberate energy as metabolic energy quantum to overcome activation energy barrier.

The O-S separation would drive CO_2 from the exterior to interior and bring it back as CS_2 and replace S with O in the interior. Proto cell membrane would emerge before the standard chemical realisation of the genetic code. The usual hen-egg problem "Which came first, cell membrane or genes?" is avoided since the dark variant of the genetic code would be represented using sequences of dark proton triplets representing the analogs of DNA, RNA, tRNA, and amino acids. Also the other two hen-egg problems: "Which came first, metabolism or genetic code?" and

"Which came first, metabolism or cell membrane?" would be circumvented. The fact that the lipids of the cell membrane involve phosphates with negative charge suggests that they are accompanied by dark protons and genetic code has a 2-D variant assignable to the lipid lattice as 2-D dark proton lattice and decomposing to 1-D sequences [L39, L132]. The ordinary chemical genetic code would emerge later than this realisation after the emergence of basic biomolecules in the protocell interior.

More radical options for sulfuric life at Venus

There are also other options based on a radical modification of the chemistry of the ordinary life. They look less realistic from TGD point of view (which has been changing on daily basis during this week!).

1. Venus receives a lot of sunlight but one can ask whether photosynthesis be replaced with chemisynthesis? Chemical energy would be liberated in cycles involving sulfur containing compounds with varying degrees of oxidation of sulphur would liberate chemical energy as metabolic energy. At the bottoms of terrestrial oceans there are lifeforms around volcanoes, which might have this kind of metabolism.

2. **Option I** below: The extreme adicity of the Venusian atmosphere is the basic problem and the data about the composition of Venusian atmosphere suggest that O should be replaced with S in basic bio-molecules and water should be replaced with hydrogen sulfide H_2S (about bacteria producing H_2S see this), which is a gas smelling like rotten egg and produced in the decay of organic matter. Note however that CO_2 dominates in the Venusian atmosphere so that the replacement of O with S can be criticized. Carbon compounds can survive in the cloud to which PH_3 is assigned. The atmosphere contains also N.

   One can ask whether the exterior of the proto cell for the minimal option discussed above could have deloped a life based on the replacedment of O with S.

3. **Option II** below: This option is radical and probably non-realistic but as a mathematician I cannot resist its formal beauty. Could Venusian life be obtained by shifting terrestrial life one row downwards along the right end of the Periodic Table so that basic elements O, N, P of terrestrial life would be replaced with their chemical analogs S, P, As?

   Remark: Phosphine PH_3 reported to smell like rotten fish would be the counterpart of ammonia NH_3 giving pee its aroma and would have a similar role for Option II.

   Si has boiling point .1687 eV to be compared with the surface temperature .0740 eV - note however that also carbon is solid up to very high temperature and also many hydrocarbons are solids physiological temperatures. Arsenic (As) is fused by some bacteria as a metabolite and one might think that the analog of the higher energy phosphate bond obtained by replacement (O,P) $\rightarrow$ (S,As). The basic objection is that the Venusian atmosphere contains a lot of C and in CO_2 and N so that Option I seems to be enough. PH_3 is produced also by the terrestrial bacteria.

Below the radical options I and II are discussed but one must bear in mind that the replacement of H_2O with H_2S in photosynthesis for bacterial life might be enough if lipid layers of cell membrane are also H_2S-phobic.

Comparing the two radical options

It is interesting to look explicitely for the modifications of the basic biomolecules for the proposed options.

1. Consider first amino-acids (`https://cutt.ly/7fGhfsj`). The replacements would be O $\rightarrow$ S for Option I and (O $\rightarrow$ S, N $\rightarrow$ P, P $\rightarrow$ As) for Option II. This would allow a realization of analogs of nucleotides and amino-acids providing representations for their dark analogs realized in terms of dark proton sequences.

   Amino acid has the structure X-(Y-R)-Z, X= NH_2, Y=C-H, Z= O=C-OH. R is the varying amino-acid residue and X,Y,Z define the constant part. The replacements would be

Option I: Z=O=C-OH → S=C-SH

Option II: X=C=NH_2 → PH_2, Y= C-H→ Si-H. Z= O=C-OH → S=Si-SH.

In the formation of peptide one has replacement X= → C-N-H and Z→ O=C-O-C. This would give replacemens:

Option I: X= → C-N-H and Z→ S=C-S -C.

Option II: X→Si-P-H and Z→ S=Si-S-Si for Option II.

In the TGD framework amino-acids would be accompanied by dark proteins with sulfuric analogs of amino-acids pairing with dark proton triplets: the dark amino-acid would be same and couple with amino-acids having the residues for with energy resonance coupling is possible.

Cyclotron excitation of dark proton triplet and excitation of R would couple resonantly: the transition of dark photon triplet would generate dark photon triplet transforming to ordinary photon and exciting the R to excited state. This would select the possible residues.

The first guess is that they are obtained by the proposed replacement too. The dark protons coming from NH_2 and one dark proton coming from C-N-H would do so also for the Option I. Amino-acid residues contain as a rule OH and O= and would be replaced with SH and S=. Note that for met and cys are the only amino acids containing S.

For Option II dark protons would come from PH_2 and Si-P-H for option II and would be neutralized by dark electrons to give rise to dark hydrogens.

2. For DNA (`https://cutt.ly/OfGhhWs`) the replacements would be following

   Option I: O → S in sugar 5-ring and in nucleotides

   Option II: (C, O, N) → (Si, S, P) in sugar 5-ring and nucleotides and PO_4 → AsS_4.

3. Similar replacements would be carried in metabolic energy currencies AXP, X= M,D,T and GXP having also role as storages of metabolic energy. Saccharides like $C_6H_{12}O_6$ as chemical energy storages would have analogs obtained by replacement

   Option I: O → S

   Option II: (C,O,N) → (Si, S, P).

4. In the lipids of cell membrane there would be no changes for Option I and for Option to one would have (C → Si, PO_4 → AsS_4).

Option I is clearly favored over Option II if the Venusian life resides in clouds at height of 50-60 km, in particular by the possibility of having cell membrane identical that for the terrestrial life. However, in the TGD framework the most plausible option does not involve any changes in the basic biochemistry of life. The only change is the replacement of water with H_2S as the environment of the bacterial cells. Dark protons and dark photons make possible communications between bacterial cells even in the acidic environment.The empirical test is whether the Pollack effect is possible also for H_2S.

9.9 Multilocal viruses

I learned about very interesting piece of strangeness in biology known already for half a century (see `http://tinyurl.com/yyh5s2c8`): there are viruses, which can split into segments going into different host cells, replicate and produce proteins there, and self-assemble to original virus after this.

9.9.1 Findings

Virus (see `https://en.wikipedia.org/wiki/Virus`) consist of DNA or RNA, protein coat, and in some cases outside envelope consisting of lipids and analogous to cell membrane. Typically viruses consist of DNA or RNA decomposing to short segments coding for single protein. The reason for this is that RNA replication is prone to errors and for short segments these errors are

not so fatal. Also DNA can be segmented but the segments are longer. RNA can be have positive sense in which it can be directly translated to protein or negative sense in which case replication producing positive sense RNA is needed made possible by an enzyme contained by the virus.

The usual thinking about viruses is that virus finds its way to cell and then uses the genetic machinery of the cell to replicate its DNA and RNA and produce also proteins. This does not not occur in the case of multipartite viruses infecting plants. The virus can split into segments infecting host cells separately. The segments of RNA and proteins contained by the virus are thus shared by different cells are replicated and coded to proteins. The outcome of the process is then brought together in some cell which need not contain gene segments in it and self-assembly to full virus can occur. Also fractured viruses can flourish and can infect some other plant.

It has been found that the full complement of most viral segments is missing from most plant cells. Protein required for viral replication present in cells that did not have genome for producing it so that the produced proteins can be transferred from the cell where they are produced to neighboring cells: it is though that so called plasmodesmata connecting cells to a network make this possible.

In standard view assuming that the viral segments are completely independent systems multi-partitioning has high risks. In this view theoretically not more than 4 segments are possible. For instance, 8 has been observed in the examples discussed. Even flu virus decomposes into 8 DNA segments with the cell inside which it replicates. Multi-partitioning produces also problems for spreading. In the case of FBNSV viruses mentioned in the article on the insect - aphid- eating FBNSV spreads the virus to plants. How can it get all 8 parts of virus simultaneously? This is very difficult to understand if the segments are really independent.

This suggests that the view about these viruses somehow wrong. Multi-partitioning happens and standard view does not allow it.

9.9.2 TGD based model for multi-local viruses

One can start by asking why the multi-partitioning implying modular reproduction (something analogous to that in industry!)? One good reason is that host cell might not be able to recognize the segments. Also transcription of too large number of RNAs might be too much for the host and kill it. It seems that viruses act as populations.

TGD based model is based on familiar basic notions.

1. The basic mystery of the biology is coherence of organisms. Bio-chemistry alone cannot explain it. In TGD quantum coherence of dark matter identified as $h_{eff} = nh_0$ phases of ordinary matter at magnetic flux tubes of the magnetic body (MB) of the system is quantum coherent in long scales and this quantum coherence forces the coherence of ordinary living matter.

2. The flux tubes of MB connect cells to larger networks (tensor networks). In particular the segments of virus can be connected to a network in this manner. The segments would be effectively free but their behavior would be correlated. Virus would be multi-local entity at the level of ordinary matter but single connected structure at the level of MB.

3. The TGD based model for bio-catalysis and replication and the model for monopole flux tubes suggests that the phase transition increasing $h_{eff}/h_0 = n$ increases the length of the flux tube. This process requires metabolic energy since quite generally the energy of system increases with n serving as a kind of IQ of the system measuring its algebraic complexity and identifiable as the dimension of extension of rationals assignable to the system. Multi-partitioning requires metabolic energy presumably given by a host cell. The components of multi-partitioned virus are virtually independent but flux tube connections are not lost. There are very many possible multi-partitions and the individual host cell can contain several segments.

4. If the decay of virus to multi-partition corresponds to ordinary state function reduction ("big" state function reduction (BSFR) in zero energy ontology (ZEO) the arrow of time changes at the level of MB of virus (dark matter). n increases in statistical sense in BSFR so that the multi-partitioned state should have higher IQ and is thus favored by quantum TGD. One

might perhaps say that when virus is not active it does not need too much IQ: IQ requires metabolic energy feed and low IQ is the most economical choice in the dormant space. When virus infects the host it become active and and increase of n makes it multi-local at the level of ordinary matter.

If this view is correct the self-assembly of the virus would lead back to dormant state with opposite arrow of time. That dormant state of virus would correspond to opposite arrow of time for "virus self" would conform with the general view that observer with opposite arrow of time than conscious entity experiences it as sleeping. One must be of course however very cautious with interpretations.

5. These dormant states would not be specific to viruses. Also folded protein would be dormant. External perturbation would feed metabolic energy feed waking up the dormant protein and protein would un-fold and become active and intelligent.

   Same applies to multi-locality. Also bacterial colony could be seen as single organism multi-local only at the level of ordinary bio-matter. When bacterial colony suffers starvation the bacteria form a single tightly connected structure also at the level of ordinary bio-matter. In the absence of metabolic energy feed the values of n associated with the flux tubes would be reduced and they would shorten causing the phenomenon.

   For cellular organisms the multi-locality at the level of ordinary bio-matter be realized for cell but the distances of cells would be fixed. Also at the level of DNA, RNA, tRNA and amino-acids multi-locality would be realized but the distances would not be fixed. In bio-catalysis the reactants are brought together and here h_{eff} reducing phase transition would take place providing also the energy needed to overcome the potential wall making the reaction extremely slow otherwise. In TGD based model for replication, transcription, and translation this flexible multi-locality is indeed assumed [L68].

6. How sexual reproduction (see `http://tinyurl.com/kuvswc9`) emerged is one of the mysteries of biology. The formation of tightly bound multi-local states of mono-cellulars would have increased the probability for lateral gene transfer between neighboring cells, and also the replacement of mere replication with a two-step process consisting of replication followed by meiosis and fertilization as its inverse. The reconnection of flux tubes assignable to DNA is a prerequisite of this process in TGD framework so that the formation of states analogous multi-cellulars would have made this process plausible.

It has been found (`http://tinyurl.com/qkzwk5t`, thanks for Nikolina Bendedikovic for a link) that multicellulars have monocellular colonies as precedessors in the sense that the bacteria (monocellulars) form temporarily tight structures resembling multicellular embryos. The transition from loose multi-locality to a more tight one suggets itself. When metabolic energy feed is low bacteria form tightly bound non-multilocal structures analogous to multi-cellulars. The flux tubes are shorten and metabolic energy is liberated, and also the need form metabolic energy is lower when flux tubes have lower values of h_{eff}. Multi-cellulars would be permanently in this configuration and their intelligence coded by distribution of h_{eff}:s would be realized differently.

Multi-cellulars would have been formed when these multi-cellular like bacterial colonies became permanent and began to evolve from embryos to more developed forms [L46, L60]. Hitherto I have assumed that multi-cellulars were formed already before the Cambrian explosion assumed to be induced by a relatively rapid phase transition increasing reducing the local cosmological constant by factor 1/2, and increasing the radius of Earth by a factor 2. This transition would have brought multi-cellulars to the surface from underground oceans giving also rise to the ordinary oceans. I have compared underground oceans to a womb of magnetic Mother Gaia. Ontogeny recapitulates phylogeny principle suggests that the life of the multicellular embryo in womb corresponds to the period of multicellular life in underground oceans.

Second possibility is that the multi-cellulars emerged from underground mono-cellulars during this transition or immediately after it. Could the emergence of bacterial colonies to the surface perhaps providing less metabolic energy feed forced them to form tightly bound colonies forcing the evolution of multi-cellulars?

9.10 Oil Droplets In Water Solution As A Primitive Life Form?

The origin of life is one the most fascinating problems of biology. The classic was carried out almost 60 years ago. In the experiment sparks were shot through primordial atmosphere consisting of methane, ammonia, hydrogen and water and the outcome was many of the amino-acids essential for life. The findings raised the optimism that the key to the understanding of the origins of life. After Miller's death 2007 scientists re-examined sealed test tubes from the experiment using modern methods found that well over 20 amino-acids - more than the 20 occurring in life - were produced in the experiments.

The Urey-Miller experiments have yielded also another surprise: the black tar consisting mostly of hydrogen cyanide polymer produced in the experiments has turned out to be much more interesting than originally thought and suggests a direction where the candidates for precursors of living cells might be found. In the earlier experiments nitrobenzene droplets doped with oleic anhydride exhibited some signatures of life. The droplets were capable to metabolism using oleic anhydride as "fuel" making it possible for the droplet to move. Droplets sensed each other's presence and reacted to it and also demonstrated rudimentary memory.

In the sequel a model for the oil droplets as primitive life form is developed using as a constraint the TGD inspired quantum model for living matter. The key ingredients are the notions of magnetic body, the assignment of dark matter identified a hierarchy of macroscopic quantum phases to a hierarchy of Planck constants, zero energy ontology, the model for DNA-cell membrane system as topological quantum computer, and Negentropy Maximization Principle combined with the notion of number theoretic entropy. This entropy can be negative for rational and even algebraic entanglement probabilities, which inspires the vision about life as something in the intersection of real and p-adic worlds.

The basic objection against the identification of oil droplets as a primitive life form is that droplets have no genetic code and do not replicate. The TGD inspired model for dark nucleons however predicts that the states of dark nucleon are in one-one correspondence with DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code is naturally realized. The question is whether the realization of the genetic code in terms of dark nucleon strings might provide the system with genetic code and whether the replication could take place at the level of dark nucleon strings rather than droplets. TGD inspired quantum model of biology leads to a model for oil droplets as a primitive life form. In particular, a proposal for how dark genes could couple to chemistry of oil droplets is developed.

9.10.1 Intelligent Oil Droplets

New Scientist (see `http://tinyurl.com/y8qyxymd`) tells about a new twist related to the Urey-Miller experiment (see `http://tinyurl.com/y83eks2s`). Martin Hanczyc (see `http://tinyurl.com/ybvwbvg3`) and his colleagues of University of Southern Denmark in Odense are doing research with a rather ambitious goal: the discovery of the recipe of life. The highly demanding challenge is to find candidates for the protocell that preceded the recent cell. What makes the task so difficult that it is not even clear what one should be searching for. For instance, what basic characteristics distinguishing living matter from inanimate systems protocell is expected to have before one can speak about primitive life form? And if one accepts the dogmas of standard biology, one encounters also the nasty hen-egg question which came first: metabolism or the genetic machinery.

Hanczyc and his colleagues have been experimenting with simple candidates for primitive life forms: oily nitrobenzene [I24] (see `http://tinyurl.com/678a2a`) droplets doped with oleic anhydride [I27] (see `http://tinyurl.com/y7ua8mwq`) immersed in alkaline (see `http://tinyurl.com/zelgz`) aqueous solution (alkalinity is by definition an ability to reduce acidicity). They have found that these systems have some attributes generally associated with life. The recent experiments replaced oleic anhydrite with the black tar consisting of complex branched and fractal looking hydrogen cyanide (HCN) polymer [I13] (see `http://tinyurl.com/nehrmu4`) produced by Urey-Miller experiments and found that also now the droplets exhibit lifelike behavior: they sense and respond their neighbors and move towards "food" sources.

The earlier experiments using nitrobenzene droplets doped with oleic anhydridge immersed

in alkaline solution began immediately to move along straight lines. What happened that the oleic anhydride at the surface of the droplet reacted with the water splitting to two oleic acid molecules [I26] (see http://tinyurl.com/yf34q92) by hydration. This dropped the surface tension of the droplet and by a kind of spontaneous symmetry breaking the reaction rate had maximum at some point of the droplet and a "hot spot" was generated drawing oleic anhydride from the interior of the droplet and generating a convective flow. A pH gradient develops along the surface. The oleic acid in turn moved along the droplet surface from the hot spot to the diametrically opposite side of the droplet [I78] (see (http://tinyurl.com/yc627j5k). The net effect was a linear motion. pH gradient is claimed to be essential for the generation of motion but I must admit that I do not quite understand this point. A primitive metabolism liberating energy is obviously in question. By momentum conservation the total momentum for the convective flow and flow of oleic acid was compensated by a center of mass motion of the droplet.

One could claim that this process belongs to the same class of self-organization processes as the generation of convection patterns as one heats liquid from below. Other researchers have however discovered that the oil droplets can also travel along chemical gradients, something known as chemotaxis used by many bacteria to find food and void threats. One oil droplet managed even to (see "solve" (see http://tinyurl.com/yb7muvg) a complex maze containing "food" at its other end [I77]. Whether this kind of behavior can be regarded as a mere chemistry is far from obvious to me. To me this a achievement look like a genuinely goal directed intentional behavior.

Hanczyc has also found that when the oil droplets approach each other they change course to avoid collision, or can circle each other-like partners in Viennese waltz! Oil droplets seem to have even memory. By videoing the paths of oil droplets Hanczyc found that the decision to stop or continue was not random but the behavior at any point of orbits was affected by the earlier behavior. This is by the way an elegant experimental manner to show that non-deterministic behavior is not just randomness. The experiments have been also carried using instead of oleic anhydride mineral oil consisting of a mixture of alkanes having as building block polymers from from CH_4 by dropping two hydrogen from each C as also lipids have (methane CH_4 is the simplest alkane). What distinguishes mineral oil molecules from the oleic anhydride molecules are the oxygen atoms in the middle of the reflection symmetric linear molecule. Also now the droplets move although the process takes place with a slower rate.

The basic objections against the identification of the oil droplets as a life form is that they do not replicate and there is no genetic code. One must be however very cautious with this kind of statements. Maybe the primary life forms are not the droplets and the behavior of droplets reflects the control actions of these life forms on droplets. Perhaps also genetic code could be realized at at totally different level. The recent findings of the group of HIV Nobelist Montagnier [I86] (see http://tinyurl.com/2co7s6j) indeed suggest a new realization of genetic code in water closely related to water memory and TGD suggests a concrete realization of this code [K47].

9.10.2 Some Key Ideas Of TGD Inspired Quantum Biology

Before proposing a model for intelligent oil droplets as a primitive life form its good to list some of the basic ideas of TGD inspired quantum biology.,

1. The basic hypothesis is that the dark matter at the magnetic flux tubes of the magnetic body assignable to any physical system serves as an intentional agent controlling the behavior of the ordinary matter [K35]. Dark matter can correspond to just the ordinary particles- at least electrons and protons- in a phase with non-standard large value of Planck constant forming macroscopic quantum phases. Also biologically important ions could form this kind of phases. TGD inspired nuclear physics [L2] allows also the bosonic counterparts of fermionic with same nuclear charge so that every fermionic ion could be accompanied by exotic bosonic ion so that Bose-Einstein condensates could become possible.

2. The model for dark nucleons [L2, K47] as entangled triplets of three quarks leads to the identification of the counterparts DNA, RNA, tRNA, and amino-acids as three-quark states and one can identify also vertebrate genetic code. DNA sequences correspond to dark nucleon sequences - dark nuclei - in this correspondence. The proposal is that dark proton sequences in water form dark nucleons with so large a Planck constant that nucleon size corresponds to size of singe DNA codon. There is indeed evidence that in atto-second time scale (time scale

for corresponding causal diamonds) water obeys effective chemical formula $H_{1.5}O$ as far as scattering of electrons and neutrons is considered [D12, D17, D8]. This would suggest that 1/4 of protons are in dark large Planck constant phase in the experimental situation. This proportion is expected to depend on temperature and pressure and should explain the rich spectrum of anomalies of water [D14] by regarding it as a two phase system [K37]. Perhaps these protons could form dark nucleon sequences realizing genetic code. These sequences could replicate and evolve and could define at least the analog of DNA or RNA. Maybe even DNA-mRNa-amino-acids translation processing could take place. If a translation machinery transforming exotic DNA to ordinary has developed during evolution, this fundamental realization of genetic machinery might make possible kind of Research & Development making possible to experiment with different genomes. Evolution would not be a random process anymore [K47].

3. The proposal is that the ordered water layers associated with polar molecules dissolved in water are attached to the magnetic body of the molecule induced in water environment and that this magnetic body mimicking ithe original molecule is an essential element of this primitive life [K47]. The self-organization processes of these layers induced by external perturbations could be the precedessor of processes like protein folding and de-folding. The mechanism of water memory could be based on "dropping" of the magnetic bodies of molecules as a result of repeated shaking involved with homeopathic procedure inducing a sequence of catastrophes driving the evolution of these primitive life forms. One can also ask whether these magnetic bodies could define the analog of proteins providing one realization of dark matter genetic code.

4. If dark nucleons have been the precedessors of chemical life forms, one can circumvent the hen-egg question about whether the genetic code or metabolism came first. In zero energy ontology negative energy signals propagating in the direction of geometric past would in turn provide fundamental mechanism of intentional action, metabolism, and memory. If this is the case, evolution would have only led to a refinement of the fundamental mechanisms of life already existing: there would be no need to pull anything out of hat. The mechanisms for chemical storage and utilization of energy are needed and moving oil droplets would provide a primitive realization of these mechanisms.

5. The notion of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) makes sense if one accepts the role of p-adic number fields and the vision about life as something residing in the intersection of real and p-adic worlds [K60]. Entanglement probabilities for negentropic entanglement must be rational or algebraic numbers in the algebraic extension of p-adic numbers involved and there is unique prime for which this entanglement entropy is maximally negative. Negentropic entanglement makes possible new kind of many particle states analogous to bound states but with negative binding energy. The reason is that negentropic entanglement is stable against state function reduction if Negentropy Maximization Principle determines its dynamics also in the case of negentropic entanglement. The proposal is that the mysterious high energy phosphate bond corresponds to negentropic entanglement and carries both metabolic energy and information [K11]. In this framework ATP-ADP cycle has also information theoretic interpretation as a transfer of conscious information.

The model for DNA as topological quantum computer [K2, K96] led among other things to an identification of magnetic flux tubes connecting bio-molecules as a basic building bricks of living matter.

1. Flux tubes are assumed to connect DNA nucleotides to lipids of the nuclear and cell membranes. Flux tubes could begin from =O in the double bonds R=O or from negatively charged oxygens. In the case of DNA R would correspond to the basic unit in phosphate deoxiribose backbone (see `http://tinyurl.com/69okq`) consisting of aromatic 5-cycle and PO_4 containing one =O and one O^- [I12]. The lipid end would contain =O and -OH and the flux tube could end to either of these or possibly -OH ionized to $-O^-$ by a transformation of proton to dark proton.

2. The braiding of flux tubes makes topological quantum computation like processes possible [K2]. The contractions and expansions of flux tubes induced by phase transitions changing the value of Planck constant would be a basic control mechanism allowing to understand how two biomolecules (say DNA and its conjugate) can find each other in the thick soup of organic molecules. The reconnections of the magnetic flux tubes would be second basic control mechanism and ATP →ADP process (see `http://tinyurl.com/clnu4`) [I2] involving splitting of phosphate group and liberating metabolic energy and its reverse would represent standardized reconnection process and its reversal.

3. The flux tube ends would contain quark and antiquark (u, d and their antiquarks are involved) coding for the four DNA letters A, T, C, G so that also dark quarks and their antiquarks would provide an elementary particle level realization for the codons. Note that topological quantum computation does not necessitate genetic code and therefore also the repeating DNA sequences regarded as junk could be used for topological quantum computations.

9.10.3 General Ideas About Oil Droplets As A Primitive Life Form

It is interesting to see what one obtains if one takes the dark nucleon realization of genetic code, the mechanism of water memory realized as magnetic bodies attached to the ordered water layers associated with polar molecules, the model for DNA as topological quantum computer, and the ideas about magnetic body with dark matter as fundamental bio-control as basic ingredients of the model of intelligent oil droplets.

1. The formation of hot spot on the oil droplet resembles spontaneous symmetry breaking. The interpretation as a generation of magnetic body of approximately dipolar magnetic field is attractive. The magnetic body would control the droplet. The change of the direction of the motion of the oil droplet would correspond to the change of the orientation of the magnetic body and would thus reduce to a motor action of the magnetic body.

2. The flux tubes of the magnetic body would be most naturally parallel to the direction of the nitrobenzene polymer strands. Oleic anhydride molecules and the hydrogen cyanid polymers would be transferred along the magnetic flux tubes of an approximately dipolar magnetic field entering to the hot spot from interior and the oleic acid molecules could move along the flux tubes continuing along the surface of the droplet to the diametrically opposite point. The migration of birds along magnetic field lines is a direct analogy for this.

3. The dark matter at the magnetic body would give the oil drop its "intelligence". The dark nuclear genome could be realized at the magnetic body and the magnetic bodies might define the replicating life form as in the TGD based model of water memory for which the magnetic bodies represent molecules as far as low frequency electromagnetic fields characterized by cyclotron frequencies are considered. One could see intelligent oil droplets as manifestation of control actions of a life form defined by dark matter at magnetic flux tubes and the first step in the process eventually leading to a complex control and coordination of the behavior of ordinary matter.

4. The ability of droplets to react to the presence of other droplets would be due to the communications between magnetic bodies based on low frequency photons at cyclotron frequencies but having energy above thermal energy if the value of Planck constant is large enough.

At least oleic anhydrite, hydrogen cyanide, and mineral oil can serve as a fuel of oil droplets and this raises the question what might be the common property shared by them. For illustrations of various molecules involved see **Figs.9.1**, **9.2**, **9.3**, **9.4**, **??**, **9.5** in the section containing figures. Certainly this property must relate to metabolism and the model for ordinary metabolism suggests that this property is shared also by the high energy phosphate bond.

1. Oleic anhydrite (see `http://tinyurl.com/y7ua8mwq`) is a lipid formed by as a fusion of two oleic acids consisting of a sequence of CH_2 units and the characteristic (C=O)-(O-H) group at its end. The burning of the molecule splits it to two oleic acids by hydration meaning utilizing one water molecule. The formation of oleic acid in turn involves dehydration so that

the burning process is analogous to de-polymerization of DNA or amino-acid sequence by hydration.

2. Mineral oil (see `http://tinyurl.com/eoy5x`) is also a lipid and looks like oleic anhydride locally. In the ideal case however the crucial..(C=O)-O-(C=O)-.. portions are lacking. Oxygenation could however produce this kind of defects to the mineral oil molecules so that the mechanism of burning would remain the same.

3. Hydrogen cyanide (see `http://tinyurl.com/nv8qt8`) HCN involves valence bond of valence 3 between C and N. The polymers are constructed from H-C-N sequences with single valence bond between both C: s and N: s of two subsequent horizontal H-C-N units, which one can think of as being obtained from (H-C)-(H-C)... sequence and ..N-N-N... sequences with each N and C connected by horizontal valence bond. This polymer replaces oleic acid as a "fuel" reacting with water and liberating metabolic energy. These polymers - which would serve as primitive analogs of proteins- would be transferred along the magnetic flux tubes and burned at the hot spot by hydration. HCN has been proposed to have been a primitive precursor of both amino acids and nuclei acids. With motivations coming from the general vision about quantum biology, it will be proposed that also hydrogen cyanide polymers contain in their C-backbone..(C=O)-O-(C=O)-.. portions as local defects due to oxygenation so that the burning would occur via hydration in all three cases.

9.10.4 What Are The Prerequisites For Metabolism And Topological Quantum Computation Like Processes?

The basic question is whether metabolism interpreted in TGD framework as negentropy transfer and thus requiring the analogs of high energy phosphate bond and ATP-ADP cycle is possible. The high energy phosphate bonds make also possible flux tube structures serving as a prerequisite for topological quantum computation like process. Both oleic anhydride, hydrogen cyanide and mineral oil can serve as a metabolic source and one should identify the common property of them making. This property should be the analog of high energy phosphate bond.

1. High energy phosphate bond carries metabolic energy. This bond is poorly understood and I have proposed that high energy phosphate bond carries negentropic entanglement which identified in TGD framework as the basic characteristic of life [K60]. In the middle of oleic anhydride there (C=O)-O-(C=O) structure and its splitting in hydration liberates energy. This suggests that this structure also now carries the negentropic entanglement and the metabolic energy. The splitting process of oleic anhydrite occurring at the hotspot would be analogous to ATP$\rightarrow$ADP process involving splitting of PO_4 molecule from ATP.

2. Oleic acid is a lipid containing at its second end the characteristic (C=O)-OH group assumed to serve as a terminal for the magnetic flux tubes in the model of DNA-cell membrane system as quantum computer. In the presence energy feed one could imagine that the inverse process transforming oleic acid to oleic anhydride takes place and a primitive version of the metabolic cycle involving photosynthesis and cellular breathing can be imagined. Metabolic and quantum information processing would be very intimately related. By DNA as topological quantum computer analogy the magnetic flux tubes connecting oleic anhydride molecules would make be responsible for primitive topological quantum computation if present in the system.

3. Also when the tar from Urey-Miller experiment replaces oleic anhydrite small amount of oleic anhydride was used to build a film around oil droplet to lower surface tension. This suggests that the oleic anhydride has a deeper purpose and defines the analog of cell membrane and make possible for the magnetic flux tubes from the interior of the droplet to attach to the lipids? This could occur at least in the hot spot and at point opposite to it so that magnetic flux tubes would connect the diametrically opposite points of the droplet Oleic anhydride would therefore serve a dual purpose serving both as a metabolic resource and a building brick of the protocell membrane: metabolic energy would be accompanied by information. Also in real life lipids -about which fats are a special case- have this double role.

4. The process occurs also both for hydrogen cyanide and mineral oilandthis raises obvious objections since the energy and information carrying (C=O)-O-(C=O) structures making also possible the flux tube connects are not present in the ideal situation. One must however remember that the situation in real life is far from ideal and the most obvious idea is that the polymers as such are not enough: oxygen is the basic metabolic resource and oxygenation serving as the loading of metabolic batteries might be the crucial element.

   (a) The backbone of both oleic acid (see `http://tinyurl.com/yf34q92`), oleic anhydride, and of mineral oil polymers (see `http://tinyurl.com/eoy5x`) is CH_2 sequence common to all lipids. If some fraction of mineral oil polymers contain (C=O)-O -(C=O): s serving as carriers of metabolic energy and information the situation reduces to that for oleic anhydride apart from effects caused by the fact that the density of metabolic energy per volume is expected to be lower, which would explain why the motion is slower.

   (b) Also in the case of hydrogen cyanide (see `http://tinyurl.com/nv8qt8`) polymers one can imagine the presence of similar defect structures due to oxygenation. A portion of...(H-C)-(H-C)-(H-C).... sequence would be replaced with....(H-C)-(C=O)-O-(C=O)-(H-C)... with three carbons lacking. The nitrogen sequence...N-N-N-N-N.. would split to...N-OH and OH-N... so that three nitrogens would be lacking. The total number of hydrogens would remain the same.

Under these assumptions the model explains all three cases using hydration as the basic mechanism of metabolism as well as the conditions required by DNA as topological quantum computer model. Note that the process consumes oxygen just as the ordinary breathing.

9.10.5 What About Genetic Code And Counterpart Of DNA?

Consider next the possible realization of the genetic code. The first thing to notice is that even in the case that genetic code is not realized the braiding would make possible topological quantum computation like processes and a realization of memory in terms of braiding patterns. Furthermore, chemical realization of the genetric code is not possible so that dark nucleons remain the only possibility in TGD framework. The challenge is to try imagine whether DNA like structures having flux tube connections with the counterparts of lipids in the cell membrane could exist. The following suggestion is a product of free imagination based on analogies and reflects my amateurish skills in biochemistry.

1. Aromatic rings (see `http://tinyurl.com/ycf3kv24`) [I3] are an essential element of both phosphate deoxiribose backbone of DNA and of DNA letters itself. Nitrobenzene molecule obeys chemical formula (C_6H-5)-NO_2 and contains benzene ring to which NO_2 nitro group is attached. The oily character is due to the benzene ring. Benzene rings could serve as a counterpart for the hydrocarbon 5-cycles appearing in phosphate deoxiribose backbone. Note however that in deoxiribose ring one carbon is replaced with O and two hydrogens with OH. Moreover, single benzene molecule would correspond to the counterpart of DNA triplet rather than single nucleoside. One could however argue that only a backbone is in question so that the differences might not matter.

2. One would naïvely expect that both nitrogen and phosphorus have same valence equal to three. In PO_4 phosporus has 5 valence bonds as a rule and the interpretation is that phosphorus tends to donate its valence electrons to get empty shell. This kind of states are known as oxidation states and are possible also for nitrogen: hydroxylamine NO_2H is one example of this kind of state. In fact, from the from structural formula of nitrobenzene (see **Fig. 9.1**) one finds that nitrogen gives one electron to second oxygen so that also this state can be regarded as an oxidation state. This inspires the idea that nitrogen takes the role of phosphorus at least partially.

3. If one does not allow oxidation states, the simplest manner to construct the analog of phosphate deoxiribose backbone is as structure ...X-X-X..., with X= R-O- $(R_1$-N)-O, where R denotes oleic anhydride and R_1 is for benzene residue. The bridges connecting benzene rings

would be reflection symmetric. The breaking of reflection symmetry is however essential since it determines the reading direction of DNA.

4. If one accepts oxidation states, the simplest option is that in benzene-NO_2 complex NO_2 is replaced with (N=0)-O and the counterpart of phosphate deoxiribose backbone would have the structure ...X-X-X—, X=R- (R_1-N=0)-O with R denoting oleic anhydride and R_1 benzene. Oleic anhydride has valence bond to N so that N has 5 valence bonds as phosphorus in phosphate. Also the crucial =O is present. The units connecting subsequent benzene rings are not reflection symmetric anymore as indeed required. There is however no charged oxygen as in the case of ordinary DNA. Note that the analogs for AMP, ADP, ATP make sense since one can single replace P by N phosphate PO_4.

5. An interesting question is whether the nitrogen based metabolism could be realized as a primordial metabolism. Nitroglycerin (see `http://tinyurl.com/y9a23qen`) is analogous to tri-phosphate although the nitrates are not arrranged linearly as in ATP and is used as both heart medicine and as an active incredient of explosives. The latter use conforms with the idea about the presence of high energy nitrate bond in NO_4.

6. The two mirror image branches of oleic anhydride molecule consist of 15 carbon atoms and the structure is rather long as compared to the basic unit of phosphate deoxiribose backbone so that the distance between subsequent benzene units would be rather long- of order 10 Angstroms. On the other hand, 10 DNA codons correspond to 10 nm length in a good accuracy so that one codon would take 1 nm length also in this case. If double strand is formed, twisting is possible so that the scales could be the same. The size scale of the dark nucleon representing single DNA codon should correspond to the size scale of single oleic anhydride molecule and the required value of Planck constant would be of order 10^6 as the ratio of this scale and nucleon size of order 10^{-15} meters.

7. The counterparts of DNA nucleotides forming a linear structure should join to the benzene rings. Dark nucleon sequences remain the only possibility if one wants a realization of genetic code. Each dark codon represented by dark nucleon would be connected by three flux tubes with quark and antiquark at their ends to single unit of the proposed structure. There would be three =O: s per single benzene ring. Since single benzene ring corresponds to single DNA codon three =O: s are indeed expected. Therefore =O: s could indeed correspond to terminals for flux tubes coming from single dark nucleon representing single DNA codon.

8. The division of oil droplet would be the analog of cell replication and would involve at the deeper level the replication of dark nucleon sequences. This requires the analog of DNA double strand and the analogs of DNA codons would be dark nucleons. Genetic codons could be realized in terms of flux tubes connecting dark nucleon sequences to the oleic acids or oleic anhydrides at the surface of the droplet. It remains to be seen whether the division can be achieve in real world.

To sum up, the proposed model is rather direct application of TGD based vision about life and the killer test is whether the mineral oil oil molecules and hydrogen cyanide molecules are not ideal but actually contain the (C=O)-O-(C= O) pieces carrying energy and information and serve as terminals for the magnetic flux tubes.

9.10.6 Another Approach To Protocell

Also the group led by Jack. W. Szostak (see `http://tinyurl.com/y8avsbzd`), who was the 2009 Nobel Prize winner in physiology - has carried out beautiful experiments in which they are able to create a candidate for protocell satisfying many of the basic requirements [I95].

One such condition is the ability of protocell to transfer various nutrient molecules through the protocell membrane. In modern cell pumps and channels consisting of proteins are believed to serve that purpose (for a different view see the remark below). Genetically coded proteins were however absent during the primordial era. Therefore the membrane is constructed of branching lipids believed to exists during prebiotic era allowing sugars which are basic building bricks of DNA

to permeate to the protocell. Given the DNA template, the basic building bricks of DNA molecule assemble to a copy of DNA in this protocell.

What is still lacking is the generation of the template strand of DNA itself and also the replication of protocell. If dark DNA in the form of dark nucleon strings is really there, the template could result as the assembly of the basic bricks of DNA around it and above a proposal for the analog of this kind of process is suggested. The replication of the dark genes would have been also present from the beginning and would have preceded the replication of genes and protocell. Biological evolution could be seen as a migration from dark space-time sheets to ordinary ones and somewhat analogous to the migration of life from sea to land.

Remark: There are puzzling experimental findings about quantal currents through cell membrane even in absence of metabolic sources. In many-sheeted space-time [K78] one could interpret these currents as various kinds of Josephson currents running between cell interior and exterior along current carrying space-time shees. Pumps and channels would be more like a diagnostic tool allowing cell to measure the concentrations of various important biomolecules and ions.

At first sight the approaches of Szostak and Martin Hanczyc look very different. These approaches have however a lot of common at deeper level if one accepts TGD based view as DNA-cell membrane system or its more primitive version as a topological quantum computer like system relying on the braiding of magnetic flux tubes connecting the counterpart of DNA nucleotides to the lipids of protocell membrane and on the prebiotic realization of genetic code at the level of dark nuclear physics.

One could also argue that the protocell of Hanczyk represents oil based life as opposed to life as we know it. In TGD framework this is a mis-interpretation. The protocells of Hanczyk live in an aqueous environment. Nitrobenzene oil is an aromatic compound as also sugars and contains nitrogen taking in the proposed scenario same role as phosphorus in ordinary life. Oleic anhydride is lipid and- would provide basic building brick for a particular variant of DNA like structure halfway between dark and completely chemical realization. Oleic anhydride would provide also the building bricks of protocell membrane and serve as a nutrient just like fat molecules- also lipids-serve in "real life".

9.11 Figures

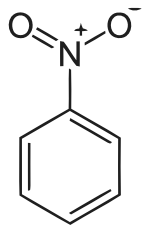

Figure 9.1: Nitrobenzene

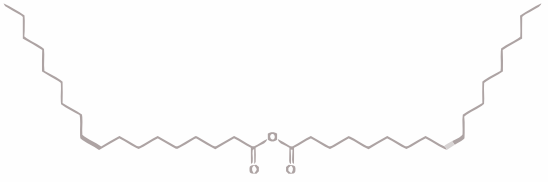

Figure 9.2: Oleic anhydride

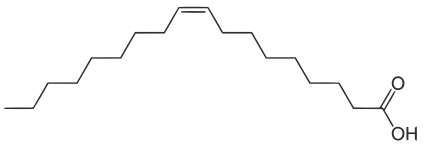

Figure 9.3: Oleic acid

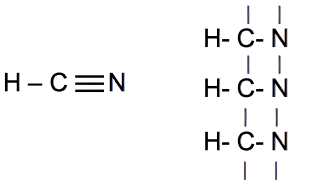

Figure 9.4: Hydrogen cyanide and hydrogen cyanide polymer.

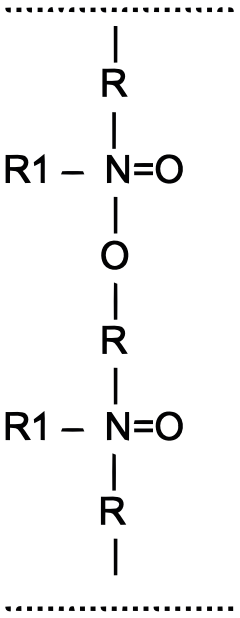

Figure 9.5: The analog of the deoxiribose phosphate backbone. R denotes oleic anhydride containing two =O: s and R1 benzene ring.

Chapter 10

Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life

10.1 Introduction

TGD inspired quantum cosmology [K87, K86] predicts that astrophysical objects do not follow cosmic expansion except in jerk-wise quantum leaps increasing the gigantic value of the gravitational Planck constant characterizing space-time mediating gravitational interactions between two masses or gravitational self interactions. This assumption provides explanation for the apparent cosmological constant.

Also planets are predicted to expand in a stepwise way. This provides a new version of Expanding Earth theory originally postulated to explain the intriguing findings suggesting that continents have once formed a connected continent covering almost the entire surface of Earth but with radius which was one half of the recent one [K86].

This leads also to a rather fascinating vision about biology. The mysterious Cambrian Explosion [I6] in which a large number of new species emerged suddenly (realized already Darwin as the strongest objection against his theory) could be understood if the life would have gone to underground lakes and seas formed during the expansion period as fractures were formed and the underground cavities expanded and were filled with water. This would have allowed the life to escape cosmic radiation, meteoric bombardment, and the extremely cold climate during Proterozoic period preceding the Cambrian Explosion and migrate back as highly developed life forms as the period of glaciations ended.

Before the Proterozoic era the radius of Earth would have been one half of its recent value and started to grow with gradually accelerating rate. This forces to rewrite the entire geological and climate history of Earth during the Proterozoic period.

1. The postulated physically implausible cyclic appearance of single connected super-continent containing all land mass can be given up and replaced with a single continent containing large inland seas. There is no need to postulate the existence of series of super-oceans whose ocean floor would have subduced totally so that no direct information about them would exist nowadays. It is also possible that the underground oceans have burst into the surface during the phase transition.

   What is amusing that this kind of sea with water volume three times that in ordinary seas has been discovered quite recently (`http://time.com/2868283/subterranean-ocean-reservoir-core-ringwoodite/`) at depth of about 600 km to be compared to the depth of core which is about 2900 km. Water is associated with a mineral known as ringwoodite and ordinary sea water could have originated from this water.

2. The dominating model for pre-Cambrian climate is so called Snowball Earth model [F31] inspired by the finding that signatures of glaciations have been found at regions of Earth,

which should have been near Equator during the Proterozoic. Snowball model has several difficulties: in particular, there is a lot of evidence that a series of ordinary glaciations was in question. For $R/2$ option the regions located to Equator would have actually been near North Pole so that the glaciations would have indeed been ordinary glaciations proceeding from the poles. A killer prediction is the existence of non-glaciated regions at apparent southern latitudes around about 45 degrees and there is evidence for these indeed exists [F56]! The model makes also testable paleomagnetic killer predictions. In particular, during periods when the magnetic dipole in the direction of rotation axis the directions of the magnetic fields for $R/2$ model are predicted to be same at South Pole and apparent Equator and opposite for the standard option.

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` [L10].

10.2 Experimental Evidence For Accelerated Expansion Is Consistent With TGD based model

There are several pieces of evidence for accelerated expansion, which need not mean cosmological constant, although this is the interpretation adopted in [E4]. It is interesting to see whether this evidence is indeed consistent with TGD based interpretation.

10.2.1 The Four Pieces Of Evidence For Accelerated Expansion

Supernovas of type Ia

Supernovas of type Ia define standard candles since their luminosity varies in an oscillatory manner and the period is proportional to the luminosity. The period gives luminosity and from this the distance can be deduced by using Hubble's law: $d = cz/H_0$, H_0 Hubble's constant. The observation was that the farther the supernova was the more dimmer it was as it should have been. In other words, Hubble's constant increased with distance and the cosmic expansion was accelerating rather than decelerating as predicted by the standard matter dominated and radiation dominated cosmologies.

Mass density is critical and 3-space is flat

It is known that the contribution of ordinary and dark matter explaining the constant velocity of distance stars rotating around galaxy is about 25 per cent from the critical density. Could it be that total mass density is critical?

From the anisotropy of cosmic microwave background one can deduce that this is the case. What criticality means geometrically is that 3-space defined as surface with constant value of cosmic time is flat. This reflects in the spectrum of microwave radiation. The spots representing small anisotropies in the microwave background temperature is 1 degree and this correspond to flat 3-space. If one had dark matter instead of dark energy the size of spot would be.5 degrees!

Thus in a cosmology based on general relativity cosmological constant remains the only viable option. The situation is different in TGD based quantum cosmology based on sub-manifold gravity and hierarchy of gravitational Planck constants.

The energy density of vacuum is constant in the size scale of big voids

It was observed that the density of dark energy would be constant in the scale of 10^8 light years. This length scale corresponds to the size of big voids containing galaxies at their boundaries.

Integrated Sachs-Wolf effect

Also so called integrated Integrated Sachs-Wolf effect supports accelerated expansion. Very slow variations of mass density are considered. These correspond to gravitational potentials. Cosmic

expansion tends to flatten them but mass accretion to form structures compensates this effect so that gravitational potentials are unaffected and there is no effect of CMB. Situation changes if dark matter is replaced with dark energy the accelerated expansion flattening the gravitational potentials wins the tendency of mass accretion to make them deeper. Hence if photon passes by an over-dense region, it receives a little energy. Similarly, photon loses energy when passign by an under-dense region. This effect has been observed.

10.2.2 Comparison With TGD

The minimum TGD based explanation for accelerated expansion involves only the fact that the embeddings of critical cosmologies correspond to accelerated expansion. A more detailed model allows to understand why the critical cosmology appears during some periods.

Accelerated expansion in classical TGD

The first observation is that critical cosmologies (flat 3-space) imbeddable to 8-D embedding space H correspond to negative pressure cosmologies and thus to accelerating expansion. The negativity of the counterpart of pressure in Einstein tensor is due to the fact that space-time sheet is forced to be a 4-D surface in 8-D embedding space. This condition is analogous to a force forcing a particle at the surface of 2-sphere and gives rise to what could be called constraint force. Gravitation in TGD is sub-manifold gravitation whereas in GRT it is manifold gravitation. This would be minimum interpretation involving no assumptions about what mechanism gives rise to the critical periods.

Accelerated expansion and hierarchy of Planck constants

One can go one step further and introduce the hierarchy of Planck constants. The basic difference between TGD and GRT based cosmologies is that TGD cosmology is quantum cosmology. Smooth cosmic expansion is replaced by an expansion occurring in discrete jerks corresponding to the increase of gravitational Planck constant. At space-time level this means the replacement of 8-D embedding space H with a book like structure containing almost-copies of H with various values of Planck constant as pages glued together along critical manifold through which space-time sheet can leak between sectors with different values of $\hbar$. This process is the geometric correlate for the phase transition changing the value of Planck constant.

During these phase transition periods critical cosmology applies and predicts automatically accelerated expansion. Neither genuine negative pressure due to "quintessence" nor cosmological constant is needed. Note that quantum criticality replaces inflationary cosmology and predicts a unique cosmology apart from single parameter. Criticality also explains the fluctuations in microwave temperature as long range fluctuations characterizing criticality.

Accelerated expansion and flatness of 3-cosmology

Observations 1) and 2) about super-novae and critical cosmology (flat 3-space) are consistent with this cosmology. In TGD dark energy must be replaced with dark matter because the mass density is critical during the phase transition. This does not lead to wrong sized spots since it is the increase of Planck constant which induces the accelerated expansion understandable also as a constraint force due to embedding to H.

The size of large voids is the characteristic scale

The TGD based model in its simplest form model assigns the critical periods of expansion to large voids of size 10^8 ly. Also larger and smaller regions can express similar periods and dark space-time sheets are expected to obey same universal "cosmology" apart from a parameter characterizing the duration of the phase transition. Observation 3) that just this length scale defines the scale below which dark energy density is constant is consistent with TGD based model.

The basic prediction is jerk-wise cosmic expansion with jerks analogous to quantum transitions between states of atom increasing the size of atom. The discovery of large voids with size of order 10^8 ly but age much longer than the age of galactic large voids conforms with this prediction.

One the other hand, it is known that the size of galactic clusters has not remained constant in very long time scale so that jerk-wise expansion indeed seems to occur.

Do cosmic strings with negative gravitational mass cause the phase transition inducing accelerated expansion

Quantum classical correspondence is the basic principle of quantum TGD and suggest that the effective antigravity manifested by accelerated expansion might have some kind of concrete space-time correlate. A possible correlate is super heavy cosmic string like objects at the center of large voids which have negative gravitational mass under very general assumptions. The repulsive gravitational force created by these objects would drive galaxies to the boundaries of large voids. At some state the pressure of galaxies would become too strong and induce a quantum phase transition forcing the increase of gravitational Planck constant and expansion of the void taking place much faster than the outward drift of the galaxies. This process would repeat itself. In the average sense the cosmic expansion would not be accelerating.

10.3 Quantum Version Of Expanding Earth Theory

TGD predicts that cosmic expansion at the level of individual astrophysical systems does not take place continuously as in classical gravitation but through discrete quantum phase transitions increasing gravitational Planck constant and thus various quantum length and time scales. The reason would be that stationary quantum states for dark matter in astrophysical length scales cannot expand. One would have the analog of atomic physics in cosmic scales. Increases of $\hbar$ by a power of two are favored in these transitions but also other scalings are possible.

This has quite far reaching implications.

1. These periods have a highly unique description in terms of a critical cosmology for the expanding space-time sheet. The expansion is accelerating. The accelerating cosmic expansion can be assigned to this kind of phase transition in some length scale (TGD Universe is fractal). There is no need to introduce cosmological constant and dark energy would be actually dark matter.

2. The recently observed void which has same size of about 10^8 light years as large voids having galaxies near their boundaries but having an age which is much higher than that of the large voids, would represent one example of jerk-wise expansion.

3. This picture applies also to solar system and planets might be perhaps seen as having once been parts of a more or less connected system, the primordial Sun. The Bohr orbits for inner and outer planets correspond to gravitational Planck constant which is 5 times larger for outer planets. This suggests that the space-time sheet of outer planets has suffered a phase transition increasing the size scale by a factor of 5. Earth can be regarded either as n=1 orbit for Planck constant associated with outer planets or n= 5 orbit for inner planetary system. This might have something to do with the very special position of Earth in planetary system. One could even consider the possibility that both orbits are present as dark matter structures. The phase transition would also explain why n=1 and n=2 Bohr orbits are absent and one only n=3, 4, and 5 are present.

4. Also planets should have experienced this kind of phase transitions increasing the radius: the increase by a factor two would be the simplest situation.

The obvious question - that I did not ask - is whether this kind of phase transition might have occurred for Earth and led from a completely granite covered Earth - Pangeia without seas - to the recent Earth. Neither it did not occur to me to check whether there is any support for a rapid expansion of Earth during some period of its history.

Situation changed when my son visited me and told me about a Youtube video [F54] by Neal Adams, an American comic book and commercial artist who has also produced animations for geologists. We looked the amazing video a couple of times and I looked it again yesterday. The video is very impressive artwork but in the lack of references skeptic probably cannot avoid

the feeling that Neal Adams might use his highly developed animation skills to cheat you. I found also a polemic article [F1] of Adams but again the references were lacking. Perhaps the reason of polemic tone was that the concrete animation models make the expanding Earth hypothesis very convincing but geologists refuse to consider seriously arguments by a layman without a formal academic background.

10.3.1 The Claims Of Adams

The basic claims of Adams were following.

1. The radius of Earth has increased during last 185 million years (dinosaurs [I11] appeared for about 230 million years ago) by about factor 2. If this is assumed all continents have formed at that time a single super-continent, Pangeia, filling the entire Earth surface rather than only 1/4 of it since the total area would have grown by a factor of 4. The basic argument was that it is very difficult to imagine Earth with 1/4 of surface containing granite and 3/4 covered by basalt. If the initial situation was covering by mere granite -as would look natural- it is very difficult for a believer in thermodynamics to imagine how the granite would have gathered to a single connected continent.

2. Adams claims that Earth has grown by keeping its density constant, rather than expanded, so that the mass of Earth has grown linearly with radius. Gravitational acceleration would have thus doubled and could provide a partial explanation for the disappearance of dinosaurs: it is difficult to cope in evolving environment when you get slower all the time.

3. Most of the sea floor is very young and the areas covered by the youngest basalt are the largest ones. This Adams interprets this by saying that the expansion of Earth is accelerating. The alternative interpretation is that the flow rate of the magma slows down as it recedes from the ridge where it erupts. The upper bound of 185 million years for the age of sea floor requires that the expansion period - if it is already over - lasted about 185 million years after which the flow increasing the area of the sea floor transformed to a convective flow with subduction so that the area is not increasing anymore.

4. The fact that the continents fit together - not only at the Atlantic side - but also at the Pacific side gives strong support for the idea that the entire planet was once covered by the super-continent. After the emergence of subduction theory this evidence as been dismissed.

5. I am not sure whether Adams mentions the following objections [F6]. Subduction only occurs on the other side of the subduction zone so that the other side should show evidence of being much older in the case that oceanic subduction zones are in question. This is definitely not the case. This is explained in plate tectonics as a change of the subduction direction. My explanation would be that by the symmetry of the situation both oceanic plates bend down so that this would represent new type of boundary not assumed in the tectonic plate theory.

6. As a master visualizer Adams notices that Africa and South-America do not actually fit together in absence of expansion unless one assumes that these continents have suffered a deformation. Continents are not easily deformable stuff. The assumption of expansion implies a perfect fit of *all* continents without deformation.

Knowing that the devil is in the details, I must admit that these arguments look rather convincing to me and what I learned from Wikipedia articles supports this picture.

10.3.2 The Critic Of Adams Of The Subduction Mechanism

The prevailing tectonic plate theory [F27] has been compared to the Copernican revolution in geology. The theory explains the young age of the seafloor in terms of the decomposition of the litosphere to tectonic plates and the convective flow of magma to which oceanic tectonic plates participate. The magma emerges from the crests of the mid ocean ridges representing a boundary of two plates and leads to the expansion of sea floor. The variations of the polarity of Earth's magnetic field coded in sea floor provide a strong support for the hypothesis that magma emerges from the crests.

The flow back to would take place at so called oceanic trenches [F20] near continents which represent the deepest parts of ocean. This process is known as subduction. In subduction oceanic tectonic plate bends and penetrates below the continental tectonic plate, the material in the oceanic plate gets denser and sinks into the magma. In this manner the oceanic tectonic plate suffers a metamorphosis returning back to the magma: everything which comes from Earth's interior returns back. Subduction mechanism explains elegantly formation of mountains [F21] (orogeny), earth quake zones, and associated zones of volcanic activity [F37] .

Adams is very polemic about the notion of subduction, in particular about the assumption that it generates steady convective cycle. The basic objections of Adams against subduction are following.

1. There are not enough subduction zones to allow a steady situation. According to Adams, the situation resembles that for a flow in a tube which becomes narrower. In a steady situation the flow should accelerate as it approaches subduction zones rather than slow down. Subduction zones should be surrounded by large areas of sea floor with constant age. Just the opposite is suggested by the fact that the youngest portion of sea-floor near the ridges is largest. The presence of zones at which both ocean plates bend down could improve the situation. Also jamming of the flow could occur so that the thickness of oceanic plate increases with the distance from the eruption ridge. Jamming could increase also the density of the oceanic plate and thus the effectiveness of subduction.

2. There is no clear evidence that subduction has occurred at other planets. The usual defense is that the presence of sea is essential for the subduction mechanism.

3. One can also wonder what is the mechanism that led to the formation of single super continent Pangeia covering 1/4 of Earth's surface. How probable the gathering of all separate continents to form single cluster is? The later events would suggest that just the opposite should have occurred from the beginning.

10.3.3 Expanding Earth Theories Are Not New

After I had decided to check the claims of Adams, the first thing that I learned is that Expanding Earth theory [F6], whose existence Adams actually mentions, is by no means new. There are actually many of them.

The general reason why these theories were rejected by the main stream community was the absence of a convincing physical mechanism of expansion or of growth in which the density of Earth remains constant.

1. 1888 Yarkovski postulated some sort of aether absorbed by Earth and transforming to chemical elements (TGD version of aether could be dark matter). 1909 Mantovani postulated thermal expansion but no growth of the Earth's mass [F53].

2. Paul Dirac's idea about changing Planck constant led Pascual Jordan in 1964 to a modification of general relativity predicting slow expansion of planets. The recent measurement of the gravitational constant imply that the upper bound for the relative change of gravitational constant is 10 time too small to produce large enough rate of expansion. Also many other theories have been proposed but they are in general conflict with modern physics.

3. The most modern version of Expanding Earth theory is by Australian geologist Samuel W. Carey. He calculated that in Cambrian period (about 500 million years ago) all continents were stuck together and covered the entire Earth. Deep seas began to evolve then.

10.3.4 Summary Of TGD Based Theory Of Expanding Earth

TGD based model differs from the tectonic plate model but allows subduction which cannot imply considerable back-flow of magma. Let us sum up the basic assumptions and implications.

1. The expansion is or was due to a quantum phase transition increasing the value of gravitational Planck constant and forced by the cosmic expansion in the average sense.

2. Tectonic plates do not participate to the expansion and therefore new plate must be formed and the flow of magma from the crests of mid ocean ridges is needed. The decomposition of a single plate covering the entire planet to plates to create the mid ocean ridges is necessary for the generation of new tectonic plate. The decomposition into tectonic plates is thus prediction rather than assumption.

3. The expansion forced the decomposition of Pangeia super-continent covering entire Earth for about 530 million years ago to split into tectonic plates which began to recede as new non-expanding tectonic plate was generated at the ridges creating expanding sea floor. The initiation of the phase transition generated formation of deep seas.

4. The eruption of plasma from the crests of ocean ridges generated oceanic tectonic plates which did not participate to the expansion by density reduction but by growing in size. This led to a reduction of density in the interior of the Earth roughly by a factor 1/8. From the upper bound for the age of the seafloor one can conclude that the period lasted for about 185 million years after which it transformed to convective flow in which the material returned back to the Earth interior. Subduction at continent-ocean floor boundaries and downwards double bending of tectonic plates at the boundaries between two ocean floors were the mechanisms. Thus tectonic plate theory would be more or less the correct description for the recent situation.

5. One can consider the possibility that the subducted tectonic plate does not transform to magma but is fused to the tectonic layer below continent so that it grows to an iceberg like structure. This need not lead to a loss of the successful predictions of plate tectonics explaining the generation of mountains, earthquake zones, zones of volcanic activity, etc...

6. From the video of Adams it becomes clear that the tectonic flow is East-West asymmetric in the sense that the western side is more irregular at large distances from the ocean ridge at the western side. If the magma rotates with slightly lower velocity than the surface of Earth (like liquid in a rotating vessel), the erupting magma would rotate slightly slower than the tectonic plate and asymmetry would be generated.

7. If the planet has not experienced a phase transition increasing the value of Planck constant, there is no need for the decomposition to tectonic plates and one can understand why there is no clear evidence for tectonic plates and subduction in other planets. The conductive flow of magma could occur below this plate and remain invisible.

The biological implications might provide a possibility to test the hypothesis.

1. Great steps of progress in biological evolution are associated with catastrophic geological events generating new evolutionary pressures forcing new solutions to cope in the new situation. Cambrian explosion indeed occurred about 530 years ago (the book "Wonderful Life" of Stephen Gould [I133] explains this revolution in detail) and led to the emergence of multicellular creatures, and generated huge number of new life forms living in seas. Later most of them suffered extinction: large number of phylae and groups emerged which are not present nowadays.

   Thus Cambrian explosion is completely exceptional as compared to all other dramatic events in the evolution in the sense that it created something totally new rather than only making more complex something which already existed. Gould also emphasizes the failure to identify any great change in the environment as a fundamental puzzle of Cambrian explosion. Cambrian explosion is also regarded in many quantum theories of consciousness (including TGD) as a revolution in the evolution of consciousness: for instance, micro-tubuli emerged at this time. The periods of expansion might be necessary for the emergence of multicellular life forms on planets and the fact that they unavoidably occur sooner or later suggests that also life develops unavoidably.

2. TGD predicts a decrease of the surface gravity by a factor 1/4 during this period. The reduction of the surface gravity would have naturally led to the emergence of dinosaurs 230 million years ago as a response coming 45 million years after the accelerated expansion

ceased. Other reasons led then to the decline and eventual catastrophic disappearance of the dinosaurs. The reduction of gravity might have had some gradually increasing effects on the shape of organisms also at microscopic level and manifest itself in the evolution of genome during expansion period.

3. A possibly testable prediction following from angular momentum conservation ($\omega R^2 = constant$) is that the duration of day has increased gradually and was four times shorter during the Cambrian era. For instance, genetically coded bio-clocks of simple organisms during the expansion period could have followed the increase of the length of day with certain lag or failed to follow it completely. The simplest known circadian clock is that of the prokaryotic cyanobacteria. Recent research has demonstrated that the circadian clock of Synechococcus elongatus can be reconstituted in vitro with just the three proteins of their central oscillator. This clock has been shown to sustain a 22 hour rhythm over several days upon the addition of ATP: the rhythm is indeed faster than the circadian rhythm. For humans the average innate circadian rhythm is however 24 hours 11 minutes and thus conforms with the fact that human genome has evolved much later than the expansion ceased.

4. Scientists have found a fossil of a sea scorpion with size of 2.5 meters [I52], which has lived for about 10 million years for 400 million years ago in Germany. The gigantic size would conform nicely with the much smaller value of surface gravity at that time. The finding would conform nicely with the much smaller value of surface gravity at that time. Also the emergence of trees could be understood in terms of a gradual growth of the maximum plant size as the surface gravity was reduced. The fact that the oldest known tree fossil is 385 million years old [I112] conforms with this picture.

10.3.5 Did Intra-Terrestrial Life Burst To The Surface Of Earth During Cambrian Expansion?

Intra-terrestrial hypothesis [K39, K40] is one of the craziest TGD inspired ideas about the evolution of life and it is quite possible that in its strongest form the hypothesis is unrealistic. One can however try to find what one obtains from the combination of the IT hypothesis with the idea of pre-Cambrian granite Earth. Could the harsh pre-Cambrian conditions have allowed only intra-terrestrial multicellular life? Could the Cambrian explosion correspond to the moment of birth for this life in the very concrete sense that the magma flow brought it into the day-light?

1. Gould emphasizes the mysterious fact that very many life forms of Cambrian explosion looked like final products of a long evolutionary process. Could the eruption of magma from the Earth interior have induced a burst of intra-terrestrial life forms to the Earth's surface? This might make sense: the life forms living at the bottom of sea do not need direct solar light so that they could have had intra-terrestrial origin. It is quite possible that Earth's mantle contained low temperature water pockets, where the complex life forms might have evolved in an environment shielded from meteoric bombardment and UV radiation.

2. Sea water is salty. It is often claimed that the average salt concentration inside cell is that of the primordial sea: I do not know whether this claim can be really justified. If the claim is true, the cellular salt concentration should reflect the salt concentration of the water inside the pockets. The water inside water pockets could have been salty due to the diffusion of the salt from ground but need not have been same as that for the ocean water (higher than for cell interior and for obvious reasons). Indeed, the water in the underground reservoirs in arid regions such as Sahara is salty, which is the reason for why agriculture is absent in these regions. Note also that the cells of marine invertebrates are osmoconformers able to cope with the changing salinity of the environment so that the Cambrian revolutionaries could have survived the change in the salt concentration of environment.

3. What applies to Earth should apply also to other similar planets and Mars [L60] is very similar to Earth. The radius is .533 times that for Earth so that after quantum leap doubling the radius and thus Schumann frequency scale (7.8 Hz would be the lowest Schumann frequency) would be essentially same as for Earth now. Mass is.131 times that for Earth so that surface

gravity would be.532 of that for Earth now and would be reduced to.131 meaning quite big dinosaurs! have learned that Mars probably contains large water reservoirs in it's interior and that there is an un-identified source of methane gas usually assigned with the presence of life. Could it be that Mother Mars is pregnant and just waiting for the great quantum leap when it starts to expand and gives rise to a birth of multicellular life forms. Or expressing freely how Bible describes the moment of birth: in the beginning there was only darkness and water and then God saidLet the light come!

To sum up, TGD would not only provide the long sought mechanism of expansion of Earth but also a possible connection with the biological evolution. It would be indeed fascinating if Planck constant changing quantum phase transitions in planetary scale would have profoundly affected the biosphere.

10.4 Implications Of Expanding Earth Model For The Pre-Cambrian Evolution Of Continents, Of Climate, And Of Life

Expanding Earth hypothesis is by no means not new. It was proposed by Mantovani and I learned about it from the video animations of [F54, F1] demonstrating that the continents fit nicely to form a single continent covering entire Earth if the radius is one half of the recent radius. What TGD has to give is a new physics justification for Expanding Earth hypothesis: cosmic expansion is replaced with a sequence of fast expansion periods increasing the value of Planck constant and these transitions occur in all scales.

If Expanding Earth hypothesis is correct it forces to modify dramatically the view about pre-Cambrian period. The super-continent theory could be replaced by much simpler theory and it might be possible to give up the assumption about hypothetical super continents and super oceans. The view about glaciations [F8] must be modified dramatically. Concerning the evolution of life the natural hypothesis is that it escaped to the underground seas formed as a consequence of expansion during pre-Cambrian era and returned back to the surface in Cambrian Explosion. In this section super-continent and super-ocean theory is discussed from TGD point of view. A model for glaciations based on the assumption that the radius of Earth was in good approximation one half of the recent radius during pre-Cambrian era is developed and shown to reduce to a sequence of ordinary glaciations initiated at pole caps. Snowball theory serves as a convenient reference. Expanding Earth theory is discussed also from paleomagnetic point of view and some experimental signatures of $R/2$ scenario differentiating it from standard scenarios are developed. Finally the hypothesis about underground evolution is discussed.

10.4.1 Super-Continent Theory

Super-continent theory assumes a cyclic formation of hypothetical super continents [F32]. Rodinia [F29], Pannotia [F25], and Pangea [F24] might have preceded by earlier super-continents. The period would be roughly 250 Myr.

1. The super-continent Rodinia [F29] is assumed to have existed during interval: 1100-750 Myr. 750 Myr ago Rodinia rifted into three continents: Proto-Laurasia which broke up and eventually reformed to form Laurasia (North America and Asia), the continental craton of Congo (part of Africa), and Gondwana (now southern hemisphere plus India).

2. Pannotia [F25] existed during time interval 600-540 Myr. Pannotia rifted in the beginning of Cambrian era to Laurentia (North America), Baltica, Siberia and Gondwana. See the illustration of Pannotia at [F14].

3. Wegener [F3] ended up to postulate that super-continent Pangea should have existed about 250 Myr ago [F24]. The support for its existence is rather strong since tectonic plate model and paleo-magnetic methods allows to trace the drift of the tectonic plates.

One can criticize the cyclic model. The concentration of land mass to Southern Hemisphere during Rodinia period does not look very probable event. The cyclically occurring formation of connected land mass surrounded by much larger ocean looks even less probable unless one can develop some very good physical mechanism forcing this. The basic motivation for super-continent theory are various correlations between distant parts of Earth which would cannot be understood otherwise. In $R/2$ model the continents would have been quite near to each other during the expansion and the notion of cyclic formation of super-continents becomes un-necessary since land bridges between the continents could explain the correlations. There would have been just single super-continent all the time.

10.4.2 Standard View About Oceans

In the standard model the total area covered by oceans has reduced since pre-Cambrian era due to the increase of the continental cover, which is nowadays 29 per cent. Oceans cover the remaining 71 per cent with Antarctica and Arctica included. The evolution of Oceans in standard model requires the introduction of hypothetical oceans which left no trace about their existence (subduction mechanism provides perhaps too convenient trash bin for hypothetical theoretical constructs).

1. Proto-Atlantic Ocean was introduced to explain some contradictions with Wegener's Pangea model allowing to conclude which parts at opposite sides of Atlantic Ocean had been in contact. Proto-Atlantic Ocean closed as Pangea formed and opened again in slightly different manner to form Atlantic Ocean. This process implied mixing of older pieces of the continents and explained the contradictions. Large inland sea is a natural counterpart of the Proto-Atlantic Ocean in $R/2$ option.

2. Mirovia [F18] was the super-ocean surrounding Rodinia. It transformed to Pan-African Ocean surrounding Pannotia. Pan-African ocean was then closed so that the ocean floor of Mirovia disappeared by subduction and left no signs about its existence.

3. In the rifting [F28] of Pannotia Panthalassic ocean [F26] emerged and was the precedessor of the Pacific ocean.

The presence of super-oceans is forced by the assumption that the radius of Earth was the recent one during the pre-Cambrian era plus the local data related to the evolution of continents. The questionable aspect is that these oceans did not leave any direct trace about their existence. In $R/2$ model there is no need for these super-oceans except possibly the counterpart of Panthalassic Ocean [F26].

10.4.3 Glaciations During Neoproterozoic Period

Glaciations dominated the Neoproterozoic period [F19] between 1-.542 billion years. The period is divided into Tonian [F36], Cryogenian [F4], and Ediacaran periods [F5]. The most severe glaciations occurred during Cryogenian period.

It is believed that during Cryogenian period [F4] two worldwide glaciations -Sturtian and Marinoan glaciations- took place. This involves extrapolation of continental drift model and plate tectonics theory. Also hypothesis about hypothetical super-continents is needed so that one must take these beliefs with some skepticism. In $R/2$ model the world wide glaciations are replaced with ordinary glaciations proceeding from poles.

1. Sturtian glaciation occurred 750-700 Myr. The breakup of Rodinia is believed to have occurred at this time. One can wonder whether there is a correlation between these events. $R/2$ model suggest that the energy needed to compensate the reduction of gravitational energy in expansion could have caused the cooling.

2. Marinoan (Varanger) glaciation ended around 635 Myr ago.

Deposits of glacial tillites [F34] at low latitudes serve as support for the claim that these glaciations were world wide. In $R/2$ model Equator corresponds to North pole in TGD framework where Rodinia covered entire Earth and the interpretation would as ordinary glaciations.

After the end of Marinoan glaciation followed Ediacaran period during 635-542 Myr [F5]. The first multicellular fossils appeared at this time. Their relationship to Cambrian fossils is unclear. The standard interpretation for the small number of fossils in pre-Cambrian period is that hard shells needed for fossilization were not yet developed. The problem is that these shells should have developed almost instantaneously in Cambrian explosion.

10.4.4 Snowball Earth Model For The Glaciation During Pre-Cambrian Era

Snowball Earth [F52, F43, F31] is recently the leading model for the glaciations [F9] during Proterozoic era. The term is actually somewhat misleading: Iceball Earth would more to the point. Slushball earth [F47] is a variant of Snowball Earth which does not assume total freezing near equator.

The history behind the Snowball Earth concept is roughly following [F31].

1. Mawson studied the Neoproterozoic stratigraphy of South Australia and identified extensive glacial sediments and speculated with the possibility of global glaciation. He did not know anything about continental drift hypothesis and plate tectonic theory and thought that the ancient position of Australia was the same as it is today. Continent drifting hypothesis however explained the finding as sediments deposited at the higher latitudes the hypothesis was forgotten.

2. Later Harland suggested on basis of geomagnetic data that glacial tillites [F34] in Svalbard and Greenland were deposited at tropical latitudes. In TGD framework with with $R \to R/2$ these tillites would have been at higher latitudes towards North Pole.

3. The facts are that Sun was 6 per cent fainter at that time and glaciations are known to occur. The question is whether they were global and long-lasting or a sequence of short-lasting possibly local glaciations. The Russian climatologist Budyko constructed a model based on energy balance and found that it is possible to have a global glaciation if the ice sheets proceeded enough from polar regions (to about 30 degree latitude). The model was based on the increased reflectiveness (albedo) of the Earth's surface due to the ice covering giving rise to positive feedback loop. Budyko did not believe that global glaciation had occurred since the model offered no way to escape eternal glaciation.

4. Kirschwink introduced the term Snowball Earth, which is actually misleading. Iceball Earth would be more to the point. He found that the so called banded iron formations are consistent with a global glaciation. He also proposed a mechanism for melting the snowball. The accumulation of CO_2 from volcanoes would have caused ultra-greenhouse effect causing warming of the atmosphere and melting of the ice.

5. Slushball Earth [F47] differs from Snowball Earth in that only a thin ice cover or even its absence near equator is assumed. The model allows to explain various findings in conflict with Snowball Earth, such as the evidence for the presence of melt-water basins.

6. Zipper rift model [F46] assumes that there was a sequence of glaciations rather similar to the glaciations that have occurred later. The model assumes that the rifts [F28] of the supercontinent Rodinia occurred simultaneously with glaciations. The associated tectonic uplift led to the formation of high plateaus hosting the glaciers. The iron band formation can be assigned with inland seas allowing complex chemistries and anoxicity near the sea floor.

The basic ideas of the Snowball Earth model

Snowball Earth [F52, F43, F31] differs from ordinary glaciations in that only oceans are frozen whereas in the ordinary glaciation land mass is covered by ice. The basic ideas of the snowball Earth relate to the mechanism initiating the global freezing and melting.

1. The glaciation would have been initiated by some event, say a creation of super-volcano. Also astrophysical mechanism might be involved. Somewhat paradoxically, tropical continents

during cryogenian period [F4] are needed for the initiation because they reflect the solar radiation more effectively than tropical oceans.

2. The positive ice-albedo feedback is an essential concept: the more ice the larger the fraction of the radiation reflected back so that the more ice is generated. If the glaciation proceeds over a critical latitude about 30 degrees positive feedback forces a global glaciation.

3. The problem of the model is how to get rid of the glaciation. The proposal of Kirschvink was that the accumulation of CO_2 from volcanoes could have led to a global super-warming. The time scale for CO_2 emissions is measured in millions of years. The needed atmospheric concentration of CO_2 is by a factor 350 higher than the recent concentration. Due the ice cover the CO_2 could not be absorbed to the siliceous rocks and concentration would increase. The melting of the ice meant higher absorbtion of heat by uncovered land. Positive feedback loop was at work again but in different direction.

Evidence for and objections against Snowball Earth

Wikipedia article about Snowball Earth [F31] discusses both evidence for and objections against Snowball Earth. Low latitude sediments at tropical latitudes and tropical tillites at Equatorial latitudes provide strong piece of evidence for Snowball Earth. Calcium carbonate deposits having ^{13}C signature (per cent for the depletion of ^{13} isotope and large for organic material) consistent with that for mantle meaning abiotic origin is second evidence. Iridium anomaly located at the base of Calcium Carbonate deposits is third piece of evidence. The evidence for Snowball Earth will be discussed in more detail later since it is convenient to relate the evidence to $R/2$ model for glaciations.

1. Paleomagnetic data [F23] used to the dating of sediments assuming tectonic plane theory and super-continent drifting might be misleading. No pole wandering maps exist and the polarity of the magnetic field must be deduced by statistical methods. The primary magnetization could have been reset and the orientation of the magnetic minerals could have changed from the original one. It is also possible that magnetic field patterns were not dipolar. Also the assumption of hypothetical super-continents and oceans brings in uncertainties. In $R/2$ model of course the determination of the positions changes completely.

2. Carbon isotope ratios are not what they should be. There are rapid variations of $^{12}C/^{13}C$ ratio with organic origin. Suggests that freezing and melting followed each other in rapid succession. In standard framework this would suggest Slushball Earth meaning ice-free and ice-thin regions around the equator and hydrological cycles. In $R/2$ model the regions at Equator are near North Pole and the explanation would be in terms of ordinary glaciations.

3. The distribution of isotopes of element Boron suggest variations of pH of oceans. The explanation is in terms of buildup of carbon dioxide in atmosphere dissolved into oceans/seas. In $R/2$ model a sequence of glaciations would explain the findings.

4. Banded iron formations providing support for the model are actually rather rare and absent during Marinoan glaciation.

5. Wave-formed ripples, far-traveled ice-rafted debris and indicators of photosynthetic activity, can be found throughout sediments dating from the "Snowball Earth" periods. This serves a evidence open-water deposits. In snow-ball model these could be "oases" of melt-water but computer simulations suggest that large areas of oceans would have left ice-free. in $R/2$ model these would be signatures of ordinary glaciations.

6. Paleomagnetic data have led to the conclusion that Australia was at Equator. In $R/2$ model it would have been near North Pole. Namibia was also thought to be near Equator [F33]. Indirect arguments forced the conclusion that it at 75 degree Southern latitude. In $R/2$ model this corresponds to 60 degrees Southern latitude and ordinary glaciation proceeding from South Pole is a natural explanation and ordinary glaciation would be in question in both cases.

7. There is evidence for the continental ice cover does not fit with Snowball Earth predicts that there should be no continental ice-cover. The reason is that freezing of the ocean means that there is no evaporation from oceans and no water circulation so that ice-cover cannot develop on continents. There is considerable evidence that continents were covered by thick ice [F31]. This suggests ordinary glaciations possible in $R/2$ model.

10.4.5 TGD Point Of View About Pre-Cambrian Period

What is new in TGD based view about pre-Cambrian period is basically due to the $R/2$ hypothesis.

TGD view about evolution of continents

The hypothesis about the existence of the super-continent Pangea [F24] was inspired by the work of Wegener [F3]. The hypothesis about the existence of former super-continents were forced by the correlations with fossil records suggesting connected continent. This is not necessary if the gigantic ocean was absent during $R/2$ era. The continent Rodinia [F29] could look much like the Rodinia of standard geology except that they formed single connected region with radius $R/2$.

1. It is possible that there was only single super-continent with widening inland seas all the time until 250 billion Myr. The first option is R increased slowly and that inland lake formed. Rifts could have got wider gradually during this era. If there were land bridges between the continents there would be no need for postulating the cyclic re-formation of super-continent.

2. One can pose many questions about the character of the expansion.

   (a) What was the duration of the expansion? Could the expansion have occurred in the time period 750-100 Myr (100 Myr corresponds to the age of dinosaurs with large body size made possible by the reduced gravitation and oxygenation of the atmosphere)? Duration would have been about 650 Myr in this case. Or did it began already at the beginning of Neoproterozoic period [F19] when super-continent Rodinia began to break up? In this case the duration would be about 1 Myr. The estimate based on the quantum model of gravitational radiation predicts that the transition lasted for about 1.1 Gy so that the latter option would be more plausible in this framework.

   (b) Did the expansion accelerate as does also cosmic expansion in TGD based universal model for the expansion periods containing only the duration of the expansion period as a parameter [K87] and applying in alls scales? It seems that accelerated expansion is the only sensible option since around 540 Myr the size of Earth should have been rather near to $R/2$ (perhaps so even at the period of Pangea around 250 My) unless one assumes that super-continent re-formed again.

3. One can also consider the possibility that the continents indeed broke up and reformed again during Cambrian era. One should however have a good physical reason for why this happened. Something must have connected the pieces together and created correlations. Gravitational magnetic flux tubes and phase transitions increasing and reducing Planck constant? Or could it be that the bridges connecting the continents acted like strings inducing oscillation of the distance between continents so that Pangea was surrounded by a large ocean?

4. The formation of the rift [F28] feeding magma from core to the surface would be due to the expansion leading to the formation of fractures. The induced local elevations would be like mountains. As in zipper-rift model ice could have covered these plateaus because the temperature was lower. This is not however essential for TGD based model of glaciations.

5. TGD based variant of Expanding Earth allows subduction but its role could have been small before the Pangeia period if the expansion was accelerating and led only to a relatively small increase of the radius before the Mesozoic period [F17] and continued with an accelerating rate during Mesozoic from 250 Myr to 65 Myr. It is interesting that Mesozoic period begins with the most intensive known extinction of history- so called Permian-Triassic extinction event [I29] - known as Great Dying. About 95 of marine species and 70 percent of terrestrial

species became extinct. Maybe genetically determined bio-rhythms could not follow the rapidly changing circadian rhythm. Another explanation for the extinction is the warming of the climate. For this there is indeed support: there is evidence that Antarctica was climate refuge during the extinction [I130]. Perhaps both factors were involved and were not independent of each other since rapid expansion might have generated massive methane leakages from underground seas and lakes.

TGD based view about evolution of oceans

Continents would have covered most of the area during $R/2$ era and the covered fraction was slightly smaller than 1/4 of the recent area of Earth. This depends on the area taken by inland seas and polar caps. Nowadays the area covered by continents and inland seas is about 31 per cent so that continental area has increased and would be due to the expansion in vertical direction and deepening of the oceans. The area covered by oceans has increased from a small value to about 70 per cent. Only a small fraction of ocean floor would be subduced in Expanding Earth model. The Proto-Atlantic would have been only a small inland sea. Panthalassic Ocean was inland sea, which expanded to Pacific Ocean during expansion. Pacific Ocean could contain data about ancient ice ages if it was frozen. It however seems that data are consistent with the absence of global glaciation.

Model for glaciations

In TGD framework single super continent covering most of Earth becomes the counterpart of Rodinia [F29]. The hypothetical oceans are replaced with inland seas and polar caps. The supercontinent covering most of Earth absorbs less solar heat than tropical oceans so that glaciations become more probable. Snowball Earth is replaced with a series of ordinary glaciations proceeding from poles since the places at Equator were near North Pole. There is no need for the glaciations to progress to the equator. The rifting for the counterpart of Rodinia is consistent with the formation of fractures due to the expansion of Earth. The reduction of gravitational binding energy due to the increase of the radius requires feed of energy and this could be one reason for the cooling and initiation of the glaciation.

There are several questions which must be answered if one wants to gain a more detailed understanding.

1. How does $R/2$ model modify the view about glaciations? Very probably there was a frozen polar cap. Snowball Earth could be replaced with ordinary glaciations proceeding from North and South Pole.

2. How does the predicted 3+3 hour diurnal cycle modify the ordinary picture? Certainly 3-hour day reduces the amplitude of the diurnal temperature variations. Could this period have left genetic traces to the mono-cellulars, say biological clocks with this period?

3. How does the predicted four times stronger surface gravity affect the glaciation process? Could strong gravity leave detectable signatures such as anomalously strong effects on the shape of surface of Earth or deeper signatures about the motion of ice.

There are also questions related to the energetics of the expansion.

1. The expansion required energy and could have induce glaciations in this manner. Energy conservation would hold for the total mechanical and gravitational energy of Earth given by

$$E = \frac{L^2}{2I} - k\frac{GM^2}{R} < 0 \ . \tag{10.4.1}$$

Here L is the conserved angular momentum of order $L \simeq I\omega$ and ω increases from $1/4\omega_{now}$ to ω_{now} during the expansion. The moment of inertia I is of order of magnitude $I \sim MR^2$ and k is a numerical constant not too far from unity. The kinetic energy is actually negligible as

compared to the gravitational potential energy. The reduction of the gravitational binding energy requires a compensating energy, which could come both from Earth interior or from the Earth's surface. Both effects would induce a cooling possibly inducing glaciations.

2. One expects that in the initial stages of the expansion there was just an expansion. This meant stretching requiring also energy. The formation of rifts leading to the formation of oceans as magma flowed out would have started already in the beginning of Proterozoic period. Eventually fractures were formed and in TGD framework one might expect that the distribution of fractures could have been fractal. A considerable fraction of fractures was probably volcanoes so that CO_2 begun to leak to the atmosphere and local "oasis" were formed. Also hot springs liberating heat energy from Earth crust could have been formed as in Island. The pockets inside Earth increased in size and were filled with water. Life started to escaped to the walls of the fractures and to the water pockets. Also the recent oceans can be seen as widened cracks which transformed to the expanding sea floors whereas continents did not expand. As the continental crust ceased to expand no heat was needed for the expansion and this together with increased CO_2 content of atmosphere would explain why there was no further glaciations and heating of the Earth. At this period the flow of the magma from Earth core provided the energy needed to compensate the reduction of gravitational energy.

3. It must be emphasized that TGD variant of Expanding Earth theory is not in conflict with tectonic plate theory. It explains the formation of tectonic plates and the formation of magma flow from rifts giving also rise to subduction and is therefore a natural extension of the tectonic plate theory to times before the expansion ceased.

Estimate for the duration of the transition changing gravitational Planck constant

The reader without background in quantum physics and TGD can skip this section developing an estimate for the duration of the transition changing Planck constant and inducing the scaling of the radius of Earth by a factor two. The estimate is about 1.1 Gy. It must be emphasized that the estimate is not first principle calculation and relies strongly on quantum classical correspondence.

The duration of the quantum transition inducing the expansion of the gravitational space-time sheet of Earth and thus of Earth itself by a factor two can be estimated by using the same general formula as used to estimate the power of gravitational radiation emitted in a transition in which gravitational Planck constant assignable to star-planet system is reduced [K68].

1. The value of gravitational Planck constant characterizing the gravitational field body of Earth is GM^2/v_0, where the velocity parameter $v_0 < 1$ ($c = 1$) is expected to be larger than $v_0 \simeq 2^{-11}$ characterizing Sun-Earth system.

2. Assuming a constant mass density for Earth the gravitational potential energy of Earth is given by

$$V = \frac{M}{2}\omega^2 r^2 \ , \ \omega = \sqrt{\frac{6GM}{R^3}} \ . \tag{10.4.2}$$

As far as radial oscillations are considered, the system is mathematically equivalent with a harmonic oscillator with mass M. The energies for the radial oscillations are quantized as $E = (n + 1/2)\hbar_{gr}\omega$.

3. The radii of Bohr quantized orbits for the harmonic oscillator scale like $\sqrt{\hbar}$ so that $\hbar \to 4\hbar$ is needed to obtain $R \to 2R$ rather than $\hbar \to 2\hbar$ as the naïve Compton length argument would suggest. This requires the scaling $v_0 \to v_0/4$. The change of the ground state energy in this quantum transition is

$$\begin{aligned} \Delta E &= \frac{1}{2}(\hbar_{gr,f}\omega_f - \hbar_{gr,i}\omega_i) \ , \\ \hbar_{gr,f} &= 4\hbar_{gr,i} = \frac{4GMm}{v_{0,i}} \ , \\ \omega_i &= 2^{3/2}\omega_f = 2^{3/2}\sqrt{\frac{6GM}{R_f^3}} \ . \end{aligned} \tag{10.4.3}$$

$R_f = R$ denotes the recent radius of Earth.

4. From the estimate for the power of gravitational radiation in similar transition the estimate for the duration τ of the quantum transition is

$$\begin{aligned} \tau &= a(v_{0,i}v_{0f})^{-k/2} \times \frac{(\hbar_{gr,i} + \hbar_{gr,f})}{2\Delta_E} \ , \\ &= a2^{-k}v_{0f}^{-k} \times \frac{1+r}{r\omega_f - \omega_i} \ , \ r = \frac{\hbar_f}{\hbar_i} = 4 \ . \end{aligned} \tag{10.4.4}$$

The average of Planck constants associated with the initial and final states and geometric mean of the parameters v_{0i} and v_{0f} is dictated by time reversal invariance. The exponent k is chosen to be same as that obtained for from the condition that the ratio of the power to the classical radiation power emitted in the transition between planetary Bohr orbits does not depend on v_0 (quantum classical correspondence). This gives $k = 5$. The condition that the power of gravitational radiation from Hulse-Taylor binary is same as the power predicted by the classical formula (quantum classical correspondence) gives $a = .75$.

5. The explicit expression for τ reads as

$$\begin{aligned} \tau &= K \times av_{0,f}^{-5} \times (\frac{R}{2GM})^{1/2} \times \frac{R}{c} \ , \\ K &= \frac{5 \times 2^{-7} \times (2 + 2^{1/2})}{3^{1/2}} \ . \end{aligned} \tag{10.4.5}$$

6. The basic data are $M_{Sun} = 332900M$ (mass of Sun using Earth's mass as unit) and the mnemonic $r_{S,Sun} = 2GM_{Sun} = 2.95 \times 10^3$ m: together with $R = 6371 \times 10^3$ m these data allow a convenient estimation of $R/2GM$. For $k = 10$ and $a = .75$ this gives $\tau = 1.17$ Gyr. This is twice the estimate obtained by requiring that the transition begins at about 750 Myr (the beginning of Sturtian glaciation) and ends around 100 My (the age of gigantic animals whose evolution would be favored by the reduction of surface gravity). The estimate would suggest that the quantum transition began already around 1.1 Gyr, which in the accuracy used corresponds to the beginning of Neoproterozoic at 1 Gyr [F19]. The breaking of supercontinent Rodinia indeed began already at this time.

7. Note that the value of v_{0f} for the gravitational field body of Earth as it is now would be $v_{0f} = 2^{-10}$ to be compared with $v_0 \simeq 2^{-11}$ for Sun-Earth gravitational field body.

Snowball Earth from TGD point of view

In TGD framework the main justification for Snowball Earth disappears since the samples believed to be from Equator would be from North pole and glaciation could be initiated from pole caps. Consider next in more detail the evidence for Snowball Earth from TGD point of view.

1. Low latitude glacial deposits, glacial sediments at tropical latitudes, tropical tillites, etc. providing support for snowball Earth [F31] would be near North pole of at Northern latitudes. Ordinary glaciations proceeding from poles would explain the findings [F11]. If total glaciations were present, a rough scaling suggests that the evidence from them should be found from southern latitudes around 45 degrees in the standard model framework.

   The testable prediction is that the evidence for glaciations in ice-ball Earth framework should be found only below Equator and near South Pole. This finding would be of course extremely weird and would strongly favor $R/2$ option. Interestingly, in Southern Brasil all indicators for glaciations are absent (see [F56] and references therein). This region belonged to Godwana continent and there is evidence that its location was at middle latitudes at Southern Hemisphere.

2. Banded iron formations [F31] are regarded as evidence for Snowball Earth and occur at tropical levels (near North Pole in $R/2$ model). Iron dissolved in anoxic ocean would have become in a contact with photosynthetically produced oxygen and implied the formation of iron-oxide. The iron formation would have been produced at the tipping points of anoxic and oxygenated ocean. One can consider also an explanation in terms of deep inland seas, which become stagnant and anoxic near the sea floor.

   In TGD framework sea floor near North Pole could contain banded iron formations. This would explain also why the banded iron formations are rather rare. The oxygen could have come also from underground after the formation of cracks and led to the oxygenation of inland seas from bottom. The assumption that oxygenation took place already during the first glaciation, could explain why banded iron formations are absent during the second glaciation.

3. Calcium carbonate deposits [F31] have ^{13}C signature (per cent for the depletion of ^{13} isotope and large for organic material) is consistent with that for mantle meaning abiotic origin. The explanation of Calcium carbonate deposits in TGD framework could be the same as in Snowball Earth model. Atmospheric CO_2 could come from the volcanoes and react with the silicates during the ice-free periods to form calcium carbonate which then formed the deposits. CO_2 could have also biological origin and come from the underground life at the walls of the expanding fractures/volcanoes or in underground seas or lakes. In this case also methane is expected. This option would predict ^{13}C signature characteristic for organic matter. Also this kind of signatures have been observed and support ordinary glaciations. Also rapid fluctuations of the signature from positive to negative take place and might have signatures of temporary melting induced organic contribution to the calcium carbonate.

4. Iridium anomaly [F31] is located at the base of Calcium Carbonate deposits. In Snowball Earth model Iridium deposits derive from the Iridium of cosmic rays arriving at the frozen ice surface. As the ice melts, Iridium deposits are formed. In $R/2$ model the condensation of Iridium would proceed through the same mechanism. The possible problem is whether the time is long enough for the development of noticeable deposits. Near poles (Equator and South pole in standard model) this could be the case.

10.4.6 Paleo-Magnetic Data And Expanding Earth Model

Paleomagnetic data from pre-Cambrian period might allow to test $R/2$ hypothesis. This data could in principle help to trace out the time development $R(t)$ from $R/2$ to R if the non-dipole contribution to magnetic field depends on $R(t)$.

About paleo-magnetism

Paleomagnetism [F23] provides quantitative methods to determine the latitude at which the sample of sedimentary rock was originally. Magnetic longitude cannot be determined because of rotational symmetry so that other information sources must be used. There are several methods allowing to deduce the direction and also the magnitude of the local magnetic field and from this the position of the sample during the time the sample was formed.

1. Below the Curie point thermal remanent magnetization is preserved in basalts of the ocean crust and not affected by the later magnetic fields unless they are too strong. This allows to deduced detail maps from continental drifting and polar wander maps after 250 Myr (Pangea period). During pre-Cambrian period the ocean floors of hypothetical oceans would have disappeared by subduction. In $R/2$ model there are no oceans: only inland seas.

2. In the second process magnetic grains in sediments may align with the magnetic field during or soon after deposition; this is known as detrital remnant magnetization (DRM). If the magnetization is acquired as the grains are deposited, the result is a depositional detrital remnant magnetization (dDRM); if it is acquired soon after deposition, it is a post-depositional detrital remnant magnetization (pDRM).

3. In the third process magnetic grains may be deposited from a circulating solution, or be formed during chemical reactions, and may record the direction of the magnetic field at the time of mineral formation. The field is said to be recorded by chemical remnant magnetization (CRM). The mineral recording the field commonly is hematite, another iron oxide. Red-beds, clastic sedimentary rocks (such as sandstones) that are red primarily because of hematite formation during or after sedimentary diagenesis, may have useful CRM signatures, and magnetostratigraphy [F16] can be based on such signatures. Snowball model predicts that nothing came to the bottoms of big oceans! How can we know that they existed at all!

During pre-Cambrian era the application of paleomagnetic methods [F23] is much more difficult.

1. Reliable paleomagnetic data range up to 250 My, the period of Pangaea, and magnetization direction serves as a reliable information carrier allowing detailed polar wander maps. During pre-Cambrian era one cannot use polar wander maps and the polarity of the magnetic field is unknown. Therefore theoretical assumptions are needed including hypothetical super-continents, hypothetical oceans, and continental drift and plate tectonics. All this is on shaky grounds since no direct information about super-continents and ancient oceans exists. $R/2$ model suggests that continental drift and plate tectonics have not been significant factors before the expansion period when only inland seas and polar ice caps were present. Measurements have been however carried out about magnetization for pre-Cambrian sediments at continents recently and gives information about the strength of the magnetic field [F15]: the overall magnitude of the magnetic field is same as nowadays.

2. At Precambrian period the orientation of iron rich materials can serve as a record. The original records can be destroyed by various mechanisms (diagenesis). Also the orientations of the sediments can change in geological time scales.

3. Tens of thousands of reversals of the magnetic polarity [F7] have occurred during Earth's history. There have been long periods of stability and periods with a high frequency of reversals. The average duration of glaciation is around one Myr. The determination of the polarity of B possible by using samples from different points.

4. Mountain building orogeny [F22] releases hot water as a byproduct. This water can circulate in rocks thousands of kilometers and can reset the magnetic signature. The formation of fractures during the expansion of Earth could have released hot water having the same effect.

Could paleomagnetic data kill or prove $R/2$ model?

The first question is how one might kill $R/2$ model using data from pre-Cambrian era. Paleomagnetic data could do the job.

1. Remanent magnetization is proportional to the value of magnetic field causing it in weak magnetic fields. Therefore the magnetization in principle gives information about the magnetic fields that prevailed in early times.

2. Suppose that the currents generating the magnetic field can be idealized to conserved surface currents K around cylindrical surfaces of radius r and height h scaled down to to $r/2$ and $h/2$ and that the value of K is not affected in the process. With this assumptions the magnetic moment behaves $\mu \sim Ir^2h \to \mu/8$. A continuous current vortices with $j = k/\rho$, which is ir-rotational outside the symmetry axis, produce a similar result if the radius of the vortices scales as $r \to r/2$. Since dipole magnetic field scales as $1/r^3$ and is scaled up by a factor 8 in $R \to R/2$, the scalings compensate and the dipole magnetic fields at surface do not allow to distinguish between the two options. Non-dipole contributions might allow to make the distinction.

3. The group led by Lauri J. Pesonen in Helsinki University [F15] has studied paleomagnetic fields at pre-Cambrian era. The summary of results is a curve at the home page of the group and shows that the scale of the magnetic during pre-Cambrian era is same as nowadays. On the other hand, the recent thesis by Johanna Salminen- one of the group members- reports abnormally high values of magnetization in Pre-Cambrian intrusions and impact structures in both Fennoscandia and South Africa [F51]. No explanation for these values has been found but it is probably not the large value of primary magnetization.

Another manner to do test the $R/2$ model is by comparing the signs of the magnetizations at magnetic equator and poles. They should be of opposite sign for dipole field. The polarity of magnetic field varies and there are no pre-Cambrian polar wander maps. One can deduce from the condition $B_r/rB_\theta = 2cot(\theta)$ holding true for dipole field the azimutal distance $\Delta\theta$ along the direction of the measured magnetic field to the pole along geodesic circle in the direction of the tangential component of B. One cannot however tell the sign of $\Delta\theta$, in other words whether a given pre-Cambrian sample belongs to Norther or Southern magnetic hemisphere. There are however statistical methods allowing to estimate the actual pole position using samples from several positions (for an excellent summary see [F51]).

For instance, if the magnetic field is in North-South direction during Rodinian period [F29], standard model would predict that the sign at the Equator is opposite to that at South Pole. In $R/2$ model the sample would be actually near North Pole and polarizations would have same sign. The sign of magnetization at apparent southern latitude around 45 degrees would have been opposite to that at South pole which is in conflict with dipole field character. Maybe the global study of magnetization directions when magnetic field was approximately in North-South direction could allow to find which option is correct. Also the dependence of the strength of the magnetic field as function of θ could reveal whether $R/2$ model works or not. The testing requires precise dating and position determination of the samples and a detailed model for the TGD counterpart of Rodinia and its construction requires a specialist.

If the expansion continued after 250 Myr with an accelerating rate and Earth radius was still considerably below its recent value, the comparison of pole wandering charts deduced from ocean floor paleomagnetic data at faraway locations might allow to show that the hypothesis about dipole field is not globally consistent for R option. Even information about the time evolution of the radius could be deduced from the requirement of global consistency.

10.4.7 Did Life Go Underground During Pre-Cambrian Glaciations?

The basic idea of Expanding Earth model is that the life developed in underground seas and emerged to the surface of Earth in Cambrian explosion. The series of pre-Cambrian glaciations explains why the life escaped underground and how the underground seas were formed.

1. If one believes that the reduction of gravitational binding energy was responsible the cooling, then the expansion of Earth could have begun at the same time as Sturtian glaciation [F4] . On the other hand, the TGD estimate for the duration of the expansion period giving 1.1 Gyr, suggests that the breakup of the Rodinia, which began in the beginning of Proterozoic period corresponds to the beginning of the expansion. The simplest assumption is that the radius of R at the beginning of Cambrian period was not yet much larger than $R/2$ and continued to increase during Cambrian period and ended up around 100 My, when dinosaurs and other big animals had emerged (possibly as a response to the reduction of gravity). This means that there were land bridges connecting the separate continents.

2. One must explain the scarcity of fossils during pre-Cambrian era. If the more primitive life forms at the surface of Earth did not have hard cells and left no fossils one can understand the absence of highly evolved fossils before Cambrian explosion [I6]. If life-forms emerged cracks and underground seas there would be no fossils at the surface of Earth. In the case of volcanoes dead organisms would have ended to gone to the bottom of the water containing volcano and burned away.

3. The expansion had formed the underground pockets and fractures made possible for the water to flow from the surface to the pockets. Life would have evolved in fractures and pockets. The first multicellular fossils appeared during Ediacaran period (segmented worms, fronds, disks, or immobile bags) [F5] and have little resemblance to recent life forms and their relationship with Cambrian life forms is also unclear. Ediacaran life forms could have migrated from the fractures and Cambrian fossils from from the underground seas and lakes. The highly evolved life-forms in Cambrian explosion could have emerged from underground seas through fractures.

One can make also questions about the underground life.

1. The obvious question concerns the sources of metabolic energy in underground seas. In absence of solar radiation photosynthesis was not possible plants were absent. The lowest levels in the metabolic hierarchy would have received their metabolic energy from the thermal or chemical energy of Earth crust or from volcanoes. The basic distinction between plants and animals might be that the primitive forms of plants developed at the surface of Earth and those of animals in underground seas.

2. At first it seems strange that the Cambrian life-forms had eyes although there was no solar radiation in the underground seas. This is actually not a problem. These life-forms had excellent reasons for possessing eyes and in absence of sun-light the life forms had to invent lamp. Indeed, many life forms in deep sea and sea trenches produce their own light [I19]. It would be interesting to try to identify from Cambrian fossils the body parts which could have served as the light source.

10.4.8 Great Unconformity As A New Piece Of Support For Expanding Earth Model

I hope that this chapter demonstrates convincingly that single hypothesis - a sudden phase transition increasing the radius of Earth by a factor 2 natural in the many-sheeted space-time of TGD - explains Cambrian explosion in biology (a sudden emergence of huge number of life forms after very slow Precambrian evolution), and also provides a model for Precambrian evolution of continents, climate and life.

Already Darwin realized that the absence of fossils from Precambrian era (see `http://tinyurl.com/65zeh5`) is a deep problem for his theory and assumed that this is an artefact due to the incomplete fossil record. Fossils of Precambrian origin have been indeed found after Darwin's time but they are simple and very rare, and the conclusion is that Cambrian explosion (see `http://tinyurl.com/3flhcw`) [I6] meaning a huge diversification was real. Two mysteries therefore remain. Why the development of life was so slow during Precambrian era? Why the diversification was so incredibly fast during Cambrian explosion? Various explanations have been proposed. Did the oxygen content of the atmosphere reach a critical value and lead to the diversification? Or did predation pose the evolutionary pressure making the pace of evolution dramatically faster?

In New Scientist (see `http://tinyurl.com/nenk8nq`) [F49] geologists Robert Gaines and Shanan Peters describe a geological finding perhaps related to the Cambrian Explosion: the mysterious "Great Unconformity" (see `http://tinyurl.com/bqm9ndz`) [F10], which is a juxtaposition of two different types of rock of very different geological ages along a prominent surface of erosion. This surface represents a very long span of "missing" time. More than 1 billion years of geological record is missing in many places! From the figure (see `http://tinyurl.com/y8tnbneb`) of the Wikipedia article [F10] about Great Unconformity visible in Grand Canyon the thickness of the missing layer can be estimated to be about 12.6 km. Somehow before the Cambrian the uppermost rocks of the continents were stripped away exposing the underlying crystalline basement rocks. The

cause of this gap remains a complete mystery so that we have three mysteries! Plus the mysteries related to the evolution of climate (problems of Snowball Earth model).

The authors suggest that the formation of Great Unconformity relates to the Cambrian explosion. Large scale erosion and chemical weathering of the exposed crystalline rock caused mineralization of the sea water. The hypothesis is that this led to bio-mineralization: animal groups possessing mineral skeletons - such as silica shells and calcium carbonate shells - emerged. This hypothesis looks rather plausible but does not solve the three great mysteries.

The authors indeed leave open the question about the origin of Great Unconformity and of Cambrian explosion. The TGD based explanation of Cambrian explosion comes from the model realizing the old idea about Expanding Earth in terms of TGD inspired new physics. Already Wegener observed that continents can be fit together nicely and this led to the recent view about plate tectonics. Wegener's model however fits only "half" of the continent boundaries together. One could however do much better: the observation is that the continents would fit nicely to cover the entire surface of Earth if the radius of Earth were 1/2 of its recent value! Expanding Earth model postulates that the radius of Earth grows slowly. Geologists have not taken Expanding Earth model seriously: one good reason is that there is no physics allowing it.

As has been found, TGD predicts a candidate for the needed new physics.

1. At given sheet of the many-sheeted space-time cosmic expansion is predicted to take place as sudden phase transitions in which the size of some space-time sheet suddenly increases. By p-adic length scale hypothesis the preferred scaling factors are powers of 2 and the most favored scaling factor is just two. The proposal is that during the Precambrian era life resided in underground seas being thus shielded from meteor bombardment and cosmic rays. This explains the scarcity of the fossil records and the simplicity of the fossils found. The sudden phase transition was a very violent process increasing the area of the Earth's surface by a factor of 4. The area of continents is 29.1 per cent from the recent area of the Earth's surface - not too far from the naïvely predicted fraction 1/4.

2. It is easy to imagine that the uppermost rocks of the continent covering the entire Earth were stripped away and correspond nowadays to 100 km thick continental tectonic plates consisting of mainly silicon and aluminium). This expansion created split first the topmost layer as continental plates and regions between them giving rise to oceans. The magma which was uncovered by the process cooled down and solidified and the continued expansion gave rise to ocean plates with different composition (mainly silicon and magnesium).

3. The expansion phase corresponds to criticality so that fractality of the expansion is expected. At least for continental plates this process could have been fractal occurring in various length scales characterizing the thickness and the area of the sub-plates generated in the process. p-Adic length scale hypothesis suggests that the scales involved should appear as powers of $\sqrt{2}$ or 2. Generation of Great Unconformity as a process in which the underlying crystalline basement rocks were uncovered could correspond to a splitting of a layer of the continental plates to pieces. The length scale characterizing the thickness is 12.6 km from the above estimate and with 1 per cent accuracy by a factor 1/8 shorter than 100 km length scale for tectonic plates. This conforms with p-adic fractality. If the process of expansion involved a cascade of scalings by factor 2, one can wonder whether it proceeded from long to short length scales or vice versa. In other words: did continental and oceanic tectonic plates form first and after than the smaller structures such as the Great Unconformity or vice versa?

4. Note that the Compton scale $L_e(237)$ corresponding $p \simeq 2^{237}$ is 88 km - ten per cent smaller than 100 km. Maybe thermal expansion could account the discrepancy if the original thickness was $L(237)$. Second interpretation could be that besides electron Compton scale $L_e(239)$ the p-adic scale $L(239) = L_e(239)/\sqrt{5} \simeq 78.7$ km matters. The importance of $L(k)$ does not implicate that of scaled up electron, and the following argument suggests that it is p-adic length scale rather than corresponding electron Compton scale that matters now. Remarkably, also M_{241} is Gaussian Mersenne and corresponding electronic Compton scale is $L_e(241) = 154.7$ km.

   Note that 88 km is rather precisely the thickness of the atmosphere above which there is ionosphere (see `http://tinyurl.com/lqr85j`) [F12]. The thickness of Kennelly–Heaviside

layer (see http://tinyurl.com/25ur2tl) [F13] inside which radio waves used in terrestrial radio communications propagate, has thickness about 150 km which roughly corresponds to $L(239)$. Note that Continental litosphere (see http://tinyurl.com/d96kw) [F27] has typical thickness of 200 km ($L(239)$) whereas oceanic litosphere is 100 km thick ($L(237)$). This fits at least qualitatively with the proposed formation mechanism of continental tectonic plates.

There is a nice fractal analogy with cell membrane and connection with Gaussian Mersennes (see http://tinyurl.com/pptxe9c) [A1] expected to be of special importance in TGD Universe. The scales $L(239)$ and $L(241)$ would be in the same relation as the thickness $L_e(149)$ of the lipid layer of cell membrane to the cell membrane thickness $L_e(151)$ characterized by Gaussian Mersenne $M_{151,G}$. The two kinds of tectonic plates (continental and oceanic) would be analogous to the lipid layers of cell membrane.

5. The rapid expansion process could have also brought in daylight the underground seas and the highly developed life in them so that Cambrian diversification would have been only apparent. Skeptic can of course ask whether it is necessary to assume that life resided in underground seas during Precambrian era. Could just the violent geological process be enough to induce extremely fast diversification? This might of course be true.

6. There is one further argument in favor of the Expanding Earth model. The fact that the solar constant was during proto Earth period (see http://tinyurl.com/pc83uvt) [F35] only 73 per cent from its recent value, is a problem for the models of the very early evolution of life. If the radius of Earth was 1/2 of its recent value the duration of day and night was from conservation of angular momentum only 1/4: th of the recent value and thus 3 hours. This could have made the environment much more favorable for the evolution of life even at the surface of the Earth since the range for the temperature variation would have been much narrower.

10.4.9 Where Did The Oceans Come From?

TGD based vision about life has been developing rapidly thanks to the realization that hierarchy of Planck constants and dark matter could relate directly to criticality: consider only long range correlations, phase separation, and classical non-determinism near critical point as common aspects [K29, K30, K31, K32]. The article "Half of the Earth's water formed before the sun was born" (http://news.sciencemag.org/earth/2014/09/half-earths-water-formed-sun-was-born) describes research results proving additional support for the TGD inspired idea about the occurrence of prebiotic evolution in underground water reservoirs shielded from meteorites and cosmic rays. The idea relies on TGD inspired variant of Expanding Earth hypothesis [K68, L46].

1. Article represents first a standard argument in favor of late formation of oceans. The collisions by astreroids and meteorites could have evaporated the water or blown off it in to space. Hence surface water at Earth should have emerged much later. Note that one can replace "water" with "life" in the argument.

2. The researchers end up to propose that the water emerged already before Sun, and also oceans did so rather early. Carbonaceous chondrites (http://tinyurl.com/75fh74p), which formed at the same time as Sun and well before the planets, could have served as a source of water. These meteorites were formed very early, already earlier than Sun. Their composition resembles that of bulk solar system composition. By studying basaltic meteorites from asteroid Vesta, which is known to be formed in the same region as Earth, the reaserachers found that they contain same hydrogen isotopic composition as carbonaeous chondrites.

   This motivates the proposal that chondrites contained the water. A further proposal is that the water reservoirs formed at the surface of Earth as it formed. Here I beg to disagree: the objection represented in the beginning is difficult to circumvent!

The article stimulates several interestig questions in TGD based conceptual framework.

1. Why not to assume formation of underground water reservoir? Here meteorites and UV radiation did not form a problem. And there is indeed recent evidence for the previous

existence of large underground reservoirs (http://tinyurl.com/k2d2ttj). The formation process for Earth could have naturally led to the evaporation of of chondrite water from the interior of Earth and its transfer nearer to surface and getting caught inside reservoirs.

Also prebiotic life could have evolved in the underground water reservoirs and already in chondrites (DNA, RNA, aminoacids, tRNA represented as dark proton sequences at flux tubes) and transformed to the life as we know. Mother Gaia's womb was nice place: no meteorite bombardment, no cosmic rays, and metabolic energy provided by Mother Gaia as dark photons. Cambrian explosion as Earth's radius increased by a factor of two was the birthday of the life as we identify it, the (child) water burst to the surface and seas were formed and life began to evolve at the surface of Earth.

Recall that in TGD continous cosmological expansion at level of space-time sheets is at quantum level replaced with a sequence of phase transitions increasing $h_{eff} = n \times h$ and/or p-adic length scale of the space-time sheet - by p-adic length scale hypothesis most naturally by a factor of two. This kind of transition explains why the continents of Earth fit nicely together to cover entire Earth if the radius is half of its recent value, the emergence of gigantic life forms, etc... [L46].

2. The basic objection relates to the basic mechanisms of metabolism. What replaced plants receiving metabolic energy from solar light as source of metabolic energy? What replaced Sun? Did the dark photon radiation generated by Earth - or maybe also Sun - and penetrating ordinary matter as dark radiation, replace sun light? Any critical system could generate this radiation and it should not be difficult to identify this kind of system: the boundary between core and mantle is the most obvious candidate for a critical system as also for a rapid self-organization process). I proposed for more than decade ago this option half-jokingly as metabolic sources of IT (intraterrestrial) life as I called it.

3. Dark photon radiation would have had a universal energy spectrum - the spectrum of biophotons in visible and UV range. Part of it would have transformed to biophotons (http://tinyurl.com/yb9hnmu7) taking the role of solar radiation as a metabolic energy source. An interesting question is whether the life at the bottom of oceans could give some hints about the counterpart of photosynthesis based on bio-photons? The discovery that the metabolic reactions thought to require complex catalytic maschinery can take place in the environment simulating ocean bottom (http://tinyurl.com/ydc8g7r4) supports the idea about the evolution of life from prebiotic life forms in the womb of Mother Gaia. In TGD framework these prebiotic life forms could correspond to dark proton sequences (dark nuclei) at magnetic flux tubes associated with the negatively charged exclusion zones discovered by Pollack [L13] (http://tinyurl.com/oyhstc2).

10.5 What about other planets?

10.5.1 How Was Ancient Mars Warm Enough for Liquid Water?

The popular article "Mars Mystery: How Was Ancient Red Planet Warm Enough for Liquid Water?" (see http://tinyurl.com/gsbwyhe) tells about a mystery related to the ancient presence of water at the surface of Mars. It is now known that the surface of Mars was once covered with rivers, streams, ponds, lakes and perhaps even seas and oceans. This forces to consider the possibility there was once also life in Mars and might be still. There is however a problem. The atmosphere probably contained hundreds of times less carbon dioxide than needed to keep it warm enought for liquid water to last. There are how these signature of flowing water there. Here is one more mystery to resolve.

The TGD version of Expanding Earth Hypothesis states that Earth has experienced a geologically fast expansion period in its past. The radius of the Earth's space-time sheet would have increased by a factor of two from its earlier value. Either the p-adic length scale or effective value of Planck constant $h_{eff}/h = n$ for the space-time sheet of Earth or both would have increased by factor 2.

This violent event led to the burst of underground seas of Earth to the surface with the consequence that the rather highly developed lifeforms evolved in these reservoirs shielded from

cosmic rays and UV radiation burst to the surface: the outcome was what is known as Cambrian explosion. This apparent popping of advanced lifeforms out of nowhere explains why the earlier less developed forms of these complex organisms have not been found as fossile. I have discussed the model for how life could have evolved in underground water reservoirs [L18].

The geologically fast weakening of the gravitational force by factor 1/4 at surface explains the emergence of gigantic life forms like sauri and even ciant crabs. Continents were formed: before this the crust was like the surface of Mars now. The original motivation of EEH indeed was that the observation that the continents of recent Earth seem to fit nicely together if the radius were smaller by factor 1/2. This is just a step further than Wegener went at his time. The model explains many other difficult to understand facts and forces to give up the Snowball Earth model. The recent view about Earth before Cambrian Explosion is very different from that provided by EEH. The period of rotation of Earth was 4 times shorter than now - 6 hours - and this would be visible of physiology of organisms of that time. Whether it could have left remnants to the physiology and behavior of recently living organisms is an interesting question.

What about Mars? Mars now is very similar to Earth before expansion. The radius is one half of Earth now and therefore same as the radius of Earth before the Cambrian Explosion! Mars is near Earth so that its distance from Sun is not very different. Could also recent Mars contain complex life forms in water reservoirs in its interior. Could Mother Mars (or perhaps Martina, if the red planet is not the masculine warrior but pregnant mother) give rise to their birth? The water that has appeared at the surface of Mars could have been a temporarily leakage. An interesting question is whether the appearance of water might correspond to the same event that increased the radius of Earth by factor two.

Magnetism is important for life in TGD based quantum biology. A possible problem is posed by the very weak recent value of the magnetic field of Mars. The value of the dark magnetic field $B_{end} = .2$ Gauss of Earth deduced from the findings of Blackman about effects of ELF em fields on vertebrate brain has strength, which is 2/5 of the nominal value of B_E. Hence the dark MBs of living organisms perhaps integrating to dark MB of Earth seem to be entities distinct from MB of Earth. Could also Mars have dark magnetic fields?

Schumann resonances might be important for collective aspects of consciousness. In the simplest model for Schumann resonances the frequencies are determined solely by the radius of Mars and would be 2 times those in Earth now. The frequency of the lowest Schumann resonance would be 15.6 Hz.

10.5.2 New Horizons About Pluto

ew Horizons (see `http://tinyurl.com/cjdzsk9`) is a space probe that has just been passing by Pluto and has taken pictures about the surface of Pluto and its Moon Kharon. The accuracy of the pictures is at best measured in tens of meters. Pluto has lost its status as a genuine planet and is now regarded as dwarf planet in the Kuiper belt - a ring of bodies beyond Neptune. Using Earthly unis its radius, mass (from New Horizons data), and distance from Sun are $R = .18R_E$, $M = .0022 \times M_E$ and $d = 40d_E$.

Pictures have yielded a lot of surprises. Pluto is not the geologically dead planet it was though to be. The following summarizes what I learned by reading a nice popular article by Markku Hotakainen in finnish weekly journal ("Suomen Kuvalehti") and also represents a TGD based interpretation of the findings.

1. Surprisingly, the surface of the Pluto is geologically young: the youngest surface shapes have age about 10^8 that is .1 billion years. This is strange since the temperature is about -240 °C at the cold side and it receives from Sun only 1/1000 of the energy received by Earth. Textbook wisdom tells that everything should have been geologically totally frozen for billions of years.

2. There is a large champaign - one guess is that it has born as an asteroid or comet has collided with the surface of Pluto. The region is now officially called Tombaugh Regio. The reader can Google the reason for this. The flat region does not seem to have any craters so that it should be rather young. The boundary of this lowland area is surrounded by high (up to 3.5 km) mountains. Also these formations seem to be young. Nitrogen, methane and CO-ice cannot form so high formations.

Several explanations have been imagined for the absence of craters: maybe there are active processes destroying the craters very effectively. Maybe there is tectonic activity. This however requires energy source. Radioactivity inside Pluto? Underground seas liberating heat? Or maybe tidal forces: the motions of Pluto and its moon Kharon are locked and they turn always the same side towards each other. There is a small variation in the distance of Kharon causing tidal forces. Could this libration deform Pluto and force the liberation of heat produced by frictional forces?

3. The flat region decomposes to large polygons with diameter of 20-30 km. The mechanism producing the polygons is a mystery. Also their presence tells that the surface is geologically young: at some places only .1 billion years old.

4. The atmosphere of Pluto has also yielded a surprise. About 90 per cent of atmosphere (78 per cent at Earth) is nitrogen but it is estimated to leak with a rate of 500 tons per hour since the small gravitational acceleration (6 per cent of that on Earth) cannot prevent the gas molecules from leaking out. How Pluto manages to keep so much nitrogen in its atmosphere?

5. Kharon - the largest moon of Pluto - has radius which is half of that for Pluto. Also the surface texture of Kharon exhibits signs about upheavals and has similarities to that in Pluto. Craters seem to be lacking. North Pole has great dark region - maybe crater. Equator is surrounded by precipices with depths of hundreds of meters, maybe up to kilometers. If they are torn away so should have been also the precipices.

Can one understand the surface texture of Pluto and Kharon? For years I proposed a model for the finding that the continents of Earth seem to fit nicely to form a single supercontinent if the radius of Earth is taken to be one half of its recent radius. This led to a TGD variant of Expanding Earth theory [L46].

1. It is known that cosmic expansion does not occur locally. In many-sheeted space-time of TGD this could mean that the space-time sheets of astrophysical objects comove at the the large space-time sheet representing expanding background but do not themselves expand. Another possibility is that they expand in rapid jerks by phase transitions increasing the radius. p-Adic length scale hypothesis suggests that scaling of the radius by two is the simplest possibility.

2. If this kind of quantum phase transition occurred for the space-time sheet of Earth about .54 billion years ago it can explain the weird things associated with Cambrian explosion (see `http://tinyurl.com/ntvx38e`). Suddenly totally new life forms appeared as from nowhere to only disappear soon in fight for survival. Could highly evolved life in underground seas shielded from UV radiation and meteoric bombardment have burst to the surface. The process would have also reduced the value of the gravitational acceleration by factor 1/4 and increased the length of the day by factor 4. The reduction of the surface gravity might have led to emergence of various gigantic lifeforms such as dinosauri, which later lost the evolutionary battle because of their small brains. Climate would have changed dramatically also and the Snowball Earth model is replaced by a new view.

If these sudden quantum phase transitions at the level of dark matter ($h_{eff} = n \times h$ phases of ordinary matter) is the manner how cosmic expansion universally happens then also Pluto might so the signs of this mechanism.

1. The surface of Pluto is indeed geologically young: the age is measured in hundreds of millions of years. Could the sudden jerkwise expansion have occurred - not only for Earth but - for objects in some region surrounding Earth and containing also Pluto?

2. The polygonal structure could be understood as a ripping of the surface of Pluto in the sudden expansion involving also cooling of magma and its compression (the analogy is what happens to the wet clay as it dries and becomes solid). The lowland region could correspond to the magma burst out from the interior of Pluto being analogous to the magma at the bottom of oceans at Earth. The young geological age of this region would explain the absence of craters. Also the surface texture of Kharon could be understood in the similar manner.

Could one understand the presence of nitrogen?

1. If the gravitational acceleration was 4 times larger (24 percent of that in Earth) before the explosion, the leakage would have been slower before it. Could this make it easier to understand why Pluto has so much nitrogen? Could the burst of material from the interior have increased the amount of nitrogen in the atmosphere? Geochemist could probably answer these questions.

2. A more radical explanation is that primitive life forms have prevented the leakage by binding the nitrogen to organic compounds like methane. If underground oceans indeed existed (and maybe still exist) in Pluto as they seem to exist in Mars, one can wonder whether life has been evolving as an underground phenomenon also in Pluto - as so many nice things in this Universe must do;-). Could these lifeforms have erupted to the surface of Pluto in the sudden expansion from underground seas and could some of them - maybe primitive bacteria - have survived. Nitrogen (see `http://tinyurl.com/yb3yexsu`) is essential for life and binds the nitrogen to heavier chemical compounds so that its leakage slows down. Could there exist an analog of nitrogen cycle (see `http://tinyurl.com/yc4r39o8`) meaning that underground life bind the nitrogen from the atmosphere of Pluto and slow down its leakage?

10.6 Expanding Earth hypothesis, Platonic solids, and plate tectonics as symplectic flow

A FB discussion inspired by the evidence reported by Nasa for the existence of life in Mars coming from a generation of methane (see `http://tinyurl.com/y735g9kn`) (thanks to Nikolina Bedenikovic for the link). It seems that it must originate below the surface of Mars - possibly from underground oceans. The emission of methane is periodic having the year of Mars as a period and has maximum during summer time. This suggests that solar radiation somehow serves as a source of metabolic energy. The TGD based explanation might be in terms of dark photons able to propagate through the crust to the underground oceans.

The finding provides support for TGD based Expanding Earth model [L46] explaining Cambrian explosion, which is one of the mysteries of recent day biology. According to this model life would have evolved in underground oceans where it was shielded from UV light, cosmic rays, and meteor bombardment, and burst to the surface of Earth during the period when Earth expanded and the crust developed cracks.

One can wonder whether Expanding Earth model is consistent with plate tectonics and with the motivating claim of Adams that the continents fit together nicely to cover the entire surface of Earth if its radius were one half of the recent radius. The outcome was what one might call Platonic plate tectonics.

1. The expansion would have started from or generated decomposition of the Earth's crust to an icosahedral lattice with 20 faces, which contain analogs of what is known as cratons and having a total area equal to that of Earth before expansion. The prediction for the recent land area fraction is 25 per cent is 4.1 per cent too low. The cause could be sedimentation or expansion continuing still very slowly.

2. Craton like objects (in the sequence briefly cratons) would move like 2-D rigid bodies and would fuse to form continents.

3. The memory about the initial state should be preserved: otherwise there would exist no simple manner to reproduce the observation of Adams by simple motions of continents combined with downwards scaling. This might be achieved if cratons are connected by flux tubes to form a network. For maximal connectivity given triangular face is connected by flux tube to to all 3 nearest neighbour faces. Minimal connectivity corresponds to an essentially unique dodecahedral Hamiltonian cycle connecting cratons to single closed string. At least for maximal connectivity this memory would allow to understand the claim of Adams stating that the reduction of radius by factor 1/2 plus simple motions for the continents allow to transform the continents to single continent covering the entire surface of the scaled down Earth.

4. The dynamics in scales longer than that of craton would be naturally a generalization of an incompressible liquid flow to area preserving dynamics defined by symplectic flow. The assumption that Hamilton satisfies Laplace equation and is thus a real or imaginary part of analytic function implies additional symmetry: the area preserving flow has dual. The flow has vanishing divergence and curl. Sources and sinks and rotation are however possible in topological sense if the tectonic plate has holes.

10.6.1 Summary of the model

Expanding Earth hypothesis in TGD framework

The TGD variant of Expanding Earth hypothesis [L46] (see `http://tinyurl.com/y75hku4x`) can be motivated by both cosmological and biological considerations.

1. The basic observation is that astrophysical objects seem to not take part of cosmic expansion but only to co-move. This leads to the idea that the corresponding space-time sheets experience cosmic expansion as relatively rapid jerks and have constant size between these jerks. Second motivation comes from the claim of Adams [F1] (see `http://tinyurl.com/fxsve`) that the continents would fit nicely together to form a single continent covering the entire surface of Earth if the radius of Earth were 1/2 its recent radius.

2. There is also a connection with biology. Cambrian explosion (see `http://tinyurl.com/ntvx38e`) is a poorly understood period in the history of life at Earth. Suddenly a burst of highly developed life forms emerged from some unknown source. TGD explanation would be in terms of rather rapid increase of the radius of Earth by factor of two from the recent size $R_{Mars} \simeq R_E/2$ of Mars to the recent size R_E of Earth with the consequences that the stretching developed cracks. Since the radial scaling caused similar stretching everywhere, the decomposition to a lattice at some critical value of the scale parameter λ would have generated the cracks. The generation of a lattice in drying clay serves as an analogy.

   The relatively highly developed underground life would had evolved below the surface of Earth, where it was shielded from the bombardment by meteors, cosmic rays, and UV radiation and was burst to the surface as the oceans were formed on the cracks.

   The increase of the radius of Earth by factor 2 increased the duration of day by factor 4 and reduced the surface gravity by a factor 1/4. The genetically conserved features preceding the expansion would be still seen in biology. For instance, there might exist a 3 hour bio-rhythm if the underground life received solar radiation somehow. The reduction of gravity could explain the emergence of giant sized organisms such as dinosaurs.

   Underground life must have some source of metabolic energy and photosynthesis should have developed already before the Cambrian expansion. This suggests that visible light from some source must have been present. I have considered possible sources in [L18]. The most science fictive proposal is that part of the photons of solar radiation transform to dark photons identified as a phase of ordinary photons residing at magnetic flux tubes. They would have had a non-standard value of Planck constant $h_{eff} = n \times h_0$ and in absence of direct interactions with the ordinary manner would have managed to penetrate through the crust to the underground oceans.

   In the recent biology bio-photons with energies in visible and UV range would emerge as energy conserving transformations of large h_{eff} photons to ordinary photons. The value of h_{eff} for charged particle of mass m would be by a generalization of Nottale's proposal equal to $\hbar_{eff} = n \times \hbar_0 = h_{gr}GMm/v_0$, where M could correspond to a dark mass assignable to Earth and v_0 is a parameter having dimensions of velocity. This hypothesis implies that cyclotron energies of charged particles do not depend at all on the mass of the charged particle so that cyclotron photons can induce transitions of bio-molecules [K29, K30, K31, K32, K70].

   Remark: h_0 is the minimal value of h_{eff}: the best guess for the ordinary Planck constant corresponds to $n = 6$ [L24, L43].

   This mechanism for the transfer of solar energy under the surface of Mars could explain the annual periodicity of the methane production in Mars. Magnetic fields serve as a shield

against UV radiation and cosmic rays in the case of Earth. Mars has only weak and local magnetic fields above its surface. This gives a good reason why for the Martian life to stay below the surface. The strengthening of the Earth's magnetic field might have preceded or accompanied the proposed expansion of Earth.

3. This vision profoundly modifies the ideas about what happened before Cambrian explosion. In particular, Snowball Earth hypothesis (see `http://tinyurl.com/prem7nj`) about the climate evolution must be given up. The magnetic history of Earth allows to test the model.

Basic ideas of Platonic plate tectonics

The FB discussion raised the question whether the TGD based Expanding Earth model [L46] is consistent with plate tectonics and with the motivating claim of Adams that the continents fit nicely to cover the entire surface of Earth if its radius were one half of the recent radius. The outcome was what one might call Platonic plate tectonics.

1. The expansion would have started from or generated decomposition of the Earth's crust to an icosahedral lattice with 20 faces, which contain what could be identified as cratons (see `http://tinyurl.com/y8juty2q`) having a total area equal to that of Earth before expansion. Cratons represent the stable part of the continental litosphere and are found in the interiors of the tectonic plates. They consist of ancient crystalline basement rock and maybe be covered by younger sedimentary rock. They have a thick crust and deep litospheric roots. The prediction 25 per cent for the recent land area is 4.1 per cent too low. The simplest explanation is that expansion still continues but very slowly. Also the formation of sedimentary rocks could have increased the area.

2. The cratons would move like 2-D rigid bodies and would fuse to form continents.

3. The memory about the initial state should be preserved: otherwise there would exist no simple manner to reproduce the observation of Adams by simple motions of continents combined with downwards scaling. This could be achieved if cratons are connected by flux tubes to form a network (for tensor networks in TGD Universe see [L23]). For maximal connectivity given triangular face is connected by flux tube to to all 3 nearest neighbour faces. Minimal connectivity corresponds to an essentially unique dodecahedral Hamilton's cycle [A7] (see `http://tinyurl.com/pf33vkt`) connecting cratons to single closed string. At least for maximal connectivity this memory would allow to understand the claim of Adams stating that the reduction of radius by factor 1/2 plus simple motions for the continents allow to transform the continents to single continent covering the entire surface of the scaled down Earth.

4. The dynamics in scales longer than that of craton would be naturally a generalization of an incompressible liquid flow to area preserving dynamics defined by symplectic flow. The assumption that Hamilton satisfies Laplace equation and is thus a real or imaginary part of analytic function implies additional symmetry: the area preserving flow has dual. The flow has vanishing divergence and curl. Sources and sinks and rotation are however possible in topological sense if the tectonic plate has holes. This would suggest conformal invariance.

The proposal is that the expansion of Earth taking place as discrete jerkes is basically a quantum phenomenon in astrophysical scales.

1. In TGD framework magnetic flux tubes are carriers of dark matter identified as phases of ordinary matter with non-standard value of Planck constant. As explained, the value of gravitational Planck constant h_{gr} would be enormous and imply quantum coherence in the size scale of Earth at the magnetic body forcing coherence at the level of ordinary matter [K70]. The transitions changing the value of h_{eff} would change the length of flux tubes and these transitions would be crucial for the dynamics of water [L51] (see `http://tinyurl.com/ydhknc2c`).

2. Also the ability of biomolecules to find each other in molecular soup would rely on the same mechanism. In biology also the formation of organs and organelles from cells would involve the shortening of flux tubes [L49] (see `http://tinyurl.com/y9pxr9dx`). In brain synchronously firing neuron groups would form dynamical networks. An interesting question inspired by the huge value of h_{gr} is whether cratons could be seen as analogs of cells and continents as analogs of organs of Mother Gaia. Note that the magnetic bodies of living systems with EEG would have layers with size scale of Earth [K36].

What happened in the expansion of Earth and after that?

One can try to imagine what happened during and after the expansion of Earth.

1. The spherical crust developed at least one hole as the radius increased by factor 2: $R_f = 2R_i$. The crust free regions became frozen magma covered by ocean. The total area of crust was preserved. A stronger condition is that only some minimal stretching required by the increase of the radius occurred. Too large a stretching would have generated the cracks.

   The experimentation with toy models leads to the conclusion that minimal stretching is achieved if the crust decomposes into a spherical lattice - regular tessellation- having maximal number of cells. Platonic solids are the only regular tessellations of sphere. The dual P_D of platonic solid P has as its vertices the faces of P and vice versa. The list of Platonic solids (see `http://tinyurl.com/p4rwc76`) is short.

   - Self-dual tetrahedron (4 faces and 4 vertices).
   - Cube with 6 faces and 8 vertices faces and its dual octahedron.
   - Icosahedron and its dual dodecahedron with 20 and 12 faces respectively. For icosahedron the number of faces is maximal and the size of the face minimal and the local stretching is therefore minimal. The faces of icosahedron correspond to the vertices of the dual dodecahedron and icosahedral tessellation is the best candidate to begin with. Note however that the 6 faces of cube could correspond to the 6 continents. One can of course image that the moving cratons later evolved to form an approximate cubical tessselation.

   Remark: Surfaces with flat metric (plane and cylinder) allow warpings (see `http://tinyurl.com/ycyregve`) for which the induced metric remains flat so that the deformation can be regarded as an isometry with no stretching but non-trivial bending. For instance, for the surface $z(x, y) = z_0$ one can have warping $z = z_0 + f(x)$. The dynamics for the page of book provides a good example of this kind of warping. Could this kind of warpings leading to one-dimensional deformations of the surface of Earth happen for continents in sufficiently short scales?

2. During subsequent evolution radius R_f remains (approxmately) constant and the pieces of crust move along the surface of Earth. No stretching condition prevents the change of shape. If changes of shape are allowed, the first guess is that this evolution was area preserving and thus generated as by a Hamiltonian flow. This would be just classical Hamiltonian mechanics in 2-D phase phase associated with the piece of crust.

   If distances inside cratons were preserved (no stretching and change of shapce), the dynamics for small enough plates would reduce in a reasonable approximation to a rigid body rotation in the tangent plane at the center of mass of the plate and movement along a geodesic line along the Earth's surface plus collisions. If one accepts that the initial state was a tessellation defined by a Platonic solid, in particular icosahedron, the symplectic evolution trivializes in this manner. The faces contain cratons with area scaled down by factor 1/4. If craton like object is a disk with radius d one would have $d = (1/2\sqrt{20})R_E \simeq .11R_E$. Using $R_E = 6371$ km this gives $d = 1425$ km.

3. The first guess is that the expansion period is over now and one has $R_f = 2 \times R_i$ exactly. As found, the predicted fraction of land area for $R_f = 2 \times R_i$ is 4.1 per cent smaller than the

actual value about 29.1 per cent. A possible explanation for 4.1 per cent is the generation of sedimentary rocks. This would give a probably testable prediction for the fractional area due to sedimentation. Subduction would increase this estimate.

One can also ask whether the expansion still continues slowly so that the radius is not yet quite equal to $R_f = 2 \times R_i$ so that the fraction of land area is larger than 25 per cent. One would have $R_f = 2xR_i$, $x = .93$. Subduction tends to increase and sedimentation to reduce the value of x. The separation of expansion period from the period during, which R_f stays constant would be a good approximation if the time scales for tectonics are considerably shorter than for the expansion.

Could flux tube network reproduce the claims of Adams?

The triangular faces can move around and can scale down their size scale by factor 1/2 to the size of craton so that a fusion of cratons to larger units forming continents becomes possible. If one takes the claim of Adams [F1] (see `http://tinyurl.com/fxsve`) seriously, the subsequent dynamics for the faces containing the cratons must be such that it is easy to see how to move continents in the scaling down of the radius of Earth to achieve the gluing together without overlaps and holes (the mere scaling down does not allow to achieve this since the distances between scaled down continents would be 1/2 of the recent distances).

The dynamics must remember the initial regular icosahedral tessellation at S_i^2. In the ideal situation every face must "remember" its former nearest neighbours at S_i^2 even when some of them can be faraway at S_f^2. This requires a network connecting the faces. If the faces are connected by a large enough number of flux tubes able to change their lengths this can be realized and as the radius is imagined to decrease by a factor 1/2, all faces combine to form a spherical crust without overlaps. One can consider two extreme situations.

1. Maximal connectedness requires that every face of icosahedron is connected to each of its 3 nearest neighbours. In this case the dynamics can only involve condensation of the cratons/faces of the network to form continents and for this option the claim of Adams seems trivial.

2. The minimally connected network would correspond to a string connecting the 20 faces to single non-self-intersecting closed string identifiable as a Hamiltonian cycle at dodecahedron. One identifies cycles differing only by an isometry of dodecahedron and already Hamilton discovered that dodecahedron allows only single cycle if one identifies cycles differing only by an isometry of dodecahedron. Given triangle would be connected by flux tube to 2 (rather than 3) nearest neighbors.

   Remark: Hamilton's cycles at icosahedron [A7, A3, A5, A2, A4] with 12 vertices play fundamental role in TGD inspired model for music harmony lead to a model of genetic code and of bio-harmony. In this case there is large number of harmonies [L11] [L52].

   Whether this option is consistent with the claim of Adams is not clear. One can argue that without additional assumptions the dynamics of the Hamiltonian cycle can destroy the information about the initial icosahedral tessellation by permuting the faces. Could the condition that no self intersections of the flux tubes (strings) of the cycle take place, be enough to preserve the information about initial configuration? The (unique apart from isometries) Hamiltonian cycle can have a fold so that it turns back. The cratons of the antiparallel nearby portions of string can fuse together. The pairing induced by the folding can take place in several ways: say ...(1,6)-(2,5)-(3,4) or ...(-1,6)-(0,5)-(1,4)-(2,3). Here (a,b) corresponding fusion of cratons and - for the Hamiltonian link between neighbouring faces. The increase of the land area by 4.1 percent forces some overlap in the final state if the expansion period has ceased.

10.6.2 Plate tectonics as a symplectic flow in scales longer than the size of craton?

For the icosahedral model the short scale dynamics reduces to much simpler dynamics of 2-D rigid bodies at S^2 having collisions leading to subductions. Cratons however fuse together to form

continents having plate tectonics as their dynamics. Tectonic dynamics applies in length scales longer than craton size and cratons could be idealized as point like objects analogous to lipids in cell membrane.

The first guess for the dynamics after the expansion period is symplectic flow preserving the signed area of the continent defining an area preserving map for each value of the time parameter. The area preserving flow is analogous to an incompressible liquid flow in 3 dimensions and serves as a natural model for liquid crystals. For instance, cell membrane is liquid crystal. In this case lipids are idealized as point like objects with symplectic dynamics making sense in length scales longer than the thickness of lipid.

Symplectic flow would be therefore a natural model for plate tectonics (see `http://tinyurl.com/hmby9d4`), and the idealization of cratons as pointlike entities would allow to overcome the objection due to stretching. Symplectic flows could be also used to model the emergence of cracks using Hamiltonians discontinuous along cuts and to model "self-subductions" as flows, which become non-injective and generate mountains.

Remark: Symplectic flows could also be used to model the liquid magma in the outer core idealized as 2-D layer analogous to liquid crystal.

What conditions could one pose on the Hamiltonian defining the symplectic flow? The observation that Hamiltonians identified as real or imaginary parts of analytic functions have additional symmetry implying the existence of a dual flow for which flow lines are orthogonal to those for the flow. A good guess therefore that the local tectonics for a continent is defined by a Hamiltonian satisfying Laplace equation. There would be a nice connection between analytic functions and symplectic flows.

A model for the continuous time evolution of tectonic plate

The simplest model for a continuous local evolution of given tectonic plate in length scales longer than the size of craton after the expansion period and formation of continents assumes the conservation of signed area meaning that the evolution is symplectic flow generated by some Hamiltonian defined in the region defined by the continent. The symplectic flow would be a 2-D variant of incompressible hydrodynamics.

1. The dynamics would be dictated by the conservation of signed area element $dS = R^2 sin(\theta) d\theta \wedge d\phi$ defined by the symplectic form of $J = J_{kl} ds^k \wedge ds^l$ of S^2. Symplectic transformations preserve the local area form and are generated by the exponentiation of Hamiltonian function H giving models for time evolutions as exponentiation of H defining a flow along the continent.

2. A model for the generation of cracks could be based on Hamiltonian function, which has line discontinuities completely analogous to discontinuities of imaginary or real part of an analytic function. The Hamiltonian flow would take the two sides of the cut to opposite directions in the Hamiltonian flow and crack would develop. The cracks would be filled with water and become oceans.

3. Hamiltonian time evolution defines symplectic map for each value of the time parameter t, which can cease to be injection at some moment of time at some point and give rise to growing regions into which two different regions of the continent are mapped. Cusp catastrophe with 3 sheets gives a standard topological description for what would have happened. The folding would have 3 plates above each other in the fold region. This "self-subduction" would produce regions analogous to those formed in subduction in which two continents drifting at the surface of magma collide and subduce. Also this process can generate mountains.

   The signed area of the middle sheet of the cusp is negative if the area of the other sheets is positive. The formation of the cusp seems therefore to reduce the land area since the middle sheet and lowest sheet of the cusp are invisible. When plate subduces another plate visible land area is also lost. One can imagine two explanations for the missing 4.1 per cent: sedimentation has generated new land area or the expansion period has not yet ended.

   One can formulate this picture in more detail as follows.

1. The area preserving symplectic time evolution obeys in general coordinates s^k for S^2 the formula

$$\frac{ds^k}{dt} = j^k = J^{kl}\partial_l H \quad , \quad J_k{}^r J^r{}_l = -s_{kl} \quad . \tag{10.6.1}$$

where J_{kl} and s_{kl} are the symplectic form and standard metric of S^2. In spherical coordinates (θ, ϕ) one has $J_{\theta\phi} = -J_{\phi\theta} = sin(\theta)$. $H = H(\theta, \phi)$ is the function defining the Hamiltonian and subject to physical constraints. j^k has vanishing divergence:

$$D_k j^k = 0 \quad . \tag{10.6.2}$$

This equation codes for the local conservation of area.

2. The real or imaginary part of an analytic function having cut along curve can serve as a Hamiltonian in this case. Analyticity would give strong additional constraints on the discontinuity since Laplace equation would be satisfied meaning that not only the current j^k but also the dual current $j_D = g^{kl}H_l$ is conserved:

$$D_k j_D^k = 0 \quad . \tag{10.6.3}$$

j_D^k and j^k are orthogonal and correspond to real and imaginary parts of an analytic function. Also j_D^k defines an area preserving flow. This connection between conformal symmetries and symplectic symmetries for Hamiltonians satisfying Laplace equation does not seem to be very familiar to physicists. As a consequence the flow has vanishing divergence and curl. Sources and sinks and global rotation are possible in topological sense if the tectonic plate has holes. This would suggest conformal invariance in some sense.

The absence of sinks implies that one can express j_D^k as a curl of vector field orthogonal to S^2. A possible interpretation is as induced Kähler magnetic field or Z^0 magnetic field. One of the first ideas related to the applications of TGD to condensed matter was that hydrodynamic flow could give rise to Z^0 magnetic fields just like em currents give rise to magnetic fields and that vortices of the flow correspond to magnetic flux tubes. This picture makes sense for Kähler magnetic field as well - an option that seems more natural now. The different directions of rotational axis and magnetic dipole axis of Earth would correspond to different directions of the ordinary magnetic field and Z^0 or Kähler magnetic field. These magnetic fields would be effective magnetic fields identified as sums of magnetic fields considered at different space-time sheets at quantum field theory limit of TGD. The flow dynamics could be essentially that of induced Kähler magnetic field orthogonal to S^2.

Remark: At fundamental level only the effects of classical fields on test particle touching several space-time sheets sum up, not the fields. At QFT limit induced fields from different space-time sheets sum up.

The equation for the flow can be integrated for a given flow line as

$$s^k(t) = exp(tj^r\partial_r)s^k(0) \quad . \tag{10.6.4}$$

3. The model for the emergence of a crack requires Hamiltonian discontinuous along a 1-D cut. One has $H = H_\pm$ at the two sides of the cut. The expression of $s^k(t)$ for the flow lines beginning from the point $s^k(0) = s_\pm^k(0)$ of the cut and continuing to the side $\pm$ is given by

$$s^k_{\pm}(t) = exp(tJ^{rl}\partial_l H_{\pm})\partial_r)s^k(0) \quad . \tag{10.6.5}$$

The model for the emergence of "self-subductions" and generation of mountains can be constructed using non-injective Hamiltonian evolutions in which regions having as pre-images two regions appear. These regions correspond to two continent plates above each other. Both self-subduction and subduction reduce the land area.

10.6.3 Appendix: Some mathematical details

The icosahedral model for the generation of continents was an outcome of experimentation. I started with a model inspired by the idea that an analog of super-continent Gondwana was generated as single cap during the expansion period but realized soon that it requires quite too large stretching unless one allows generation of cracks. Also a model with two gaps seemed non-realistic. Homogenous upwards scaling of the Earth's radius suggests strongly lattice like structure and the minimization of stretching led to icosahedral model. I however decided to include these attempts as Appendix - a kind of confession. Hasty reader can skip these parts of the Appendix.

Generation of one or two caps requires too much stretching

The basic objection against single cap model is that the proposed model for expansion requires quite much stretching, which requires large energy. It is also clear that too much stretching leads to a generation of cracks. The following argument is more precise formulation of this observation in terms of a toy model.

1. The first option is that supercontinent analogous to Gondwana (see `http://tinyurl.com/hcgjnrb`) was generated as an expanding hole hole in the crust of S_i^2 emerged somewhere in what became Pasific Ocean - call this place "South pole". Gondwana hypothesis is consistent with Wegener's construction.

2. This period corresponds to a total area preserving map taking the spherical surface (crust) of S_i^2 to a cap of S_f^2 with the same area. The area of the cap should have been thus fraction $S_f/S_i = R_i^2/R_f^2 = 1/4$ of the total area: this corresponds to 25 per cent of the area of Earth. The actual portion of continents from total area is 29.1 per cent. 4 per cent of new land area should have been generated later by some mechanism.

3. The expansion would take the crust covering entire S_i^2 to a supercontinent covering part of S_f^2. The simplest map of this kind maps the surface of S_i^2 to a cap of S_f^2 defined by the condition $\theta_f \in [0, \pi/3]$: this corresponds to $[0, 60]$ degrees. $\theta_f = 0$ would correspond to the "North Pole". This model is certainly non-realistic since it requires large stretching at the bottom of the gap. The stretching is expected to cause cracks mainly in the direction of the coordinate lines of θ_f.

   For the cap at "North pole" the stretching along the coordinate circles of ϕ_f would be very large near the bottom of the cap. One possibility is that cracks in direction of θ_f were generated or that the boundary of cap or that the boundary was "wavy".

A slightly more plausible option reducing the stretching along coordinate circles of ϕ_f would assume generation of 2 caps located at "South pole" and "North pole" as a crack along equator was generated. Also now a wavy crack would allow to minimize the stretching along the coordinate circles of ϕ_f. There would be also stretching along coordinate lines of θ_f. In this case one would have two separate super-continents from the beginning and fitting together along their boundaries of the gaps.

Cap models for the expansion period

The expansion period as generation of one or two caps is unrealistic since it produces too much stretching. In the following however the details of the model are given.

1. There exists no isometry between the crust associated with S_i^2 and connected crust associated with S_f^2. Isometry would require that curvature scalars are same and this is impossible since the radii of S_i^2 and S_f^2 are different.

2. The conservation of total area in the map $S_i^2 \to S_f^2$ taking spherical crust to cap $0 \leq \theta_f \leq \theta_{max}$ with same area: $S_f = S_i$.

3. If the expansion begins from an icosahedral lattice the dynamics of expansion period could reduces to simple scaling in a reasonable approximation. The fraction of land area is however 29.1 per cent rather than 25 per cent however that the expansion is still occurring albeit very slowly. Therefore one cannot separate expansion period completely from the tectonic dynamics. One can however think of time dependent scaling combined with the motion and collisions of cratons leading to their fusion.

   Consider a more detailed definition of the cap models.

1. In the case of single-cap model the simplest manner to guarantee this is to require $cos(\theta_{f,max}) = cos(\theta_{i,max})/4 + 3/4 = 1/2$ giving $cos(\theta_{f,max}) = 1/2$ and $\theta_{f,max} = \pi/3$, which corresponds to 60 degrees. As mentioned the large strength in ϕ_f direction requires either a wavy boundary of generations of cracks in θ_f direction.

2. For the two-cap model the hemispheres $\theta_i < \pi/2$ and $\theta_i > \pi/2$ are contracted to caps when the crack at $\theta_i = \pi/2$ is generated. The condition that no stretching occurs along the coordinate circles of ϕ_f is guaranteed if one has

$$2sin(\theta_f) = sin(\theta_i) \ . \tag{10.6.6}$$

   For small values of $sin(\theta_f)$ near poles this condition reduces approximately to the condition $2\theta_f = \theta_i$, which guarantees that the distances along coordinate lines of θ_f are same as along those of θ_i so that stretching is minimal also along this direction near poles.

   This correspondence is well-defined only for $sin(\theta_f) \leq 1/2$, which corresponds to $|cos(\theta_f)| \geq \sqrt{3}/2$. On the other hand, the condition that the sum of the areas of the caps equals the area of S_i^2 gives $|cos(\theta_f)| \geq 3/4 < \sqrt{3}/2$ so that one must have larger gaps than allowed by no-stretching condition along coordinate circles of ϕ_f. A possible manner to solve the problem is to assume that the boundaries of the gaps are wave or that cracks are generated mainly in θ_f direction.

One can model the expansion period $t = (0, T)$ as a homotopy $R = R(t)$, $[R(0) = R_i = R, R(T) = R_f = 2R]$. During this period the cap develops and $\theta_{f,max}$ satisfies the formulas guaranteeing the conservation of distances along coordinate circles of ϕ_i and of total area.

1. For single-cap case one has

$$\frac{R(t)}{R_i} sin(\theta_f) = sin(\theta_i) \ , \quad (\frac{R(t)}{R_i})^2 (1 - cos(\theta_{f,max}) = 2 \ . \tag{10.6.7}$$

   The first condition can be satisfied only for $cos(\theta_f) \geq \sqrt{1 - (R_i/R(t))^2}$. This lower limit should be smaller than the limit given by the latter condition: $R_i/R(t) \leq \sqrt{7}/4$. For $R(t)/R_i > 4/\sqrt{7} < 2$ the conditions are consistent with each other.

2. The 2-gap case gives

$$\frac{R(t)}{R_i} sin(\theta_f) = sin(\theta_i) \quad , \quad (\frac{R(t)}{R_i})^2 (1 - cos(\theta_{f,max})) = 1 \quad . \tag{10.6.8}$$

Also for this option one must have $cos(\theta_f) \geq \sqrt{1 - (R_i/R(t))^2}$. The condition $cos(\theta f, max) = 1 - (R_i/R(t))^2$ implies that the first condition cannot be satisfied for all values of $cos(\theta_f)$.

10.7 New support for the view about Cambrian explosion being caused by rapid increase of Earth radius

There was an interesting popular article in Quanta Magazine titled "*Oxygen and Stem Cells May Have Reshaped Early Complex Animals*" (see `http://tinyurl.com/y86ta45l`).

The article dicusses the work of geobiologist Emma Hammarlund and tumor biologist Sven Påhlman: their interdisciplinary hypothesis is published as article in Nature [I108] with title "*Refined control of cell stemness allowed animal evolution in the oxic realm*" (see `http://tinyurl.com/y85ufngz`).

Here is the abstract of their article.

Animal diversification on Earth has long been presumed to be associated with the increasing extent of oxic niches. Here, we challenge that view. We start with the fact that hypoxia ($\leq 1-3$ per cent O_2) maintains cellular immaturity (stemness), whereas adult stem cells continuously - and paradoxically- regenerate animal tissue in oxygenated settings. Novel insights from tumour biology illuminate how cell stemness nevertheless can be achieved through the action of oxygen-sensing transcription factors in oxygenated, regenerating tissue. We suggest that these hypoxia-inducible transcription factors provided animals with unprecedented control over cell stemness that allowed them to cope with fluctuating oxygen concentrations. Thus, a refinement of the cellular hypoxia-response machinery enabled cell stemness at oxic conditions and, then, animals to evolve into the oxic realm. This view on the onset of animal diversification is consistent with geological evidence and provides a new perspective on the challenges and evolution of multicellular life.

10.7.1 The proposal of Hammarlund and Påhlman

Cambrian explosion (see `http://tinyurl.com/ntvx38e`) during which highly advanced lifeforms suddenly emerged - prolifiration and diversification of animal life are the terms used about this - is one of the mysteries of biology. For most of its 4.5-billion-year history, Earth has sustained life — but that life was largely limited to microbial organisms: bacteria, plankton, algae. For about 540 million years ago did larger, more complex species are assumed to dominate the oceans, but within just a few tens of millions of years (very short time on the evolutionary timescale), the planet had filled up with all kinds of animals. The fossil record from that period shows the beginnings of almost all modern animal lineages: animals with shells and animals with spines, animals that swam and animals that burrowed, animals that could hunt and animals that could defend themselves from predators. Also many lineages that disappeared were present as one learns from the book of Stephen Jay Gould describing in detail the Burgess Shale finding that revolutionized the picture about evolutionary biology and remains still a puzzle (see `http://tinyurl.com/y9orfy43`).

The belief is that the environment became considerable more oxic - that is contained oxygen - and lifeforms had to cope with this change. Before the change the animals in seas (believed to exist!) were anaerobic. The shifting to aerobic respiration was however an enormous metabolic advantage since the effectiveness of metabolic energy gain become roughly 20-fold. Increased metabolic feed in turn made possible the emergence of complexity during Cambrian period.

1. The proposal of the authors is that the evolution of the capacity to maintain stem cells even in an oxic environment allowed the animals to keep stocks of stem cells needed for tissue growth and repair for that this required at gene level new genes coding for so called HIFs.

2. Stem cells require low oxygen levels to preserve their stemness. Heightened oxygen levels cause them to differentiate abruptly. This explains why stems cells are often located in hypoxic regions of the body (say bone marrow) having low oxygen levels. There are however exceptions to this rule: stem cells can also survive in ocix regions such as skin or retina. Cancers also utilize stem cells to achieve growth.

3. Hammarlund and Påhlman turned their attention to HIFs (hypoxia-inducible transcription factors), which are proteins, which for hypoxic environment shift the metabolism from aerobic to an-aerobic. For oxic environment they are not needed.

   HIF-2α remains however active also in oxic environment and make the cells behave as if the environment were hypoxic. This would allow the stem cells to survive. HIF-2α would however keep the stem cells in immature state also in the case of cancer. The hypothesis of Hammarlund and Påhlman was that HIF-2α functions similarly in normal animal tissues. They have seen some preliminary evidence for the hypothesis but further work is needed.

4. HIFs could have helped the animals to survive in oxic environment. Consider an organism as a blob of cells. Before the oxygenation the stem cells would have been forced to the deep interior of the blob, where oxygen concentration was especially low. When oxygenation took place, and oxygen level varied, this trick did not work anymore and HIFs had to be invented.

5. Hammarlund and Påhman postulate what they call HIF-1, which would have helped stem cells to behave as if the environment were hypoxic. Later HIF-2α unique to vertebrates emerged and improved the situation further. Vertebrates are bigger and have longer time spans that invertebrates and they can live in oxygenated environments. Inveratebrates such as insects live most of their life as larvae under low-oxygen conditions and they cannot regenerate tissues as vertebrates can.

6. Cancer would be the price paid for this evolutionary advance since cancer cells can proliferate because HIF-2 keeps the stem cells alive. OH present in oxygen rich environment is an oxidant causing cancer.

What caused the oxygenation? So called Great Oxygenation Event (GOE,see `http://tinyurl.com/q7qfd55`) is believed to have occurred about about 2.25 billion years ago and thus preceded Cambrian explosion that occured about .5 billion years ago.The time lapse between these events is about 1.75 billion years and much longer than the duration of Cambrian period, which was only tens of millions years. Thus GOE was not the reason for the Cambrian explosion. What caused a further oxygenation or were the effects of GOE somehow postponed (wink-wink!)?

10.7.2 TGD view

My own proposal is that life evolved in underground oceans and entered to the surface of Earth in Cambrian explosion (see `http://tinyurl.com/ntvx38e`) when oceans were formed at the surface of Eearth from cracks formed when Earth expanded rapidly in geological time scale. Before the explosion Earth did not have oceans and continents and was like Mars nowadays: even its radius was that of Mars. This picture follows from TGD based variant of Expanding Earth hypothesis [L46, L45] (see `http://tinyurl.com/yc4rgkco` and `http://tinyurl.com/yb68uo3y`) .

The habitat changed in the rapid expansion of Earth from hypoxic to oxic and the emergence of the hypothetical HIF-1 transcription factor would have been forced by this evolutionary pressure and made it possible for the lifeforms to adapt oxygen based metabolism. This would have led to a rapid evolution of animals and emergence of vertebrates. One can of course think that oxygenation developed already in the underground oceans as cracks caused in the crust by the expansion of Earth began to develop and provided oxygen. The alternative - not so plausible sounding - option is that the highly developed organisms developed underground slowly and only bursted to the surface of Earth in the explosion.

1. Chemical markers (see `http://tinyurl.com/ntvx38e`) indeed indicate dramatic change in the environment at the start of the Cambrian period. The markers are consistent with a massive warming due to the release of methane ice (clathrate hydrate, see `http://tinyurl.`

com/peq9gmw) trapped within the crystal structure of water. Methane clathrate is found deep under the sediments at the ocean floors. Methane hydrates are believed to form by migration of gas from deep along geological faults (the cracks produced by rapid expansion of Earth [L45]!).

2. During the period before Cambrian explosion Earth would have been very much like in recent Mars. Even its radius would have been that of recent Mars! One can ask whether GOE forced the existing primitive lifeforms underground or saved only those already living underground. Situation would have been be very much like in the recent Mars, which also seems to possess undergound life.

The development of HIF proteins (hypoxia inducing factor) making possible for stem cells to survive in environments with varying and thus temporarily higher oxygen content would have been a natural reaction to the dramatic changes in habitat.

What can one say about the emergence of animal life in TGD framework?

1. The rapid evolution leading to the emergence of animals - if it was present - would relate to the quantum criticality associated with the increase of the effective Planck constant $h_{eff}/h_0 = n$ by factor 2 increasing the size scale of Earth. The increase of $h_{eff}/h_0 = n$ might have occurred at several levels of dark matter hierarchy, also at biological relevant scales and led to an increase of biological "IQ" (note that evolution corresponds in TGD to gradual increase of number theoretical complexity and n characterizes the dimension of extension of rationals characterizing the complexity [L34, L35]).

2. Animals use oxygen for breathing and are multicellular eukaryotes having cell membrane enclosing nucleus and other membrane bound organelles. The quantum critical period could have led to the emergence of a kind of symbiosis of various kind of organelles within cell membrane bounded volume. The p-adic length scale $L(k)$ determined by the value of n assignable to the outer membrane of organelles could correspond to the prime $k = 163$ (or 167). Inside plant cells having no cell membrane these organelles correspond to vacuoles (see http://tinyurl.com/yd879b2d). The outer membrane that emerged in the transition increasing h_{eff}/h_0 meant increase of the scale of quantum coherence to a longer p-adic length scale - say $k = 167$ (or $k = 169 = 13^2$ if doubling took place).

3. Mitochondria would have emerged and made possible oxygen based respiration whereas plant like organisms preceding them utilized anaerobic respiration. Methanogenesis (see http://tinyurl.com/y97gkym8) utilizing carbon instead of oxygen and producing carbon-dioxide and methane CH_4(water in O_2 based respiration) is the most natural option. The large methane storages underground would be due to methanogenesis.

   The recent findings (see http://tinyurl.com/y735g9kn) indicate that there is life in Mars: methane emissions occurring periodically with a period of Martian year have been detected. This suggests that solar radiation is somehow able to enter to the interior of Mars or that it heats the underground Oceans. In TGD one can consider also the possibility that some part of solar photons transforms to dark photons and is able to propagate to the underground oceans through the Martian crust [L45].

4. What was the primary source of metabolic energy? Direct solar radiation was absent in underground oceans. The immediate source of metabolic energy for the plant like organisms might have been dark nuclei consisting of dark proton sequences and liberating energy in the transitions reducing of $h_{eff}/h_0 = n$. Dark proton triplets give rise to dark variants of DNA, RNA, tRNA, and amino-acids [L20, L18, L48]. These dark proton sequences could have formed by Pollack effect at the surface of Earth possibly containing some water and could have propagated along dark flux tubes to the interior: also in "cold fusion" dark nuclei would be formed. Some fraction of them would transform to ordinary nuclei and liberate practically all the nuclear binding energy. Also transitions to dark nuclei with a smaller value of h_{eff}/h_0 is possible and liberates energy usable as metabolic energy. Most dark nuclei could leak out along magnetic flux tubes [L30]. The hen-egg problem - which came first, metabolism or genetic code - would trivialize in this framework.

For p-adic length scale $L(k = 149) = 5$ nm - thickness of cell membrane - the typical dark nuclear excitation energy was about .5 eV, the nominal value of metabolic energy quantum. For $L(151) = 10$ nm (thickness of neuronal membrane and DNA double strand its value is .25 eV. These estimates are based on the scaling of the typical nuclear excitation energy taken to be 1 MeV and are uncertain by a factor of 2 at least. One of course expects also higher excitation energies - even so high that they correspond to visible ordinary photons. Metabolic energy could have been liberated as dark photons in dark nuclear transitions transforming to ordinary photons and absorbed by the photosynthetic machinery.

The (rough) estimate for the typical value of the dark photon energy is considerably lower than in ordinary photosynthesis. Pollack effect [L13] occurring in presence of gel phase bounding water volume suggests that for $k = 149$ the transformation of dark proton sequences to ordinary ones: this mechanism would liberate energy per proton ~ 1.5 eV [L38], which corresponds to infrared photon. The small value of the metabolic energy quantum need not be a problem: there is recent evidence that IR light with energy 1.76 eV can be used in photosynthesis (see `http://tinyurl.com/yc6pqjed`).

10.7.3 Could Mars have intra-martial life?

A popular article in National Geographic (see `http://tinyurl.com/y5unt6y7`) tells about unexpected findings made by the first robotic geophysicist, the Insight lander revealed in the European Planetary Science Congress and in the American Astronomical Society. There are odd magnetic pulsations with frequency around 10 mHz [E7] (see `http://tinyurl.com/y3ll8kcg`) occurring at Martian night-time: for Earth these pulsations occur in frequency range 1 mHz to 1 Hz. Mars has much stronger magnetic field as expected. The magnetic field was detected at heights 96-400 km.

Besides this there is evidence for the existence for a global electrically conductive layer about 6 km below the surface, which suggest an underground reservoir of water. This has enormous implications for potential existence of life in Mars. There is also earlier evidence for the existence of salty, liquid water measuring about 19 km across (see `http://tinyurl.com/ycjaky5g`).

The strange findings about Mars can be understood in the framework provided by TGD based model for expanding Earth providing also explanation for the mysterious Cambrian explosion assuming that the life developed in Earth's interior, TGD based notion of magnetic field, and dark matter identified as phases with nonstandard value $h_{eff} = nh_0$ of Planck constant.

Connection with the model of Expanding Earth

These findings bring in mind TGD based model for expanding Earth [L46, L45] (see `http://tinyurl.com/yc4rgkco`, `http://tinyurl.com/yb68uo3y`, and `http://tinyurl.com/ya68nggs`).

1. The observation is that if Earth has radius one half of itse recent radius the continents fit nicely together to cover entire surface of Earth. This lead to the proposal that during Cambrian explosion in which highly developed life formed mysteriously emerged, the Earth radius grew by factor 2 in a relatively short time. The life would have evolved in Mother Gaia's womb, underground oceans perhaps between crust and astenosphere at depth not larger than 80 km, shielded from cosmic rays and meteoric bombardment.

2. The sudden expansion can be modelled in TGD inspired new physics as a phase transition increasing the p-adic length scale of Earth and reducing the scale dependent cosmological constant assignable to Earth by factor 1/4: these kind of phase transitions replace smooth cosmological expansion in TGD inspired cosmology.

   This led to the splitting of the continuous crust to continents and oceans emerged as the water from underground oceans containing the highly developed life forms bursted to the surface.

3. The intriguing coincidence is that Mars has radius which is 1/2 of Earth's recent radius. Could also Mars have underground ocean with rather developed life forms waiting for the moment of birth? Magnetic field is necessary in TGD based model of life and the article tells that Mars has unexpectedly strong magnetic field. It also tells about underground ocean

at death about 100 km! The boundary between Earth's core and astenosphere, where the ancient oceans might have been is at dept of about 80 km.

There is something weird in the magnetic field of Mars

The assumption that magnetic field of Mars can be approximated as a dipole field leads to a paradoxical situation in Maxwellian framework.

1. Wikipedia article about Earth's magnetosphere (see `http://tinyurl.com/y3t78oka`) gives a criterion for the height below which magnetic field can survive under the pressure caused by solar wind. The criterion reads

$$\frac{R_{CF}}{R_P} = (\frac{B^2}{\rho_{sw} v_{sw}^2})^{1/6} \quad .$$

   Here R_P is planet radius, B is the strength of the magnetic field at its surface, and ρ_{sw} and v_{sw} are the mass density and velocity of solar wind. The ratio R_{CF}/R_P is essentially the ratio of the density of magnetic energy and density of kinetic energy. This implies that the strength of B is about 10 times higher than the strength of the Earth's magnetic field at surface about .5 Gauss. The recent findings should increase the earlier estimate $R_{CF}/R_P \sim 1$ given in Wikipedia. For Earth the thickness of magnetosphere is about 10 times Earth radius giving $R_{CF}/R_P \sim 11$.

2. The strength of magnetic field behaves like $1/r^3$ in dipole approximation and scaling R_P by factor 2 would reduce magnetic field strength at surface down by factor 1/8, which is near to value of the Earth's magnetic field strength B_E. Could one think that also Earth had similar magnetic field before the expansion an that the expansion of Earth radius by factor 2 gave rise to the recent magnetic field? $B_{Mars} \sim 10B_E$ however suggests that the magnetic field of Mars in dipole approximation should actually extend equally far as the Earth's magnetic field! This does not seem to make sense.

   Could one think that the matter at the flux tubes of Martian magnetic field is dark matter as $h_{eff} = nh_0$ phases and is not visible in the ordinary sense. For instance, cyclotron energies proportional to $h_{eff}eB/m$ would be much higher than expected. Another option is that the magnetic field corresponds carries monopole fluxes at its flux tubes carrying dark particles.

What looks mysterious is that if Martian magnetic field is dipole field in reasonable approximation, it should be more or less like Earth's magnetic field! One would expect cyclotron radiation and van Allen belts. Why they are not seen? The answer could be simple.

1. Also Earth's magnetic field would decompose to stable part for which flux tubes carry quantized monopole flux and ordinary part. Monopole part does not need current to sustain it and this has been used to explain why Earth's magnetic field has not disappeared long time ago. The varying part of the Earth's magnetic field would be created by convection currents in the solar. Since Mars does not have outer core, it would not have this part of magnetic field. I have proposed this model for the maintenance of Earth's magnetic field at [L17] (see `http://tinyurl.com/y5anawyk`).

2. I have assumed that dark matter as $h_{eff} = nh_0$ phases of ordinary matter essential for life resides at the flux tubes of this field having strength which is 2/5 of the Earth's ordinary magnetic field. I have called this field endogenous magnetic field and its existence and existence of h_{eff} hierarchy was deduced from the explanation of quantal effects of ELF em fields on vertebrate brain. If Mars has only dark magnetic field, the magnetic field of Mars could be invisible! The ordinary part of this magnetic field should appear in the analog of Cambrian explosion as the radius of Mars increases to that of Earth and core radius increase by factor 2 and the core becomes unstable against division to two layers.

3. It has been thought that Martian magnetic field is so weak because the outer core of Mars has been seized up in distant past leading to a collapse of the magnetic field. Could one think that the reverse of this process took place for Earth in the expansion and created the

outer core, perhaps by splitting of the core to outer and inner core? This picture would fit nicely with the p-adic length scale hypothesis suggesting layered structures with thickness of layer coming as some power of 2: the thickness of core would have double and core would have divided to two layers. If the strength of the Earth's magnetic field has been stronger by factor 8 before Cambrian explosion, this should be seen in magnetic records.

The rotation of the outer core would create ordinary magnetic field after the expansion. Before that various ions from solar wind would have entered to the dark flux tubes and entered to the interior of Mars. Same would have happened also in Earth and would explain how oxygen atmosphere emerged in Cambrian explosion and life could burst safely to the surface of Mars.

4. Intriguingly, Mars has its own version of Northern lights (see `http://tinyurl.com/y5z7jlkb`). Without magnetic field auroras should not exist! Could it be that they are dark auroras associated with dark magnetic field of Mars. In reconnections of the magnetic field o Martian magnetic field and those associated with solar wind dark ions would transform to ordinary ones and create Norther and Souther lights. Van Allen belts are in the height range .6-58 Mm (Earth radius is 6,4 Mm). Mars should have dark van Allen belts along which ions of solar wind would end down to the interior of Mars.

5. What about the pulsed oscillations of Martian magnetic field at frequency around 10 ms, which corresponds to a period of 3.33... minutes detected at the night-side of Mars?

   The pulsations could correspond to a biorhythm. Also Earth's magnetic field has pulsations with frequencies varying between 1 mHz and 1 Hz. 1 mHz corresponds to 3/3.6 minutes and 1 Hz to average DNA cyclotron frequency in endogenous magnetic field $B_{end} = .2$ Gauss identifiable as dark magnetic field.

   Could these pulsations correspond to a heartbeat or breathing of Martian magnetic Mother Gaia - rather concrete pulsation of its magnetic body made from flux tubes and/or sheets? Why the pulsations appear only at the dark side? Could the pressure of the solar wind prevent the pulsations at the day-side?

One can wonder what the measured magnetic field is. Is it the sum of dark and ordinary part or only ordinary part. If test particles touch all space-time sheets involved, they experience the sum of the magnetic fields so that the usual measurements should give the sum. If it is only the ordinary part, one would still have the problem why the field having strength near to Earth's magnetic field is not visible as van Allen belts for instance. The QFT limit of TGD indeed corresponds to the replacement of space-times sheets with single region of Minkowski space and the identification of fields as the sums of the induced fields from various space-time sheets.

Intraplanetary life

The new observations allow to make the existing model for intra-planetary life much more detailed. The following applies to both Earth and Mars.

1. At Earth the multicellular life forms would have emerged in Cambrian explosion suddenly from the Earth interior as its size increased by factor 2. The expansion would be one stepwise cosmic expansion and associated with the decrease of length scale dependent cosmological constant associated with Earth. Same should happen in Mars sooner or later. So that there is no reason to worry. If we destroy our species and many other at the same time, intelligent life forms will develop in Mars.

2. If the multicellular life forms represented intraterrestrial life, photosynhesis and even oxygen based life should have evolved in underground ocean. The breathing animals would be like fishes using the oxygen in water.

3. The dark magnetic flux tubes of planet would served as channels for solar photons propagating as dark photons to the ocean in the interior of the planet. Dark photons would have transformed to ordinary photons (that is bio-photons) and used in photosynthesis making possible chemical energy storage. Photosythesis would have produced oxygen O_2, which

would not have been lost to outer space now: a good reason for intraplanetary life when oxygen atmosphere is missing.

Thus breathing animals would have become possible besides plants like organisms performing the photosynthesis. Also animal-plants doing photosynthesis themselves can be considered. Even we could use the metabolic energy stored chemically in manner analogous to photosynthesis. The machinery is very similar and there is evidence that even humans can use sunlight as metabolic energy. Pollack effect [L13] would be key element here. Pollack effect generates charge separation and thus voltage and this gives rise to a battery.

4. The evolution of life inside planets could solve Fermi paradox. Universe is full of planetary systems. Life would be everywhere but inside the planets in planetary wombs. We might be pioneers. An alternative solution is that we are already in telepathic contact with higher life forms at dark magnetic bodies but do not realize it. We ourselves would have magnetic bodies with Earth sized and perhaps even galaxy sized layers.

   This is not the only possible TGD inspired solution of Fermi paradox. Our own magnetic body would have layers with size of Earth scale and perhaps even galactic scale. We could be in continual contact with the magnetic bodies of members of other civilizations without knowing it - say during dream states. We could have even neural machinery activating these flux tube contacts. DMT is the only psychelic produced by body itself, and is assigned with pineal gland, which Descartes identified as the seat seat of soul. In zero energy ontology light velocity would not be a problem for communications with distant civlization since signals could propagate in both directions and time reflection would make communications forth and back in time possible [L14].

The newest news from Mars tells that scientists have measured the seasonal variation of methane CO_2 and oxygen O_2 in the Gale Crater of Mars.

1. The largest amount of methane CO_2 hitherto, 21 parts per billion volume units has been measured in Mars by Curiosity Mars rover (see `http://tinyurl.com/w2p4uh8`). The presence of high level of methane discovered by Curiosity has been known for years. Methane is associated with living organisms. At Earth it is produced by microbes but can be also created through interactions between rocks and water. Curiosity cannot determine whether the source is local or is the methane present everywhere and whether the source is biology or geology. The recent measurement gave an increased level of methane but it is not known how long the transient lasts and whether there is a seasonal variation. The transient however suggests that the source of methane is local. Chemically reactive soil containing sources and sinks of methane has been considered.

2. Also oxygen was observed to behave in an unexpected manner (see `http://tinyurl.com/wlu4xq5`). The knowledge of the surface chemistry allows to estimate the yearly variation of oxygen, and the predictions confirm with measurements almost all the year. At spring time of Mars the rules of chemistry are however broken, and the concentration of oxygen rises as much as 30 per cent during spring and summer and the returns to the levels predicted by the chemistry. Something gives oxygen and then takes it back.

What smoothed out Earth's surface for 600 million years ago - or was it already smooth?

I learned about new fascinating finding (see `http://tinyurl.com/y339u6qo`) related to the geological history of Earth. During a geologically very brief period Earth's surface would have somehow lost its surface details such as rivers and lakes. This would have happened for 600 million years ago. Before this there would have been period of snowball Earth.

TGD provides different view about the renovation of the surface of Earth by loss of details and about the period before this change: snowball Earth hypothesis seems un-necessary [L46, L45]. There were no oceans. The situation would have been the same as in Mars now. Water was in underground oceans as has been observed recently in Mars. One could deduce the story of Earth from what we know about Mars on basis of latest discoveries.

Cambrian explosion, in which complex multicellulars suddenly and mysteriously emerged took place about 512 million years whereas the loss of details is claimed to have happened about 600 million years ago. TGD based theory of expanding Earth assumes that Cambrian explosion happened because of geologically very fast expansion of Earth so that the radius of Earth increased by a factor 2. Amusingly, the radius of Earth would have been before the expansion same as that of Mars now!

Expansion would correspond to one fast jerk in the sequence of jerks, which replaces smooth cosmic expansion in TGD Universe: it is indeed known that astrophysical objects co-move in expansion but do not expand themselves (except by jerks). These jerks would be induced by reduction of length scale dependent cosmological constant by factor 1/4, or more generally, negative power of 2. The findings suggest that the expansion started about 600 million years ago and happened geologically very fast. Note that length scale dependent cosmological constant solves the basic problem of standard cosmology, which has killed many theories, also superstring theory.

Before this life would have evolved in underground oceans - the womb of Mother Gaia - shielded from cosmic rays and meteors. Oxygen and other important molecules could not leak out so that oxygen based life could evolve. In the expansion the core of Earth split into two parts (Mars has same radius as Earth and only single core) and the rotation of the outer core created ordinary magnetic field preventing oxygen and other important molecules to leak out. Otherwise the life at surface would not have survived. The surface of Earth split into pieces giving rise to continents and underground oceans gave rise to the oceans.

Consider now the mystery of lost details.

1. The surface of Earth before expansion should have looked very much the same as that of Mars now. Since there was very little water, rivers, lakes and this kind of features would have been practically absent. I do not know whether this is enough to explain the findings.

2. If the surface of Earth was stretched in the sudden expansion, the details of Earth's surface would have tended to disappear since gradients are reduced in the stretching. Whether the stretching really occured is however not clear: one could argue that the surface split into pieces like clay soil as it dries and formed continents.

3. The bottoms of oceans consisted of the magma from the interior of Earth and they should have been rather smooth. Also this might help to understand the findings.

10.7.4 Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology

In ZEO the signature of "big" (ordinary) state function reduction is the change of the arrow of time at some level of the hierarchy of space-time sheets (selves) and one could start to search evidence for this effect. Also "small" state function reductions are possible and correspond to "weak" measurements. I did not however have the change of the arrow of time in mind when I encountered a highly interesting article "*Cosmic-solar radiation as the cause of earthquakes and volcanic eruptions*" by Jamal Shrair (see `http://tinyurl.com/y3g3khtd`) telling about the findings related to earthquakes and volcanic eruptions challenging the rational mind making its deductions in standard ontology.

1. The occurrence of earthquakes up to 34 kilometers below the surface of Earth and volcanic eruptions up to 9 km below the surface has strong correlation with the sunspot minima (solar activity) and cosmic ray flux. One could think that the system consisting of tectonic plates or magma is critical and sensitive to small perturbations. But how do the cosmic rays get so deep in Earth interior without losing their energy?

   TGD based answer is simple. During sunspot minimum the dark monopole part of the magnetic field of Sun is strong and the charged particles of solar wind arrive along the flux tubes and by reconnection end up to the flux tubes of the Earth's dark magnetic field (van Allen belts) and along them to the interior of Earth, where they end up to quantum critical system formed by magma or tectonic plates and induces the eruption of earthquake.

2. This however requires that the number of dark monopole flux tubes is large during sunspot minima. Sunspots would be formed in reconnections of very long U-shaped monopole flux tubes coming from Sun and carrying solar wind as dark particles. This would reduce the number of monopole flux tubes but generate ordinary magnetic field by creating currents creating them - monopole flux tubes do not need any current. Therefore the number of monopole flux tubes would be maximal during sunspot minima.

   Quite generally, cosmic rays would arrive to Sun along monopole flux tubes of flux tube network [L67] connecting galaxies and having flux tubes of stellar objects as sub-tangles and continue from Sun to Earth. The highly energetic dark cosmic rays preserving their energy as dark particles could end up to the Earth interior along monopole flux tubes and could induce eruptions and earthquakes. This mechanism would also take dark ions of solar wind to underground oceans in Earth interior in the model of prebiotic life [L46].

Consider now the observations in this framework.

1. In the model of Japanese researchers led by Toshikazu Ebisuzaki cosmic muons are assumed to induce volcanic eruptions. The assumption is that solar magnetic field repulses cosmic rays. When it is weak as believed to be during solar minima, the cosmic rays can arrive to Earth. Volcano would act as a volcanic bubble chamber in which the cosmic rays induce a phase transition (see `http://tinyurl.com/y3d52r7c`). The model however considered only the eruptions not deeper that 10 m below surface rather whereas most eruptions occur at depths up to 10 km. The objection is obvious: for the cosmic muons as ordinary particles it is difficult to get so deep into the interior.

2. NASA researchers reported that earthquakes are preceded by large fluctuations of densities of electrons and other charged particles in the upper part of atmosphere. Perturbations are detected at at heights 100-600 km above Earth's surface. For Earth quakes the depths vary down to 35 km. If cosmic rays induce the earth quakes, one would expect that the time order as indeed proposed by NASA researchers in their model. The problem is that electric perturbations precede the earthquakes rather than vice versa.

   Here ZEO comes in rescue: The time order was indeed opposite. Macroscopic quantum jump of a quantum critical system took place changing the direction of time. There is precise analogy with the findings of Minev *et al* in atomic systems showing that a deterministic and smooth time evolution seems to lead to the final state of quantum jump [L58] [L58]. The time evolution however has opposite arrow of time and starts from the final state. Libet's findings [J5] have the same explanation in terms of act of free will realized as state function reduction. Now the "big" state function reduction would correspond to the earthquake/volcanic eruption and would be induced by cosmic rays serving as stimulus. The bad news is that when the electromagnetic fluctuation are detected, the quantum jumps has already occurred and nothing can be done to prevent the catastrophe.

3. In Maxwellian picture one expects that the magnetic pressure of solar magnetic field is minimum during sunspot minimum: just the opposite is true as experiments show (see `http://tinyurl.com/y3g3khtd`! The stronger the solar minimum the stronger the magnetic pressure. This is indeed the case in TGD picture if the detected magnetic field corresponds to the sum of magnetic field associated with monopole flux tubes and ordinary flux tubes! This is what the QFT limit of TGD predicts since spacetime at this limit carries the sum of induced fields associated with the sheets of the many-sheeted space-time.

   These findings inspired the proposal of the article that motivated these comments (see `http://tinyurl.com/y3g3khtd`): the magnetic pressure of solar wind could induce the earthquake/volcanic eruption somehow but leaves the detailed mechanism open. In TGD this assumption is not needed. The dark cosmic rays from the monopole flux tubes of solar magnetic field reconnected to with similar flux tubes of the Earth's magnetic field would travel along them to the interior of Earth.

4. The article of Shrair also mentions earth lights, which are luminous phenomena associated with the lines of tectonic activity. I have proposed already earlier an explanation in terms

of dark photons liberated from the regions with high tectonic stresses. These dark photons could be phase conjugate photons with non-standard arrow of time accompanying mini earthquakes already occurred with respect to subjective time. Even bigger earthquakes could be in question if the irradiation of phase conjugate dark photons with non-standard time direction continues for a long time after the earthquake, which will happen in our geometric future.

10.7.5 Correlation between earthquakes and volcanic eruptions with the spin dynamics of Earth

Wes Johnson send a link (`http://tinyurl.com/ydqhngkq`) telling about te correlation between the dynamics of Earth's spin and earthquakes and volcanic eruptions. There are two directions involved corresponding to geographic axis and rotation axis. The direction of Earth's magnetic field defines the geographic axis. These events tend to occur and are largest when the angle between Earth's rotation axis and geographic (magnetic) axis is largest. This is is an excellent benchmark test for TGD based view about magnetic fields.

The new findings might have a connection with the TGD inspired solution of several other mysteries.

1. Quantal effects of radiation at ELF frequencies on vertebrate brain discovered by Blackman and others [J8]. Photon energies are ridiculously small: there should be no effects.
2. Maintenance problem of Earth's magnetic field.
3. Why the direction of Earth's magnetic field is different from that for the rotation axis which is a natural direction for convective plasma currents?
4. What causes the precession of Earth's rotation axis? The explanation in terms of gravitational effects fails.
5. There are time anomalies associated with earthquakes and volcanic eruptions. Cause and effect seem to be in wrong order.

Earth's magnetic field should have disappeared long time ago. TGD based solution relies on difference between magnetic fields in Maxwellian theory and TGD:

1. TGD provides a solution to the maintenance problem [L17] (`http://tinyurl.com/yjstfvg3`.

   In TGD framework magnetic field has two parts.

   (a) Monopole flux tube part with strength B_{end} = about .2 Gauss ($B_E$has nominal value of .5 Gauss). The existence of B_{end} is deduced from the effects of radiation at ELF frequencies on vertebrate brain (Problem 1). It would carry dark matter in TGD sense ($h_{eff} = n \times h_0$ phases of ordinary matter) and be crucial in biology. This part needs no current to maintain it and this solves the maintenance problem for Earth's B_E having nominal value $B_E = .5$ Gauss (Problem 2).

   (b) Second part B_o is the ordinary Maxwellian part and currents are needed to maintain it since it decays exponentially due to the dissipation of the currents. The change of the direction of monopole flux induces currents refreshing B_o. Just now monopole flux part is changing direction and this causes the direction of B_o part to change: magnetic North Pole is moving towards Siberia rather fast. A good first guess for the direction of B_o is the rotation axis of Earth.

   It would not be surprising if the difference between directions of B_{end} and B_o would have physical effects and that the effects occur when Θ becomes large enough. The size of the effects would naturally increase as Θ increases. Earthquakes and volcanic eruptions could be these effects.

   Remark: The direction of monopole flux part is not that of geographic axis since it represents direction of the entire magnetic field having nominal value $B_E = 0.5$ Gauss. The angle Θ between B_{end} and rotation axis is larger than that of geographic and rotational axis.

2. Monopole flux tubes provide also a solution to the precession problem [L4] (http://tinyurl.com/ybezl7tj).

   The change of the direction of monopole part B_{end} inducing change of the rotation axis could be due to the change direction of flux tubes in much longer length scale than that of Earth. Precession of the rotation axis could be the outcome and precession would not be caused by gravitational effects in solar system. TGD explanation involves magnetic flux tubes and dark matter in TGD sense in much larger scale than that of Earth.

3. TGD suggests also a solution to the time anomalies associated with earthquakes and volcanic eruptions [L62] (http://tinyurl.com/yjpjgozk).

   Zero energy ontology (ZEO) is the corner stone of TGD based quantum measurement theory solving its basic paradox and allowing to extend it to a theory of consciousness. ZEO changes profoundly the views about the relationship between experienced time and geometric time. The arrow of time changes in the counterpart of the ordinary state function reduction and is preserved in the counterpart of weak measurement.

   (a) Earthquakes and volcanic eruptions would be induced by macroscopic quantum jumps - ordinary state function reductions in ZEO - involving large value of $h_{eff} = nh_0$ and its change at the level of magnetic body (MB) of the system. MB would correspond to flux tubes of B_{end}.

   (b) In ZEO these quantum jumps change the arrow of time temporarily at the level of MB involved and induce effects in "wrong" direction of time also at the level of ordinary matter. Indeed, ELF radiation has been observed *before* the earthquake as it would cause the earthquake it - not very realistic sounding idea - and could therefore used to predict the Earth quakes.

   The original model however predicted that ELF should occur after the earthquake as is indeed very natural. The ZEO based explanation of the paradox is that the arrow of time changes at MB. This would be the effect of Minev *et al* [L58] [L58] (http://tinyurl.com/yj9prkho) observed recently in atomic systems but in macroscopic scale. Also Libet's finding [J5] that neural activity seems to precede conscious decision would be similar illusion and at the same time proof the idea that act of free will corresponds to macroscopic quantum jump in ZEO.

This picture suggests an understanding of the correlation between earthquakes and volcanic eruptions and the dynamics of Earth's spin. As noticed, the macroscopic quantum jumps associated with changes of directions of B_{end} and B_o are expected to cause more dramatic effects when the deviation between the B_{end} and B_o (rotation axis) is largest. The angle Θ would change in these events. If B_{end} flux tubes change direction, a current is induced. This would change the direction of rotation axis if it is same as the direction of convective current generating B_o.

Question: Could the precession of the rotation axis consist of small steps changing the directions of B_{end} and B_o and their relative direction and be associated to earthquakes and volcanic eruptions?

10.7.6 No continents before Cambrian Explosion

I learned about highly interesting finding by geobiologists Benjamin Johnson and Boswell Wing. One can find a a popular article about the work with title "*Earth Could Have Once Been a Waterworld Covered by a Global Ocean, Study Suggests*" (http://tinyurl.com/uwjgfew). The research article with title "*Limited Archaean continental emergence reflected in an early Archaean 18O-enriched ocean*" is published in Nature Geoscience (http://tinyurl.com/rq7o4t9).

The finding is very interesting from the point of view of TGD based Expanding-Earth model [L46] (http://tinyurl.com/yc4rgkco) allowing to understand Cambrian Explosion (CE) (http://tinyurl.com/ntvx38e) that happened about .54 billion years ago leading to a sudden and rather mysterious emergence of multi-cellular life in a rather short time scale (13-25 million years).

TGD inspired cosmology predicts that cosmic expansion occurs for various astrophysical objects as relatively rapid jerks rather than smoothly. This allows to understand the paradoxical finding that astrophysical objects participate in cosmic expansion but do not seem to expand themselves. The expansion occurs in jerks in which the value of scale dependent cosmological constant characterizing the system decreases.

1. The radius of Earth would have expanded by a factor 2 in relatively short time scale from a value near to the radius of recent Mars and led to the formation of continents as the Earth's crust ripped. Multi-cellular life would had evolved in underground oceans shielded from meteoric bombardment and cosmic rays and bursted to the newly formed oceans at the surface.

2. The basic prediction of the model is that before CE there were no continents. This also kills the so called Snowball Earth model (`http://tinyurl.com/prem7nj`) for the climate before CE.

The findings give a direct support for the absence of continents before CE. What the researchers did was following.

1. The goal was to understand the temperature ancient Earth about 3.2 billion years ago, and the researchers studied what they believed to be a bottom of an ancient sea. The isotope ratio of ^{16}O to ^{18}O decreases with temperature. The researchers constructed the temperature profile of the ancient Earth, and the surprising finding was that there was 3.2 per cent more ^{18}O than expected. This is 4 per cent more than in today's relatively ice-free oceans and much higher than the previous estimates.

2. The isotope ratio is sensitive to landmass. The conclusion of researchers is that the unexpectedly low ratio could be due to the lack of landmasses. The Earth's surface could have been wet but there is no need to assume oceans. TGD prediction does not exclude wet surface but just the existence of continents. The high wetness could have been due to the percolation of water from underground oceans preceding the great burst - note that 3.2 billion years is by factor about 6 longer time than .54 billion years.

This picture however poses difficult questions. When and how did the continents emerge? How did life emerge if there were no landmasses so that standard model must be given up?

As already explained, TGD based model for Expanding Earth solving basic mystery of standard cosmology provides an answer to these questions and also to the mystery of Cambrian Explosion.

10.8 Updated version of Expanding Earth model

This section was motivated by several articles. The first popular article "Was ancient Earth a water world?" (`https://cutt.ly/fbFqydU` tells that Earth could have been covered by water for billions of years ago. As the Earth cooled, this water later sinked in the interior of Earth as water of crystallization forming underground "oceans". The amount of salty crystal water inside the Earth is estimated to be of the same order of magnitude as in the recent oceans.

The article "Constraining the Volume of Earth's Early Oceans With a Temperature-Dependent Mantle Water Storage Capacity Model" [F40] (`https://cutt.ly/wbFqekI`) The model of the article assumes that the water in the mantle and crust is water of crystallization `https://cutt.ly/nbD65jZ`. The water bound on on salt and metal crystals is not chemically bound but forms hydrogen bonds. In heating this water is liberated. For proteins the amount of crystal water can per 50 per cent. Heating leads to a loss of water of crystallization. Cooling induces opposite process and this would have led to the leakage of the water at the surface to the interior, even to mantle, where it bonded with crystals.

The water of crystallization does not however seem to be the only form of water inside Earth. The popular article "Pockets of water may lie deep below Earth's surface" (`https://cutt.ly/4bFqi8M`) told about pockets of exotic solid water - ice VII - in the mantle, which corresponds to the range of depths 610-800 km. The temperature in this range varies between

1300-4000 K and the corresponding thermal is in the range .13-.4 eV. The solid form is made possible by the large pressure.

The article also tells about the presence of freely flowing liquid water in the transition zone between Earth's crust and mantle. This corresponds to the depth range 410-660 km (https://cutt.ly/4bD0JIr) and temperatures below 1300 K. Underground life is known to exist at surprisingly large depths although high temperature and pressure pose strong constraints.

The popular article "Life Thrives Within the Earth's Crust" published in TheScientist provides a nice summary about what is known (https://cutt.ly/qbD0A0N. From the article one learns that bacteria found at depths reaching 6 km. Fungi (multicellulars differing from animals in that they have chitin in their cell walls) and even animals are found at depths 700-800 m. The article "Anaerobic consortia of fungi and sulfate reducing bacteria in deep granite fractures" [I65] (https://cutt.ly/VbD0Gvb)tells about sulfate reducing bacteria and fungi found at at granite fractures at depth 740 m.

The reason why these articles are so interesting from the TGD point of view, is that they lead to a more detailed version of the TGD inspired Expanding Earth model (EEM) [L46, L45]. EEM predicts that Earth suffered in the Cambrian Explosion (CE) about half billion years ago a relatively rapid expansion during which the radius of Earth increased by factor 2. There are however several objections against this model and the article provides insights allowing to circumvent these objections and supports the original vision.

In the sequel motivations for and objections against EEM are summarized. Also a resolution of objections based on a more precise model for EEMis discussed.

10.8.1 Motivations for EEM

There are three basic motivations for EEM.

1. The theoretical motivation is that the occurrence of this rapid expansion of Earth fits with the TGD view about cosmological expansion [L59] as rapid phase transitions replacing smooth cosmological expansion of GRT and solve the problem of GRT caused by the fact that astrophysical objects are not found to expand themselves although they participate to expansion by comoving with it.

2. The geological motivation is that the continents seem to fit nicely together to cover the entire Earth if the radius of Earth is 1/2 of its recent radius.

3. Cambrian explosion (CE) (https://cutt.ly/AbFljuv) serves as a biological motivation. CE started roughly 541 million years and lasted about 13 – 25 million years. During this relatively short period highly advanced multicellular life forms emerged. From the times before this there are only monocellular fossils.

4. Fermi paradox summarizes the empirical fact that there is no evidence for life as we understand it anywhere in the known Universe. One can imagine several reasons for this. A possible TGD based explanation is that life is present in the interiors of planets as it was in the interior of Earth before CE.

The rapid expansion would have broken the crust of Earth to pieces creating continents and the water from the interior of Earth containing multicellular life would have bursted to the surface and created oceans, absent before CE. The rapid evolution would have occurred during CE or already before CE in the "womb of Mother Gaia" in water pockets or even underground oceans shielded from cosmic rays and meteor bombardments.

The effects of Cambrian Explosion in deep mantle

Roughly a year after writing the original version of this article I learned about a possibe new piece of evidence for the TGD view about Cambrian Explosion. The popular article titled "Traces of life in the Earth's deep mantle" in Phys-Org (https://cutt.ly/AAIj7Ss) told about the work

of Giuliani *et all* about discussed in the article "Perturbation of the deep-Earth carbon cycle in response to the Cambrian Explosion" [F41] (`https://cutt.ly/wAIko6S`).

The sudden emergence of advanced multicellular lifeforms in the Cambrian Explosion (CE) about 540 Ma ago is still one of the great mysteries of mainstream biology. The team led by ETH researcher Andrea Giuliani found in rocks from deep mantle what can be regarded as traces of CE. The proposal is that partly organic material would have been subducted to the deep mantle after CE and changed the isotopic compositions of Carbon and other elements. Also other elements, for instance strontium and hafnium showed a pattern similar to carbon.

The group of Giuliani examined rare diamond-containing volcanic rocks known as kimberlites from different epochs of the Earth's history. These special rocks originate from the lowest regions of the Earth's mantle. The isotopic composition of carbon in about 150 samples of these special rocks was determined. The composition of younger kimberlites, which are less than 250 million years old, was found to vary considerably from that of older rocks. In many of the younger samples, the composition of the carbon isotopes differs significantly from that expected for typical rocks from the mantle.

The isotope ratio $R = {}^1\mathrm{3C}/{}^1\mathrm{2C}$ for Carbon in the deep mantle is considerably lower for the kimberlites younger than 250 Ma whereas the value for kimberlites older than 250 Ma is typical mantle value. The values of younger kimberlites are also more variable. More quantitatively, $\delta^{13}C = (R_{sample}/R_{standard} - 1) \times 10^3$ serves as a parameter. For a typical sample from the mantle, the value is $\delta \simeq -5 \pm 1$ per mille whereas for the studied samples δ is in the range [-20.-30] per mille.

The increased subduction caused by plate tectonics of the material from the surface of Earth could explain this. The estimate is that it takes 200 Ma for the material from the surface to reach the lower mantle. In the standard geology, the natural interpretation is that the dramatic increase in the generation of organic matter in CE has reduced the carbon isotope ratio. One must however assume that the partly organic material from the surface should have ended down to the deep mantle along specific routes by subduction.

Is the TGD inspired hypothesis for Cambrian Explosion life consistent with these findings?

1. The proposal is that life evolved in underground oceans ("womb of Mother Gaia") and suddenly emerged to the surface in the CE as highly developed multicellular organisms. CE was caused by a rapid increase of Earth radius by factor 2, which generated bursts of the underground water reservoirs to the surface and created the oceans. The expansion broke the Earth's crust to pieces and led to the emergence of plate tectonics, subduction, and oceans. Note that in Mars this tectonics is not present and the radius of Mars is actually roughly 1/2 of the radius of Earth.

2. The rapid increase of the Earth radius is the TGD counterpart for a smooth increase of Earth radius in cosmic expansion. All astrophysical objects look as if they would not participate in cosmic expansion: this is a mystery in general relativity. In TGD this mystery is resolved by replacing smooth cosmological expansion with a sequence of rapid expansions followed by stationary periods [L46] [L93].

Is the TGD view consistent with the findings of Giuliani *et al*?

1. The conclusion of Giuliani *et al* seems undeniable: the isotope decomposition in the mantle changed 200 Ma ago and was caused by the transport of the material affected by CE to the lower mantle.

2. In the TGD framework these findings do not however force the conclusion that life emerged suddenly in CE. Rather, multicellular life was present in the underground oceans before CE but plate tectonics and subduction were absent.

   The increase of the radius of Earth reduced the average density of Earth dramatically, and created the proposed subduction routes to the lower mantle, which dramatically increased the rate of transport of the organic material to the deep mantle.

3. Interestingly, the process analogous to CE appears to have occurred episodically throughout most of Earth's history, with the oldest diamonds that contain eclogitic inclusions forming

at roughly 3 billion years (Ga) [F41]. In the TGD framework this suggests that the rapid expansions of Earth have occurred episodically and have led to the emergence of life forms from the interior to the surface and the transport of the material containing organic carbon to the mantle.

10.8.2 Objections against EEM and their resolution

There are several objections against EEM.

The reduction of density by factor 1/8 is impossible in standard physics

New physics is needed to make so dramatic a reduction of the density possible. The natural assumption is that the thickness of flux tubes of the magnetic body basically responsible for the density of condensed matter increased by a factor 2 and induced the increase of the radius of atomic volume. One can consider two options for what happened at the atomic level.

Option I. The value of h_{eff} labelling dark matter as phases of ordinary matter increased by factor 2, which led to scaling of atomic sizes by this factor and induced the reduction of the density by factor 1/8. The findings of Randel Mills can be explained if one has $h_{eff} = 6h_0$, where h_0 is the minimum value of $h_{eff} = nh_0$. The problem is that the total binding energy of electrons must have been compensated in the transition and it is not clear whether the energy liberated in the thickening of the flux tubes can provide the needed energy.

For Fe, which is also biologically important, the needed energy is for for $h_{eff} = h/2$ about 52 keV and seems quite too large if the string tension of atomic flux tubes is scaled to atomic scale from the hadronic string tension giving energy of order 10 keV per atomic length $L(137)$. The phase transition should have been entropy driven.

Note that in the TGD framework, the second law is implied by the negentropy maximization principle (NMP) for the sum of non-positive entanglement negentropy in the real sector, and the non-negative p-adic entanglement negentropy assignable to cognition. NMP forces the increase of the total entanglement negentropy and its positivity. This also forces the increase of entanglement entropy of ordinary matter. Thus the entropy driven phase transition allowing the emergence of Fe essential for oxygen based life would have meant an increase in negentropy and an evolutionary leap as it indeed meant. $h/2$ option is of course non-realistic but the argument applies also to the second option.

$h/2$ phase could have prevailed only during the period when the temperature was so high that atoms were unstable against ionization for the ordinary value of h. One can argue that as atomic physics with $h_{eff} = h$ became thermodynamically possible, it emerged in a phase transition. The electronic binding energies in question are of order $(Z/n)^2 E_H$, $E_H = 13.6$ eV. For instance, for Ca this temperature is about 2.7×10^8 K and corresponds to the temperature at which nuclear reactions become possible. The possible $h/2$ atomic physics might make itself visible at these temperatures.

Option II. Chemistry, and therefore the density of the condensed matter, is believed to be determined by chemical bonds, in particular by valence electrons. The TGD based view of valence bonds is discussed in [L31, L132]. Could the thickening of flux tubes by a factor 2 have induced the increase of h_{eff} of the valence electrons by a factor 2.

In the sequel these two options will be considered.

How could photosynthesis emerge in the Earth interior?

The animals that emerged in EEM performed photosynthesis. How could photosynthesis emerge inside Earth where ordinary solar light cannot get? I have proposed that dark photons with non-standard value of h_{eff} travelling along magnetic flux tubes managed to reach the evolving life inside Earth.

The recent proposals allow variants of this explanation.

Option I. The solar radiation with $h_{eff}/h_0 = 6$ was dark relative to the environment surrounding the water pockets. Life could have evolved already before or during CE in the water pockets with $h_{eff} = h = 6h_0$ larger than $h_{eff} = 3h_0$ in the environment. Solar photons with

$h_{eff} = h = 6h_0$ did not "see" the presence of the environment because via direct interactions describable as Feynman graphs. Only the transformation $h_{eff} = 6h_0 \to 3h_0$ of the solar photon made scattering and absorption possible.

Option II. If the values of h_{eff} for the valence electrons were scaled up by a factor 2 inside the water blobs with flux tubes having thickness twice of those in the environment, and if valence electrons indeed determine what atoms are chemically, the water blobs would have behaved like dark matter relative to environment, and could have survived inside Earth.

The temperatures in crust and mantle are too high to allow the emergence of multicellular life

One can argue that the temperature in the crust and mantle is too high to allow the presence of multicellular or even monocellular life. However, if the pockets and environment were dark relative to each other, the situation changes. There would have been a very low rate of transfer of energy between these phases. The temperatures of pockets could have been much lower than that of the environment.

The gradual approach to thermal equilibrium characterized at magnetic body (MB) by Hagedorn temperature would have led to "death" of these primitive life forms but the occurrences of ordinary ("big") state function reduction reversing the arrow of time would have meant reincarnation with opposite arrow of time. This would conform with the TGD based view about life based on zero energy ontology (ZEO) [L131].

The original proposal that multicellular life evolved in the Earth's interior already before CE, is consistent with both options. The water at the surface of Earth was present already billions of years ago, and could have been dark in either of the proposed senses so that it could have leaked to the Earth interior and formed pockets with low temperature and low pressure. Note that solar light must have had $h_{eff} = 6$ already at time and for Option I could have induced the h_{eff} changing phase transition for the water molecules and perhaps also of the other molecules at the surface of Earth.

The proposed explanation of the Fermi paradox in terms of intra-planetary life would be nice but the obvious objection is that the circumstances in the interior make chemical life (as we know it) impossible unless some new physics, which allows the thermo-dynamical conditions prevailing at the surface of Earth, is involved.

Option I. Could the dark planets with $h_{eff} = h/2$ contain intra-planetary life as Earth did before CE, so that both the darkness of these planets and the lower evolutionary level of this life would be the reason for the failure to observe this life.

Option II. Also the scaling $h_{eff} \to 2h_{eff}$ for valence electrons could allow dark water blobs inside all planets if one believes that valence electrons dictate chemistry.

10.8.3 How the reduction of the density of Earth was possible?

The increase of the radius of Earth by a factor of 2 means that the average density is reduced by a factor 1/8 (in the case the system is genuinely 3-D; one can consider also effectively 1-D flux tube spaghetti). In standard condensed matter physics this kind of change in the local density is impossible.

The reason is that the density ρ - and thus the number density $n = \rho/mp$ of nucleons of condensed matter increases slowly with the mass number A (`https://cutt.ly/LbGMu9u`. Only very high pressures and chemical composition involving heavy elements can affect n significantly. For instance, the density of Earth varies from 2.2 g/cm^3 in the crust to 13 g/cm^3 in the inner core (`https://cutt.ly/4bD0JIr`) and therefore roughly by a factor 6.

Interestingly, the density of water is 1 g/cm^3 and by a factor $r < 1/2$ lower than the densities of the components of the crust. The low mass density of water might make it somehow special. Could water be seen as a mixture of phases with varying densities corresponding to varying radii for the flux tubes as suggested in [L51] to explain the numerous thermodynamic anomalies of water. The phases would correspond to different values of $h_{eff} = nh_0$ for flux tubes. The thickness of the flux tube would correspond to the p-adic length scale determined by the p-adic prime identified as a ramified prime associated with the extension.

If the local density at least in the mantle and crust contributing roughly one half to the total mass of Earth remained unchanged, a kind porous structure with pores filling 7/8 of the volume would have been formed. This looks implausible.

It seems that the expansion - if it happens at all - involves new physics.

Does the TGD view about dark matter allow to understand the reduction of the density

The basic prediction of the adelic physics [L34, L35, L9] is the identification of dark matter as hierarchy of phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$.

1. In adelic physics n is interpreted as a degree of polynomial determining the space-time regions which corresponds to the particle. n measures the algebraic complexity of space-time region and serves as a kind of IQ and measure of the scale of quantum coherence. Evolution would corresponds to the increase of algebraic complexity and therefore also to the increase of n.

2. Functional composition of polynomials would give rise to evolutionary hierarchies in which the degree of polynomial at a given level divides the degrees at higher levels [L73, L74]. For instance $n = 3 \to n = 6$ conforms with this picture.

3. $n = 1$ would correspond to the simplest form of matter: the roots of polynomials defining the the space-time region would be rational and if the polynomial is irreducible, it is linear polynomials with rational coefficients. It is not clear whether $n = 1$ phase does exist.

   The phases with different values of n would not have direct couplings with ordinary matter describable in terms of Feynman diagrams. The transformation of particles, say photons, with different values of h_{eff} to each other are however possible and would occur for photons. Biophotons would be ordinary photons resulting from $h_{eff} > h$ dark photons by this kind of transition.

There are two guidelines available.

1. The scaling by factor 2 suggests a transition $h_{eff} \to 2h_{eff}$. Option I and II are possible.

2. The findings of Randel Mills [D7] can be understood if $h_{eff} = h = 6h_0$ holds true for ordinary matter [L24] and in the experiments of Milss a phase with $h_{eff} = 3h_0$ was formed. This would support Option I.

Although it turns out that Option I is not plausible model for CE, the phase transition $h_{eff} = 3 \to h_{eff} = 6$ is interesting as such.

1. This transition could have preceded by a transition $h_{eff} = h_0 \to 3h_0$ of $n = 1$ phase is possible at all. One could imagine a hierarchy in which cosmic strings correspond to $n = 1$ and flux tubes obtained by their thickening correspond to $n > 1$ phases. n cannot however directly relate to the value p-adic length scale characterizing the string like object.

2. Fine structure constant is proportional to $1/h_{eff}$ and would have decreased by a factor 1/2 from its value before the transition. The atomic binding energy scale would have been 4 times larger.

   If $h_{eff} = 3$ is possible for stars, the radiation from them has an energy spectrum scaled up by factor 4. $h_{eff} = 3$ photons should transform to ordinary $h_{eff} = 6$ photons before interaction with the ordinary matter. The rate for this transformation could be low so that this kind of stars are difficult to observe. Dark matter could therefore be partially also $h_{eff} < 6$ matter.

3. One can ask whether the $h_{eff} = 3 \to 6$ transformation of the planetary matter near the planetary surface was induced by the interaction with solar radiation. The second question is whether it took place for each planet independently or whether a collective phase transition in cosmological scales occurred. The minimal assumption is that this transition is part of the evolution of the astrophysical object and those objects for which it has not occurred are dark relative to us.

$h_{eff} < h$ phase would represent only one form of dark matter when darkness is regarded as a relative notion. Valence electrons would also represent dark matter with $h_{eff} = h_{em} > h$ as also dark protons assignable to hydrogen bonds. Another form would be the Kähler magnetic and volume energy and possibly dark particles at cosmic strings transformed to flux tubes. This includes the dark matter satisfying Nottale hypothesis $h_{eff} = h_{gr} = GMm/v_0$ and associated with gravitational flux tubes [E5].

4. Both planets and observed exoplanets must have $h_{eff} = 6$ since the reflection of solar light from the surface is expected to be occur only if the $h_{eff} = 6$ stellar photons transform to $h_{eff} = 3$ photons. Note that the known exoplanets belong to the Milky Way whose size is about 50,000 ly and much shorter scale than the 500 million ly defined by the time of CE.

5. Planet 9 (`https://en.wikipedia.org/wiki/Planet_Nine`, whose existence has been proposed because its gravitational field could explain the unusual clustering of orbits for a group of extreme trans-Neptunian objects (ETNOs), bodies beyond Neptune that orbit the Sun at distances averaging more than 250 times that of the Earth. Planet 9 is too distant to be seen directly. Witten has proposed an interpretation as a blackhole [E6]. An alternative identification would be as an $h_{eff}/h_0 < h$ object.

6. The $h_{eff} = 6h_0$ life in the interiors of $h_{eff} = 3$ planets could be considered as a possible solution of the Fermi paradox. In the proposed model, the life below the surface of Mars would be possible only near its surface and mono-cellular as most of the life in the Earth's crust.

Cambrian explosion as a quantum jump in a planetary scale?

In ZEO [L69, L85] based quantum measurement theory, there are two kinds of state function reductions (SFRs): "big" (ordinary) state function reductions (BSFR), which involve time reversal and "small" SFRs, which correspond to "weak" measurements in which the arrow of time is preserved. The sequence of SSFRs defines a conscious entity and aBSFR can be regarded as death in a universal sense.

In biology BSFR [K50] [L131, L130] corresponds to the death of subsystem and its re-incarnation with an opposite arrow of time occurring at the level of magnetic body (MB) of the system controlling it because of this higher IQ due to the much larger value of h_{eff}. h_{eff} hierarchy predicts that quantum coherence and SFRs are possible in all scales at the level of MB.

Although BSFR is discontinuous, it looks for an observer with a standard arrow of time (briefly, "outsider") like average over deterministic time evolutions leading to the final state of BSFR. In the ZEO framework, the Universe looks therefore classical in all scales.

Could CE correspond to BSFR, or actually two BSFRs to achieve original arrow of time - at the level of MB? The duration of the average deterministic classical time evolution of this BSFR seen by an outsider would be about 13-25 million years.

What CE as BSFR could look like for an outsider?

1. Water has a unique role in biology since living matter consists mostly of water. In TGD inspired quantum biology it is seen as a primitive life form preceding chemical life. For instance, water memory would be behind the immune system [K47].

   Pollack effect [L13, I143, I123], associated with water irradiated in the presence of gel phase and leading to the formation of negatively charged exclusion zones (EZs), would be behind charge separation associated with cell, DNA, and microtubules. Part of protons would become dark and would be transferred to magnetic flux tubes where they could give rise to a fundamental representation of genetic code [L20, L57]. An attractive assumption is that the phase transition thickening the flux tubes by factor of 2 occurred first for the water phase. The density of water is one half of that from that for the density of the crust and this could be understood if water consists of flux tube-like structures.

2. Since solar radiation was present already billions of years ago and also Earth was covered by water, it is possible that the solar radiation induced the phase transition for water at the surface of Earth. Call this water activated water.

For both Options I and II, the electromagnetic interactions of the activated water with the matter of primordial Earth were very weak and it could leak to the Earth interior - not as a crystal water but as pockets with much lower temperature and pressure inside Earth. The solar radiation also reached the interior of the Earth so that an evolution leading to photosynthesis and metabolic machinery could have indeed occurred in the interior in the womb of Mother Gaia.

Note that the TGD based model for valence bonds [L31] requires that solar radiation corresponds to several values of h_{eff} or that the transitions of $h_{eff} = 6 \rightarrow h_{eff} > h$ are possible.

3. Pollack effect could have led to the formation of the basic structures of the chemical life inside these pockets. The flux tube connections with large h_{eff} between pockets could have formed and made possible larger structures consisting of separate units and controlled by its MB. Even underground oceans can be imagined.

4. One can consider two options for the evolution of multicellulars. According to the original option, multicellular life evolved already before CE. The standard view about CE is that it occurred during CE. In the TGD framework, the original option looks more plausible. The emergence of life would mean a scaling $h_{eff} \rightarrow 2h_{eff}$ for valence electrons (Option II) $h_{eff} = 3 < h$. Scaling $h/2 \rightarrow 2h$ for all electrons (Option I) looks implausible. Maybe the liquid phase and low density could allow to understand why.

10.8.4 The transition increasing flux tube thickness as a phase transition induced by magnetic body

There are two options to consider: I and II. Option I assuming that the thickening of flux tubes by factor 2 induces the phase transition $h/2 \rightarrow h$ does not seem realistic. It is however possible that this phase transition has occurred much earlier at temperatures allowing nuclear fusion and could also occur in the laboratory in these circumstances.

The following discussion applies to both options: the only difference is that the total electron binding energy E_B is replaced with that for valence electrons.

The best manner to proceed is to develop objections against the proposals. It is easy to develop a rather scaring objection.

Minimization of free energy as basic principle

The minimization of free energy F can be taken as a basic principle since temperature is expected to remain constant during the phase transition.

1. If the temperature stays constant in the transition,the basic thermodynamic condition is that free energy decreases

$$\Delta F = \Delta E - T\delta S \leq 0 \ . \tag{10.8.1}$$

2. One can express ΔE as

$$\Delta E = \Delta E_B + \Delta E_{MB} \ . \tag{10.8.2}$$

The subscript "B" refers to the binding energy which for Option I is the total binding energy $E_B = E_{B,atom}$ and for Option II the total binding energy $E_{B,val}$ of valence electrons. The subscript "MB" refers to the magnetic body assignable in the TGD framework to magnetic flux tubes, whose thickening by a factor 2 would liberate energy and kick the atoms to new ground states.

3. From the $1/h_{eff}^2$ proportionaly of the binding energies, the reduction of the binding energy in the transition is given by

$$\Delta E_B = \frac{3E_B}{4} \quad . \tag{10.8.3}$$

The thickness of the flux tube is expected to correspond to the atomic length scale of order Angstrom so that atomic physics would involve a new length scale relevant for the density of condensed matter.

$$\Delta E = \Delta E_{B,tot} + \Delta E_{MB} \quad . \tag{10.8.4}$$

4. One can express ΔS in an analogous manner

$$\Delta S = \Delta S_{atom} + \Delta S_{MB} \quad . \tag{10.8.5}$$

The subscript "atom" refers to entropy assignable to scaledup atoms and "MB" to magnetic body.

One can consider two ways to satisfy this condition depending on whether the transition is energy or entropy driven.

1. For $\Delta S = 0$, one has $\Delta E \leq 0$. This would mean that the energy needed to kick electrons to new states with binding energy reduced by factor $1/4$ must come somewhere. The fundamental quantum phase transition at MB should provide it, most naturally as energy liberated when the string tension of flux tubes is reduced as they thicken.

2. The alternative option is that that the transition develops a lot of entropy

$$\Delta S \geq \frac{\Delta E}{T} \quad . \tag{10.8.6}$$

It is important to note that in the TGD framework negentropy maximization principle (NMP) is the basic principle and implies second law for ordinary matter.

The p-adic contribution to entanglement negentropy coming from cognition ispositive unlike real contribution, which is non-positive. NMP implies that in adelic physics p-adic contribution to negentropy exceeds in general real contribution. The generation of p-adic negentropy however forces also a generation of real entropy and this conforms with the paradoxical proposal of Jeremy England that living systems produce entropy.

In the recent case the generation of large entropy at the level of visible matter would correspond to a generation of large p-adic negentropy assignable to the MBs in question. Hence the Cambrian phase transition would mean a cognitive revolution of some kind.

Estimates for the total binding energy

The following rough estimates assume Bohr model. In Bohr model, the atomic energies at a given shell n, which corresponds to the row of the Periodic Table. The energy shell contains n^2 states with angular momenta $l = 0, .., n-1$ are given by $E_n = (Z^2/n^2)E_H$. The number of states in full shell is $2n^2$. Full shells are realized only for $n = 1, 2$. The total binding energy in a full shell is nZ^2E_H, $E_H \simeq 13.6$ eV.

One could naively argue that the filling of all sub-shells l is energetically more favorable since the total binding energy would be maximized in this manner. However, already for $n > 3$ only the 8 states at s and p subshells are realized and d shell is missing so that the $n = 3$ shell contains the same angular momentum eigenstates as $n = 2$ shell. For $n = 3$ shell Argon corresponds to configuration $[Ne]s^2p^6$. K does not correspond to$[Ne]s^2p^6d$ but to [Ar]4s. The reason for this is not clear to me and one can of course ask whether the $h/2 \to h$ could have favored smaller binding energies and even led to the increase of n instead of full shell.

The expression for the total binding energy is given by

$$E_B = \sum_n N_n \frac{Z^2}{n^2} E_H \quad , \quad E_H = 13.6\ eV \quad . \tag{10.8.7}$$

For full shells (the rows $n = 1, and 2$) $N_n = 2n^2$ and the energy is $2Z^2$.

The following equations represent the total binding energies in Bohr model for some important ions in biology.

$atom$	Z	$configuration$	E_B/E_H	E_B/keV	$\lambda/\AA$
O	8	$[He]2s^22p^4$	$8^2(2+3/2) = 224$	3.05	4.1
P	15	$[Ne]3s^23p^3$	$15^2(2+2+5/9) = 1025$	13.9	.9 (10.8.8)
Ca	20	$[Ar]4s^2 = [Ne]3s^2p^64s^2$	$20^2(2+2+8/9+1/8) = 2050 - 400/9 \simeq 2005.6$	27.3	.45
Fe	26	$[Ar]3d^64s^2$	$26^2(2+2+14/9+1/8) = 3840.1$	52.2	.22

Note that Bohr radius is .53 Å so that for Ca the wavelength defined λ defined formally by the total binding energy is rather near to Bohr radius. The energies are rather high. For valence electrons the total binding energies are much lower and for Fe one has $E_{val}(Fe) = 1.15keV$.

These results support the view that Option II is more realistic than Option I.

1. The flux tubes are characterized by a p-adic length scale L_p, where p-adic length scale hypothesis states $p \simeq 2^k$. One has $L_p \equiv L(k) \simeq 2^{(k-151)/2}L(151)$, $p \simeq 2^k$, $L(151) \simeq 10$ nm. p-adic length scale $L(137) = 2^{-7}L(151)$, corresponds to .78 Å and $L(139)$ to 1.56 Å.

2. The magnetic flux tubes assignable to condensed matter and determining the density of the condensed matter should have thickened by a factor 2 in the transition. The phase transition $k = 137 \to 139$ is a natural candidate. Note that this pair defines twin primes.

   An estimate for the value of string tension follows from the hadronic string tension $T_H \simeq 1$ GeV^2, which corresponds to $k = 107$: this gives $T(137) = 2^{-137-127}T_H = 2^{-30}T_H \simeq 1eV^2$. The energy of a string portion with length $L(137)$ is $E(137) \simeq 10$ keV. An energy of this order would would be been liberated in the transition $k = 137 \to 139$.

3. Option I does not look realistic. From **Eqs.** 10.8.8 one finds that for Ca the total binding energy is 27.3 keV. For Fe the energy is 46.1 keV. These energies are too large: the transition in the case of Fe should be strongly entropy driven.

4. Option II looks more reasonable. For Fe the total binding energy assignable to the valence bonds is $E_{val} = 1.2$ keV. The maximal binding energy of valence electrons is $Z^2(n^2 - 1)/n^2E_H \simeq Z^2E_H$. Not all angular momentum subshells are however filled and this energy is maximum for atoms towards the right end of the row and for Krypton one has $n = 3$ is $D_{val} = 1.1$ keV. 1.24 keV corresponds to the energy of a photon with a wavelength of 1 Angstrom, qhixh looks also reasonable. Since the energy liberated from the flux tube portion is considerably higher than E_{val}, it would have induced expansion.

What could one say about the phase transition at the level of MB?

The phase transition at the level of MB induces the phase transition at the lower levels. Can one say anything about the phase transition at the level of MB?

1. The twistor lift of TGD predicts that energy of the magnetic flux tube is a sum $E = E_1 + E_2$ of two terms.

   The first term is a volume term proportional to the TGD counterpart of cosmological constant Λ predicted to be length scale dependent and by dimensional considerations proportional to $1/L_p^2 G$. Λ would be reduced by a factor 1/4 in the proposed transition transitions. This terms gives a contribution

   $$E_1 = aSL \ ,$$

   where S is the transversal area of the flux tube and L its lengthThe scaling $a \to a/2$ would occur in the transition.

   The energy also contains Kähler magnetic energy. If the flux tube carriesmonopole flux, the contribution is of form

   $$E_2 = \frac{b}{S} L \ ,$$

   Assume that the scaling $b \to b/2$ occurs in the transition.

2. The minimization of the total energy

   $$E = E_1 + E_2 = aS + \frac{b}{S} \tag{10.8.9}$$

   with respect to S is assumed and gives

   $$E = 2\sqrt{ab} \ . \tag{10.8.10}$$

   In the scaling the energy transforms as $E \to E/2$. The liberated energy $E/2$ could be used to reduce the binding energy of the atoms by $3E_B/4$.

3. The natural expectation is that the total energy for a flux tube portion of length L_p is of order of photon with a wavelength L_p. This energy is given by $E = \hbar/L_p = 1.24/L_p/\mu m$. For $k = 137$ this gives energy $E \simeq 16$ keV. For Ca one has $3E_B/4 = 20.5$ keV and for P one has $3E_B/4 = 10.3$ keV.

   This suggests that the first phase transition could take place only for the biologically important atoms and molecules formed from them - in particular water molecules - and would not produce much entropy. Second phase transitions identifiable as Cambrian explosion would take place for heavier atoms and require large ΔS in turn requiring large generation of negentropy at the level of MB. This would accompany a rapid evolution of life at the surface of Earth.

10.8.5 Cambrian explosion, the Great Oxidation Event, and Expanding Earth hypothesis

I encountered two interesting articles related to the Great Oxidation Event that started long before the Cambrian Explosion (CE) and reached its climax during CE (about 541 million years ago) leading to the oxygen based multicellular life in a very rapid time scale.

The standard view is that oceans before CE had very low oxygen content. The emergence of photosynthesizing cyanobacteria producing oxygen as a side product led to the oxygenation of the atmosphere and to mysteriously rapid evolution of life. How this is possible at all is not understood.

The first popular article (`https://cutt.ly/UQWZA31`) discusses the proposal [I83] that the slowing down of the spinning of Earth was somehow related to this. The idea is that the lengthening of the day made photosynthesis by cyanobacteria more effective since their reaction to the dawn of the day was slow. The second article in Quanta Magazine (`https://cutt.ly/PQWZDzD`) tells about the finding [I80] that during the Cambrian Explosion (`https://cutt.ly/1QWZF4E`) the oxygen content of the studied shallow ocean show fluctuations with with about 4-5 peaks. The reduction/increase of the oxygen content was even 40 per cent, which is a huge number. The reduction of oxygen content caused extinctions and its increase was accompanied by the emergence of new species. The mystery is how this could happen so fast and which caused the fluctuations.

Expanding Earth hypothesis

Expanding Earth theory hypothesis is not originally TGD based but TGD provides its realization. The proposal is that the Cambrian Explosion was caused by a rapid increase of the radius of Earth by factor 2 [L46, L93].

This hypothesis also solves one of the basic mysteries of cosmology. Astrophysical objects participate in cosmological expansion by comoving with it but do not expand themselves. Why? The prediction that the expansion of the astrophysical objects did not occur smoothly but as rapid phase transitions and the expansion was very slow in the intermediate states. Cambrian Explosion would correspond to one particular jerk of this kind in which the radius of Earth grew by a factor 2 (p-adic length scale hypothesis). The length of the day increased by factor 4 from conservation of angular momentum. This might relate to the conjecture of the first article.

The rapid expansion led to the breakage of the Earth crust and to the birth of plate tectonics. It also led to the burst of underground oceans to the surface of the Earth. The photosynthesizing multicellular life had developed in these oceans and emerged almost instantaneously and led to a rapid oxygenation of the atmosphere. One can say that life evolved in the womb of Mother Gaia shielded from meteorites and cosmic rays. No superfast evolution was needed. Already Charles Darwin realized that the sudden appearance of trilobites was a heavy objection against the theory of natural selection.

Possible scenarios for the phase transition are discussed in [L93]. The thickening of magnetic flux tubes for water blobs at the surface of Earth led to the increase of the volume of water blob and induced the increase of h_{eff} a factor 2 for valence electrons but not for the inner electrons. Since valence electrons are responsible for chemistry, atoms became effectively dark and the water blobs could leak to the interior of Earth. By their darkness they could have much lower temperature and pressure than the matter around them and the life could evolve.

How photosynthesis was possible underground?

What made photosynthesis possible in the underground oceans? One possible explanation is that the photons from the Sun propagated along flux tubes of the "endogenous" part of the Earth's magnetic field as dark photons with $h_{eff} = nh_0 > h$. Endogenous part would be the part of Earth's magnetic field with a strength about 2/5 of the Earth's magnetic field for which flux tubes carry monopole flux: this is possible in TGD but not in Maxwell's theory.

Since these photons behave like dark matter with respect to the ordinary matter, they were not absorbed considerably and reached the water blobs (or actually their magnetic bodies consisting of flux tubes) in underground oceans having a portion with the same value of $h_{eff} \geq h$. Of course, several values of h_{eff} were possible since this is the case in quantum critical system (large values of h_{eff} characterize the quantum scales of long range fluctuations). One can also consider other

variants of the model. The ordinary matter in Earth's crust had $h_{eff} = h/2$ and photons with $h_{eff} = h$ propagated to the interior and reached the water blobs with $h_{eff} = h$.

The sudden emergence of multicellulars and oxygen fluctuations

Before the expansion period was much like the surface of Mars now and contained no oceans, perhaps some ponds allowing primitive monocellular lifeforms. As the ground of Earth broke here and there during the rapid expansion period, lakes and oceans were formed at the surface of Earth. The multicellulars bursted to these oceans and oxygenation of the atmosphere started locally.

Since the oxygen rich water was mixed with the water in the shallow oceans, the local oxygen content of the burst water was reduced and this led to an eventual extinction of many multicellulars in the burst. Burgess Shale fauna contained entire classes, which suffered extinction. In the average sense the oxygen concentration increased and led to the apparent very rapid evolution of multicellulars, which had actually already occurred underground. Of course, also evolution at the surface of Earth took place.

10.9 Has venus turned itself inside-out and why its magnetic field vanishes?

News about unexpected findings relating to the physics of astrophysical objects emerge on an almost daily basis. The most recent news (`https://cutt.ly/YQSZgpv`) told about the lack of craters and volcanic activity in Venus (`https://cutt.ly/wQSZzaS`). The findings are actually not new. The resurfacing history of Venus was summarized 1979 by Schaber *et al* [E10] . Turcotte and Rome have proposed cyclic global catastrophic events as an analog of the plate tectonics allowing a heat transfer from the interior of Venus and effectively turning Venus inside out [E13].

The Venus does not have appreciable magnetic field although dynamo mechanism suggests magnetic field as in the case of Earth, has been also known.

10.9.1 Has Venus turned itself inside-out?

The surface of Venus was expected to have craters, just like the surface of Earth, Moon, and Mars but the number of craters is very small. The surface of Venus also has weird features and many volcanoes. Also trace signs of erosion and tectonic shifts were found. The impression is that the surface of Venus had been turned inside out in a catastrophic event that occurred about 750 million years ago.

Since Venus is our sister planet with almost the same mass and radius, it is interesting to notice that the biology of Earth experienced the Cambrian explosion 541 million years ago.

1. The TGD explanation for Cambrian Explosion relies on Expanding Earth Model (EEM) [L46, L45, L93]. The model assumes that there was a relatively fast increase of the Earth's radius by factor, which led to the burst of underground oceans to the surface of the Earth and led to the formation of oceans. Standard cosmology predicts a continuous smooth expansion of astrophysical objects. Contrary to this prediction, astrophysical objects do not seem to expand smoothly. In the TGD Universe, the smooth expansion is replaced by rapid jerks and the Cambrian Explosion would be associated with this kind of phase transitions.

2. In this expansion the multicellular photosynthesizing life burst to the surface. This explains the sudden emergence of highly evolved life forms during the Cambrian Explosion that Darwin realized to be a heavy objection against his theory.

3. There are many objections to be circumvented. For instance, how photosynthesis could evolve in the underground ocean. Here TGD views dark matter as $h_{eff} = nh_0$ phases of ordinary matter, which are relatively dark with respect to each other, come in rescue. Dark water blobs could leak into the interior of Earth and the solar light possessing a dark portion could do the same so that photosynthesis became possible [L93].

4. Did Venus experience a similar rapid expansion 200 million years earlier, about 750 million years ago (or maybe roughly at the same time). Venus does not have water at its surface. This can be understood in terms of heat from solar radiation forcing the evaporation of water and subsequent loss. This also prevented the leakage of the water to the interior of Venus. If there were no water reservoirs inside Venus, no oceans were formed. The cracks of the crust created expanding areas of magma, which were like the bottoms of the oceans at Earth. Also at Earth a fraction about 2/3 of the Earth's surface is sea bottom.

10.9.2 Why does Venus not possess a magnetic field?

Venus also offers a second puzzle. Venus does not have an appreciable magnetic field although it has been speculated that it has had it (`https://cutt.ly/VQSZt9m`). The solar dynamo mechanism would suggest its presence.

1. TGD predicts that there are two kinds of flux tubes carrying Earth's magnetic field B_E with a nominal value of .5 Gauss. This applies quite generally. The flux tubes have a closed cross section - this is possible only in TGD Universe, where the space-time is 4-surface in $M^4 \times CP_2$. The flux tubes can have a vanishing Kähler magnetic flux or non-vanishing quantized monopole flux: this has no counterpart in Maxwellian electrodynamics.

   For Earth, the monopole part would correspond to about .2 Gauss - 2/5 of the full strength of B_E.

2. Monopole part needs no currents to maintain it and this makes it possible to understand how the Earth's magnetic field has not disappeared a long time ago. This also explains the existence of magnetic fields in cosmological scales.

   The orientation of the Earth's magnetic field is varying. In the TGD based model the monopole part plays the role of master. When the non-monopole part becomes too weak, the magnetic body defined by the monopole part changes its orientation. This induced currents refresh the non-monopole part [L17]. The standard dynamo model is part of this model.

3. There is an interesting (perhaps more than) analogy with the standard phenomenological description of magnetism in condensed matter. One has $B = H + M$. H field is analogous to the monopole part and the non-monopole part is analogous to the magnetization M induced by H. $B = H + M$ would represent the total field. If this description corresponds to the presence of two kinds of flux tubes, the TGD view about magnetic fields would have been part of electromagnetism from the beginning!

   Flux tubes can also carry electric fields and also for them this kind of decomposition makes sense. Could also the fields D, P, and E have a similar interpretation?

   In the linear model of magnetism, one has $M = \chi H$ and $B = \mu H = (1+\chi)H$. For diamagnets one has $\chi \leq 0$ and for paramagnets $\chi \geq 0$. Earth would be paramagnetic with $\chi \simeq 3/2$ if the linear model works. χ is a tensor in the general case so that B and H can have different directions.

4. All stars and planets, also Venus, correspond to flux tube tangles formed from monopole flux tubes. This leaves only one possibility. Venus behaves like a super-conductor and is an ideal diamagnet with $\chi = -1$ so that B vanishes. The monopole part would be present however.

   This could provide a totally new insight to the Meissner effect and loss of superconductivity. In TGD the based model [L80], monopole flux tubes carry supracurrent. The BCS model however requires the absence of a magnetic field. Could the induced non-monopole field cancelling the monopole part. Venus would indeed be a superconductor!

5. The TGD based model of superconductivity [L80] also predicts superconductivity driven by an external energy feed would be also above critical temperature. The energy feed would increase the value of h_{eff} and below the critical temperature it would be provided by the energy liberated in the formation of Cooper pairs, which need not actually be the current

carriers since dark electrons can carry the current without dissipation. In TGD inspired biology and quite universally, the basic role of metabolic energy feed is to prevent the reductions of the values of h_{eff}.

Superconductivity means in the TGD framework large h_{eff} and therefore complexity, intelligence, and long quantum coherence length [L132]. Could Venus be alive but in a very different sense than Earth?

6. Could the superconductivity be forced by the thermal energy feed from the interior of Venus? The tilt of the rotation axis relative to the plane of rotation around the Sun is very small for Venus, about 3 degrees and much smaller than for the Earth. This implies that the surface temperature of Venus is roughly constant. At Earth plate tectonics makes possible the heat transfer from the interior to the surface and its leakage to outer space. For Venus this is not possible. Could the energy flow from the interior of Venus force the superconductivity by increasing the values of h_{eff}. This would in turn force the vanishing of the magnetic field of Venus.

7. Sun has an enormous feed of metabolic energy from the core: could it be alive? Also in the case of Earth, the energy feed from the interior could have been crucial for the development of life in the interior of Earth and made possible even the development of photosynthesis.

   The possibility that life actually appears in cosmic scales and is associated with quantum coherent flux tube networks associated with the active galactic nuclei usually identified as supermassive blackholes containing stellar and planetary systems as tangles is suggested by the TGD based model of galactic jets [L91] explaining also ultrahigh energy cosmic rays. The model inspires the proposal that active galactic nuclei having typically sizes 1-2 AU (!) involve gravitationally quantum coherent regions of radius at most of the Schwartschild radius defining a minimal gravitational Compton length [L91].

8. Also Mars lacks the global magnetic field although it has auroras assigned with local fields. Could also Mars be alive in the same same sense as Venus? Note that the recent radius of Mars is about 1/2 of Earth's radius. If Venus expanded by factor 2, all these 3 planets would have had roughly the same radius for about 750 million years ago. Mars would be waiting for the moment of expansion.

10.9.3 Could superionic phase of water give rise to planetary superconductivity and Meissner effect?

A superionic ice-like phase of water at high temperature and pressure (20 GPa but much less than the expected pressure, which is higher than 50 GPa) has been discovered. Inside Earth, 20-25 GPa pressure exists in the transition zone between upper and lower mantle. The new phases, bcc and fcc cubic lattices emerge at T=2000 K. See the popular article "*Scientists find strange black 'superionic ice' that could exist inside other planets*" (`https://www.eurekalert.org/news-releases/933099`) and the article "*Structure and properties of two superionic ice phases*" of Prakapenka *et al* [D9] (`https://cutt.ly/7TPvYlL`).

The bonds between hydrogen atoms and oxygen ions are broken in this phase and ionized hydrogen atoms form a fluid, a kind of proton ocean in which the oxygen lattice floats.

In the TGD framework dark proton sequences with effective Planck constant $h_{eff} \geq h$ at monopole magnetic tubes play a key role in quantum biology. Dark DNA codons would be 3-proton triplets at monopole flux tubes parallel to DNA strands and would give rise to a fundamental realization of the genetic code.

One can wonder whether the protons of this superionic could be dark in the TGD sense and reside in monopole flux tubes. Could they form a superfluid-like or superconductor-like phase by a universal mechanism which I call Galois confinement, which requires that the total momenta of composites of dark protons with are algebraic integer valued momenta are ordinary integers in suitable units (periodic boundary conditions) [L88, L90].

It is conjectured that this kind phase could reside in the interiors of Neptune and Uranus perhaps even deep inside the Earth. Could superionic phases of water in the interior of planets

like Mars and Venus give rise to the speculated super-conductivity implying the vanishing of large scale magnetic field via the TGD variant of the Meissner effect?

Could superionic ice appear in the interior of Earth? Could one consider the following scenario?

Primordial Earth had a vanishing magnetic field by the Meissner effect caused by superionic ice. Part of the superconducting superionic water melted and formed ordinary water at lower temperature and pressure and gave rise to underground oceans. Superconductivity was lost in the Earth scale but the monopole flux based magnetic field and the ordinary magnetic field induced by the currents that it generated remained but did not cancel each other anymore. In the transition increasing the radius of Earth by factor 2 during the Cambrian explosion the water in these oceans bursted to the surface of Earth.

Earthquakes that should not occur

There is an interesting finding, which seems to relate to the superionic ice. It has been discovered that there are earthquakes much deeper in the interior of Earth than expected (`https://cutt.ly/VTSEe5j`). These earthquakes are in the transition zone between upper and lower mantle and (the depth range 410-620 km) even below it (750 km). The pressure range is 20-25 GPa. The temperature at the base of the transition zone is estimated to be about 1900 K (`https://cutt.ly/jTSWxbA`). This parameter range inspires the question whether superionic could emerge at the base of the transition zone and whether the appearance of hydrogen as liquid in pores could make possible the earthquakes below the transition zone just as the presence of ordinary liquid in pores is believed to make them possible above the transition zone.

In the crust above 20 km depth the rocks are cold and brittle and prone to breaking and most earthquakes occur in this region. At deeper the rocks deform under high pressures and no breaking occurs. Deeper in the crust the matter is hotter and pressure higher and breaking does not occur easily.

Around a depth of 400 km, just above the transition zone, the upper mantle of the rock consists of olivine, which is brittle. In the transition zone olivine is believed to transform to wadsleyite and at deeper depth ringwoodite. At 680 km, where the upper mantle ends, ringwoodite would transform to bridgmanite and periclase. The higher pressure phases are analogous to graphite, which deforms easily under pressure and does not break whereas olivine is analogous to diamond and is brittle.

One can understand the earthquakes down to 400 km near the upper boundary of the transition zone in terms of the model in which water in the proposed upper mantle is pushed away from the pores by pressure, which leads to breaking. Below this depth water is believed to be totally squeezed out from the pores so that mechanism does not work. The deepest reported earthquake occurs at a depth 750 km and looks mysterious. There are several proposals for its origin.

The area of Bonin island is a subduction zone and it has been proposed that the boundary between upper and lower mantle is at a larger depth than thought. The cold Earth crust could allow a lower temperature so that matter would remain brittle since the transition to high pressure forms of rock would not occur. Another proposal is that the region considered is not homogenous and different forms of rock are present. Even direct transition of olivine to ringwoodite is possible and it has been suggested that this could make the earthquakes possible.

Could superionic ice and earthquakes relate?

TGD allows us to consider the situation from a new perspective by bringing in the notions of magnetic flux tubes carrying dark matter. Also the zero energy ontology (ZEO) might be highly relevant. The following represents innocent and naive questions of a layman at the general level.

1. ZEO inspires the proposal that earthquakes correspond to "big" state function reductions (BSFRs) in which the arrow of time at the magnetic body of the system changes. This would explain the generation of ELF radiation before the earthquake although one would expect it after the earthquake [L62].

   The BSFRs would occur at quantum criticality and the question is what this quantum criticality corresponds to. Could the BSFR correspond to the occurrence of a phase transition

in which the superionic ice becomes ordinary water? If this is the case, the transition zone, and also a region below it, would be near quantum criticality and prone to earthquakes.

2. The dark magnetic flux tubes are 1-D objects and possess Hagedorn temperature T_H as a limiting temperature. The heat capacity increases without limit as T_H is approached. Could a considerable part of thermal energy go to the flux tube degrees of freedom so that the temperature of the ordinary matter would remain lower than expected and the material could remain in a brittle olivine form.

3. Could the energy liberated in the earthquake correspond to the dark magnetic energy (for large enough value of h_{eff} assignable to gravitational magnetic flux tubes) assignable to the flux tubes rather than to the elastic energy of the rock material? Could the liberated energy be dark energy liberated as h_{eff} decreases and flux tubes suddenly shorten? Could this correspond to a phase transition in which superionic ice transforms to an ordinary phase of water?

One can also ask more concrete questions.

1. Suppose that water below the transition zone (P$\geq$ 20 GPa and T $\geq$ 1900 K) can exist in superionic ice containing hydrogen ions in liquid form. Could the high pressure force the superionic liquid out from the pores and induce the breaking?

2. In the range 350-655 km, the temperature varies in the range 1700-1900 K (`https://cutt.ly/jTSWxbA`). The temperature at the top of transition zones would be slightly above 1700 K. Could regions of superionic ice appear already at 1700 K, which is below T=2000 K?

3. Could the transition zone be at criticality against the phase transition to superionic water? This idea would conform with the proposal that the region in question is not homogenous.

Chapter 11

Expanding Earth Hypothesis and Pre-Cambrian Earth

11.1 Introduction

In this article I continue to develop the TGD version of the Expanding Earth hypothesis [L46]. More detailed views of the pre-Cambrian biology, geology, and thermal evolution of Earth and of what happened in the Cambrian explosion induced by the increase of the radius of Earth by factor 2 will be discussed.

The Expanding Earth Hypothesis (EEH) is discussed in various articles [L93, L83, L103].

1. Cosmic expansion according to general relativity (GRT) predicts that astrophysical objects should expand smoothly. This does not happen. In the TGD Universe, the expansion would be basically a quantum phenomenon and take place in rapid jerks and such a jerk would have induced Cambrian Explosion (CE).

2. Expandng Earth Hypothesis (EEH) statrd that the radius of Earth increased rather rapidly by a factor of about two in Cambrian Explosion (`https://cutt.ly/x2zaWAe`) (CE) that started about 541 million yours ago and lasted about 13-25 million years.

11.1.1 Vision of the evolution of life on pre-Cambrian Earth

The recent view of pre-Cambrian era has problems. How to solve faint Sun paradox (`https://rb.gy/mfhavz`): was some additional source of energy present and heat the surface of Earth to make liquid water possible? What happened in Great Oxygenation even (GOE) (`https://cutt.ly/K2jAxV9`)? Did deep oceans really exist? Did Snowball Earth (`https://rb.gy/qkoiah`) precede Cambrian Expolosion (CE) ()`https://cutt.ly/x2zaWAe`)? What happened in CE?

TGD view of EEH leads to a vision of how underground oceans could have served as seats for highly evolved photosynthesizing life, which bursted to the surface and formed the recent oceans.

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. 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.

11.1.2 A model for the phase transition increasing the radius of Earth by factor 2

The idea about relatively fast growth of the Earth radius by factor 2 (during 13-25 million years) 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). It must be admitted that the question of how this scaling could have occurred has remained poorly understood.

In this article, a model for how this scaling could have occurred is proposed. The key question that I was not previously aware of, relates to the energetics. Where did the required energy compensating for the decrease of the gravitational binding energy and providing the energy required by the expansion come from? Some new physics seems to be necessary.

In the TGD framework, the quantum phase transitions of the magnetic body (MB) increases the thickness of the flux tubes and reduce their string tension determined by Kähler magnetic energy and volume energy (to which a hierarchy of values of cosmological constant can be assigned). This leads to a liberation of energy and this energy feed could have made possible to induce ordinary phase transitions requiring energy.

The analogy between recent Mars and pre-Cambrian Earth suggests that the Earth had only a single core analogous to the recent inner core which is solid and consists mostly of Fe and Ni. The most natural phase transition would have transformed part of this core to the outer core which is liquid and has a smaller density and has also lower temperature. This could have forced at least the horizontal expansion of the mantle. The thickness of the mantle could have increased in a further transformation of the newly formed outer core to mantle or transfer of material from the outer core to the mantle.

In this article I continue to develop a more detailed TGD version of the Expanding Earth hypothesis explaining Cambrian Explosion (CE). In earlier articles [L46, L93, L116] a rather detailed view of the pre-Cambrian biology, geology, and thermal evolution is developed and one can relate it to the standard view. This involves topics like faint Sun paradox, the mechanism

of the Great Oxygenation Event, understanding the TGD counterparts of supercontinents Rodinia and Pannotia preceding CE, snowball Earth, and CE that led to a sudden emergence of highly advanced multicellulars.

Also a more detailed view of what happened in the CE induced by the increase of the radius of Earth by factor 2 emerged in [L116] (in the TGD Universe, a smooth continuous cosmological expansion is replaced with a sequence of short lasting and fast expansions). One ends up with a detailed model for the phase transition leading to the increase of the Earth radius. This phase transition requires a considerable energy feed provided by the phase transition thickening monopole flux tubes of the magnetic body of Earth and liberating energy. In analogy with the recent Mars, the pre-Cambrian Earth had a solid core analogous to the inner core. In the phase transition to a liquid outer core with much larger volume. Part of the newly formed outer core could in turn have transformed to form a part of the mantle increasing its thickness.

In this article I discuss the empirical support for the Expanding Earth hypothesis that I have become aware of quite recently.

1. There is empirical support for the view that the oxygenation of oceans did not occur before CE. This conforms with the prediction that oxygenation was due to photosynthesis in underground oceans. TGD provides the new physics needed: dark photons from either Earth's core or Sun could have provided the metabolic energy making photosynthesis and therefore oxygenation possible.

2. Anomalously high recession velocities for the tectonic plates during CE have been observed and could be due to the radial expansion of the Earth lasting about 30 million years which corresponds to the duration of CE. A quantitative estimate for the expansion velocity gives an estimate consistent with the findings. CE would correspond to quantum tunnelling in astrophysical scale and involve "big" state function reductions and a temporary change of the arrow of time. One could even understand the plant fossils with age about 600 million years conflicting with the fact that the CE (CE) occurred about 540 million years ago.

3. The finding that the mantle-core boundary looks like a seafloor having even mountains has a rather convincing explanation in terms of the subduction of tectonic plates, which sink to the mantle. This however inspired the question whether life in underground oceans as porous structures containing water in some exotic form, most naturally the fifth phase of water studied by Pollack playing a key role in the TGD inspired view of biology, could make possible the needed thermal and chemical isolation. Pollack effect could provide this isolation and is certainly needed even if the temperature of the underground ocean is not far from the physiological temperature.

   Assuming that the Sun was faint so that the temperature at the surface of Earth was below the freezing point, one ends up with conflict with the isotopic determination of the temperature giving a temperature of oceans slightly higher than the temperature 38 C above which marine invertebrates cannot survive. The temperature about 30 degrees allows life but this requires a slightly lower amount of O^{18} isotope than prevailing in the recent oceans. The paradox can be solved if the warm water originated from underground oceans and mixed with the non-oxygenated water (or actually ice) at the surface of Earth so that the isotopic fraction was reduced. The optimal situation for life would have been at depths of order kilometer and one can say that life had no other option than developing underground.

11.2 A possible view of the expansion of Earth?

The most natural TGD inspired guess is that a phase transition at the level of MB, increasing flux tube thickness, induces a phase transition at the level of ordinary matter by providing energy in the case that it requires energy. There are several questions to be answered.

11.2.1 Did the inner core participate the expansion?

Did the inner core (`https://cutt.ly/P2jSljB`) participate in the expansion?

1. Could it be that the outer core emerged and this led to a generation of convective currents giving rise to the Maxwellian part of the magnetic field. The temperature at the boundary of the inner core is the same as the solar surface temperature. Note that in the "standard model" the weak interactions within the mantle are assumed to produce energy.

   The recent radius of the inner core is $R/5$ and so small that there is no need for it to participate in the expansion: one would $4R/5 \to 8R/5$ for the outer and he radius would increase by factor 9/5: not far from 2.

2. Could it be that the outer core with the recent thickness 2400 km emerged in a phase transition transforming the Fe-Li solid of the inner core to Fe-liquid of the outer core so that the inner core could have reduced in size? Was the mantle+crust with recent thickness 2390 km (the recent Earth radius is 2890+2400+1220= 6370 km) scaled in the transition by factor 2 also in the radial direction or only horizontally?

   The scaling of the Earth radius by factor 2 gives the condition

   $$d(mantle, i) + d(inner, i) = (1/2)[d(mantle, f) + d(outer, f) + d(inner, f)] \ .$$

   One has $d(mantle, f) = 2890$ km, $d(outer, f) = 2200$ km, $d(inner, f) = 1220$ km.

   (a) If the mantle thickness was scaled by factor 2 ($d(mantle, i) = d(mantle, f)/2$), one has $d(inner, i) = 1810$ km, which is larger than 1220 km as required. For this option the initial value of the mantle thickness could have been small and the thickness of the inner core correspondingly larger.

   (b) The second option is that the newly formed outer core partially transformed to mantle and increased its thickness so that no radial scaling of the mantle was needed. This option is perhaps the most plausible one.

   (c) For the no-scaling option ($d(mantle, i) = d(mantle, f)$) one would have $d(inner, i) =$ 365 km, which is suspiciously small and smaller than 1220 km. Therefore the scaling of the mantle thickness is the more realistic option.

11.2.2 How the outer core was formed?

What happened in the formation of the outer core?

1. The proposal is that regions of dark water with an increased value of $h_{eff} = h_{gr}$ were generated in the mantle. Inside these regions photosynthesis occurred using the dark photons carrying metabolic energy from the inner core and outer core. The range of energies is the same as in the radiation from Sun [L103].

2. Did the expansion of the volume force a formation of underground oceans in mantle containing dark water, which then bursted to the surface? Was the formation of oceans necessary? Were dark matter blobs enough? Did they condense to form larger dark water volumes, which eventually bursted to the surface?

3. The material in the core of Earth derives basically from chondrites, which contain water and also organic molecules. This suggests that the water of the underground oceans in the mantle derives from the chondrites and that the presence of the basic biomolecules in chondrites was essential for the evolution of life inside Earth.

4. In the case of water, superionic ice [D9] (`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 [L93, L83] 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.

   Could superionic ice in the mantle have transformed to dark water with a volume larger a factor $4^{2/3}$. This would have contributed to the increase of the volume of the mantle. Note

that the transition could have led to expansion only in horizontal directions increasing the 2-dimensional volume by a factor 4.

5. One can compare the situation with that in recent Mars. For Mars, the inner and outer core are one and the same thing so that the situation corresponds to that in pre-Cambrian Earth. Also the radii were nearly the same.

   On Mars, the temperature at the surface of the core is about 2000 K ($E = .21$ eV). If the temperature for the pre-CE Earth was the same, the temperature of the core came 1.5 times higher and inner core 2.5 times higher in the phase transition. This could be understood if energy was liberated in the thickening of the flux tubes.

11.2.3 The energetics of the transition

What can one say of the energetics of the phase transition?

1. Expansion requires energy. Where did the energy come from? The fraction of gravitational energy Earth from its mass is of the order of $GM/R \sim 10^{-9}$ and its reduction in the expansion was of the same order of magnitude 10^{-9}. Energy was needed to induce the expansion. Also the reduction of the average density and the increase of temperature required energy. Where did the energy come from? Did it come from the increase of the flux tube thickness reducing string tension?

2. Magnetic and volume energy should have been liberated in the model based on the thickening of cosmic strings or flux tubes. Generation of ordinary matter or a phase transition for an ordinary matter can be imagined.

   The liberated energy could have driven the expansion as an explosion. Also the heating of the matter would be an outcome.

3. The increase of h_{gr} by a factor 2 is one option that one can imagine. The reduction of the quantized velocity parameter β_0 by factor 1/2 could have happened $\beta_0 \to \beta_0/2$? This process should have had as a counterpart ordinary phase transition liberating energy.

One can consider two options for the phase transition at the level of the MB. The first option would correspond to a thickening of cosmic string to monopole flux tube and second option to that of an already thickened cosmic string. A more realistic mechanism involves the expansion of an already thickened flux tube with much smaller liberated energy. Factor of order 10^{-9} is enough.

1. The phase transition for the ordinary matter would have been induced by a phase transition at the level of the MB of the system involving thickening of the flux tubes. The ordinary matter would have been in the form Fe and Ni inside in the inner core.

2. The ordinary phase transition could have been melting of the inner core at its outer surface so that it would have gradually generated the outer core as a liquid layer between outer and inner cores. The process would still continue.

   Temperature would have increased in the melting from 2000 K to about 5000 K in the inner core and from 2000 K to 3000 in the outer core. The energy liberated in the thickening of the flux tubes would have provided this energy.

   The expansion of the core and the liberated energy would have driven the expansion of the volume above the contracting inner core. This process could have also forced the expansion of the outermost layer with recent thickness about .444 R_E. It is also possible that the newly formed outer core transformed partially to mantle so that no radial expansion of the mantle was not needed.

11.3 TGD view of the pre-Cambrian era

In the sequel a TGD view general view of pre-Cambrian era is proposed followed by a discussion as a series of questions. The basic idea is to take the recent Mars as a guideline in attempts to understand pre-Cambrian Earth.

11.3.1 A rough overall view of pre-Cambrian era

The recent view of pre-Cambrian era has problems. How to solve faint Sun paradox (https://rb.gy/mfhavz): was some additional source of energy present and heat the surface of Earth to make liquid water possible? What happened in Great Oxygenation even (GOE) (https://cutt.ly/K2jAxV9)? Did deep oceans really exist? Did Snowball Earth (https://rb.gy/qkoiah) precede CE?

Energetics during the pre-Cambrian era

The basic assumption is thermal flow equilibrium in which the energy from the Sun is temporarily stored and leaves the system in time determined by the planet. In the TGD framework, the flow of energy from the interior of Earth forces us to challenge this picture.

1. The total energy flux from the Sun would have been by a factor 1/4 smaller than now although local flux would have been the same. One can wonder whether this had some implications. If the biosphere is controlled by MB having quantum coherence in the scale of Earth, this might be the case. As a matter of fact, during CE the phase transition generating inner core would have feeded energy liberated in the thickening of flux tubes of the MB of Earth to also to the surface of Earth. Inner core and core could have also served as source of metabolic energy for the photosynthesizing life forms in underground oceans [L103].

2. Solar energy input and reradiation of energy by greenhouse gases storing the energy temporarily. Oceans bind 90 percent of the solar energy in the recent Earth. In the TGD framework, oceans would have been absent during the pre-Cambrian era and could not have stored energy in large scales so that the situation would have been similar to that in recent Mars. This would explain why multicellular life was virtually absent during pre-Cambrian period.

   Lakes and small oceans could have been present and the energy from the Earth interior could have warmed them. Also volcanic activity could have transferred energy to the Earth's surface as it does also nowadays. Reradiation would have been missing unless greenhouse gases were present locally.

3. Sunlight absorption depends on various factors. The spin of Earth and the tilt of the orbit with respect to the rotation plane affect the absorption in the time scale of $10^4 - 10^5$ years. Milankovitch cycle for the ice ages relates to this dependence.

   The duration of the Carbon cycle corresponds to millions of years. Also weathering and volcanic activity affect the absorption. Greenhouse gases are an important factor on recent Earth. Also the distribution of continents affects the absorption (https://cutt.ly/62jSQSU).

The atmosphere of Earth before CE

What about the surface pressure before CE?

1. Pressure is determined by the concentrations of molecules and atoms in the atmosphere. The abundances of O and N were small before CE: the situation could have been as in Mars today.

2. The composition of the Earth's earliest atmosphere is not known with certainty. Present nitrogen, N_2, and carbon dioxide, CO_2, which are also the predominant nitrogen- and carbon-bearing gases produced by volcanism today. These are relatively inert gases.

   The leakage of molecules in CE Earth was not as intense as in Mars today since the gravitational field was 10 times stronger than in Mars. Leakage partially explains low surface pressure if the production of gases has roughly the same rate.

3. It is interesting to compare the percentages of various gases in the recent Earth and recent Mars .

In the recent Earth: the fractions of N and O are 78 % and 21 % respectively. The variation of Oxygen fraction is between 10 and 35 per cent during the last 541 million years (`https://cutt.ly/22jSUzR`).

In recent Mars the fractions of CO_2, N and O are 96 %, 1.9 %, and .15 % respectively. The partial pressure of Oxygen present in the Martian atmosphere is $pO = .95 \times 10^{-2}$ atm which corresponds to the value of pO in the beginning of the second stage of GOE at Earth.

Recent Mars could give some hints of the situation in CE Earth. CO_2 or other greenhouse gases should have been present. Also methane CH_4 was prosent. These gases could have been produced in the interior of Earth as in Mars and responsible for the warm Earth.

4. Ideal gas approximation gives the estimate $P = nT$. Hydrodynamic equilibrium requires that the pressure gradient is equal to gravitational force density, which determined by the density of the atmosphere and by the strength of the gravitational field, which was 4 times stronger for pre-Cambrian Earth according to TGD. Note that the gravitational energy of protons in the Earth's gravitational field is of order 1 eV and twice the nominal value .5 eV of the metabolic energy quantum [L101].

   The transfer of oxygenated fluid from underground oceans would have made oxygenation possible in pre-CE Earth. This would have caused local oxidation of iron without deep oceans.

5. The climax of the GOE caused be accelaring expansion of Earth corresponds CE. Before GOEs there is a slow oxygenation, which in the standard model is assumed to be caused by the photosynthesis of cyanobacteria. What really happened during CE is a mystery as is also CE. In the TGD framework, the underground oceans would played a key role. Also cyanobacteria could have emerged from the underground oceans.

Maybe deep oceans are not necessary?

According to the Wikipedia article (`https://cutt.ly/K2jAxV9`), the end of the deposition of banded iron formation at 1.85 billion years ago is interpreted as marking the oxygenation of the deep ocean. Banded iron formation largely disappears from the geological record at 1.85 billion years ago, after peaking at about 2.5 billion years ago. Banded iron formations can form only when abundant dissolved ferrous iron is transported into depositional basins, and an oxygenated ocean blocks such transport by oxidizing the iron to form insoluble ferric iron compounds.

But are deep oceans really needed? One can compare the situation with the situation in recent Mars. Mars is red and contains oxidized iron.

1. Rivers and water flow at its surface and there are no deep oceans in the recent Mars. The simplest assumption is that the situation could have been the same always. This applies also to the existence of the Maxwellian part of the magnetic field requiring an inner core.

   Although the Martian atmosphere has a low Oxygen content, the iron rich material is oxidized in presence of water and develops rust giving the color red. Also in Mars, band iron formations consisting of non-oxidized iron and dating to times before the beginning of Martian GOE, should exist. The flow of a non-oxygenated water could have transported ferrous iron to the depositional basis.

2. The amount of oxygen in the Martian atmosphere is very low but he oxygenated water percolating from the underground oceans could induce the oxidation of iron. The same mechanism could be at work on the early Earth. The beginning of the oxygenation would correspond to the emergence of oxygen based life forms to the underground oceans.

11.3.2 Comparison with the recent Mars

The resemblances between Mars `https://cutt.ly/s2jAOFJ` and pre-Cambrian Earth according to TGD inspire the question whether the recent Mars could be like the pre-Cambrian Earth after the initiation of GOE. Could one use these resemblance to understand pre-Cambrian Earth in the TGD Universe.

1. For Mars the radius and distance from the Sun are $R = .53 \times R_E$ and $d = 1.523AU$. Similar tilt of a rotation axis.

   The mass of Mars is $M = .107M_E$ so that the surface gravitation is .38 g. For pre-CE Earth surface gravitation is roughly 10 times stronger.

2. Surface temperatures in Mars vary from 20 C to -153 C at poles. The average temperature is -62 C. The temperature drops rapidly with height and with the time of day since the atmosphere is very thin and cannot store heat energy. The ratio of energy fluxes to Mars and Earth is equal $d/d(Mars) = .43$ so that there is no big difference between Mars and Earth.

3. Surface pressure at Mars is $p(Mars) = 0.0628$ atm which is 6.3 % of the pressure $p(Eart) = 1$ atm.

   The Martian atmosphere contains 0.174 % Oxygen and 2.8 % Nitrogen. At the Earth, the corresponding abundances are 29 % O and 78 % N. Oxygen partial pressures for Oxygen is $pO(Mars) = 0.01$ atm. There are active sources of gases, such as methane, in the interior of Mars.

4. On Mars there are no oceans and continents are absent. If Earth is like Mars, the oceans could have been absent also on Earth. Instead of them small lakes and rivers could have been present as in the recent Mars. They would have contained oxygenated water from oceans inside the Earth interior, where photosynthesis was producing oxygen. Continents would have been absent so that the existing vision about the history of the continental drift before CE, should be obsolete albeit natural if one assumes that the radius of Earth has always been the recent one.

5. Could Mars be experiencing the analog of GOE? During the second stage of the Great Oxidation Event (GOE) (see the picture `https://cutt.ly/d2jAEd3` in Wikipedia article `https://cutt.ly/K2jAxV9`), the oxygen content of the atmosphere gradually increased during period 2.45-.84 Ga to values of .02 and .04 atm but it is assumed that Oxygen was absorbed by the oceans and seabed rock. During the third stage of GOE, the oxygen content did not change. It is assumed that the oxygen started to gas out from oceans but was absorbed by land surfaces. At the fourth state of GOE, CE occurred and the oxygen content increased rapidly to the recent 21 per cent.

   The recent value $pO(Mars) = 0.01$ atm is below .02 atm at the end of the second phase of GOE but would correspond to the value of $pO \simeq .01$ on Earth in the beginning of the secon state of GOE. Could it be that GOE on Mars has begun? The naive guess is that there is still 2.45 Gy to the recent situation on Earth.

6. The interior of Mars consists of a crust, a mantle consisting of silicates and a solid metal core consisting of Fe and Ni as the solid inner core of Earth. Crust has a typical thickness of 50 km, which is not far from that on Earth.

   There is no liquid outer core, which in the case of Earth is responsible for the convective ionic currents creating the Maxwellian part of the magnetic field (note that the monopole part needs no source). In Mars the magnetic field is indeed absent in large scales. Martian Auroras have been observed however. In the TGD framework, this suggests that only the dark part of the Martian magnetic field has a considerable strength whereas the Maxwellian part is very small.

   This suggests that in the case of Earth the emergence of the Maxwellian part of the magnetic field made possible the shielding of life against cosmic rays and that life did not have any other option than to evolve in the womb of Gaia.

7. For the recent Earth, the volume fraction of the outer core of Earth 16.5 %. The outer core carries the convective currents giving rise to the Maxwellian part of the magnetic field of Earth. The inner core however feeds heat energy to the outer core and has a considerable effect on its dynamics. This conforms with the idea that the inner core serves as a source of heat energy.

8. The temperature $T = 1900 - 2000$ K at the boundary of Martian core corresponds to a thermal energy $\simeq .2$ eV, which is below the metabolic energy quantum .5 eV.

   On the recent Earth, one has $T = 3000$ K (.3 eV) at the upper boundary of the outer core and $T = 5000$ K (.5 eV) at the upper boundary of the inner core: the latter is the temperature at the surface of the Sun. These observations lead to the proposal [L103] that the energy feed from the inner and outer cores, realized as dark photons, could have served as a metabolic energy source for the evolving life in the underground oceans. Also the solar photons might have transformed into dark photons propagating along the flux tubes of the monopole part of the Earth's magnetic field to the interior of Earth. One can even ask whether this mechanism might be still at work at polar regions of Earth covered by ice or at the bottom of oceans.

There is now a considerable evidence that ancient Mars has had lakes or even oceans see this). Could underground life in Mars bursted much earlier to the surface of Mars?

1. The average density of Mars is near to that of recent Earth (mass is .1 Earth masses and radius roughly 1/2 of the Earth radius R_E). This leads to the question of whether Mars has already experienced a similar transition increasing its radius by 1/2 and density by factor 8? This would have brought the possible underground water to the surface. Later the water would have been lost. Mars would not have been as lucky as Earth.

2. The objection is that Mars has no plate tectonics, which should have emerged in the rapid expansion. The alternative option that I have discussed earlier is that Mars is still waiting for the expansion to take place. Intriguingly, Mars has the same radius as Earth before the Cambrian explosion. The ancient presence of oceans/large lakes does not support this view. One might however think that the water from underground oceans leaks to the surface and forms lakes and even shallow oceans.

11.3.3 Some questions related to the pre-Cambrian period

Pre-Cambrian period Cambrian explosion (CE) are not well-understood and there are several paradoxical aspects involved.

Why so few multicellular fossils from pre-Cambrian period?

There is very little evidence for multicellulars from pre-Cambrian period whereas fossils of monocellulars (cyanobacteria) exist. The oldest multicellular fossils are 1.2 billion years old. Multicellular fossils with an age of 600 million years and thus preceding CE, which began 541 million years ago have been also found (`https://cutt.ly/d2jAgzb`).

The multicellular organisms preceding CE are much simpler than plants and animals that emerged in CE. The standard explanation for the nearly complete absence of multicellular fossils is that they have disappeared almost completely because they had no hard parts. What is however very strange is that suddenly the fossils of rather complex multicellulars emerge suddenly in CE [I133].

Questions related to energetics

The first questions relate to energetics.

1. Faint Sun paradox means that solar radiation was only 70 per cent from the recent temperature. The Earth surface was however warm since liquid water existed. Could Earth's interior have served as a source of heat energy? This seems to require new physics.

2. In the TGD framework one can ask whether a quantum phase transition proceeding at the level of MB (MB) of Earth could have induced ordinary phase transition at the level of ordinary matter, say solid-liquid phase transition of the Fe-Ni at its boundary giving rise to the outer core. This would have made convective charged currents generating the Maxwellian part of the magnetic field of Earth providing a shield against cosmic rays. This kind of induction of ordinary phase transitions by quantum phase transitions could be crucial for the evolution of life [L101, L98].

3. Could the energy liberated in the phase transition of the MB increasing the thickness of the flux tubes have driven this solid-liquid phase transition and have also feeded heat energy to the surface of Earth increasing the temperature. Also the increase of the gravitational potential energy in the increase of the radius by factor 2 requires a lot of energy.

   Note that nuclear physics cannot be involved with the energy production. Basic stable isotopes of Fe and Ni have atomic numbers 56 and 58. Ni has also A= 60, 61, 62, 64 as stable isotopes. Fe has stable isotopes with A=54,57,58 besides A=56. Ordinary nuclear processes cannot transform Ni nuclei Fe nuclei and new physics is needed.

Did large oceans really exist?

The existence of oceans covering most of the surface of Earth is assumed in the standard view of pre-Cambrian period. But did Earth have oceans at its surface before CE?

1. Could it be that the situation before CE was like in the recent Mars. This plus the assumption that the radius of Earth was only 1/2 of the recent radius would totally change the views about pre-CE Earth both biologically, geologically, and thermodynamically.

2. The simplest working hypothesis is that plate tectonics was not present before CE. Standard view (`https://cutt.ly/I2zf8v8`) however is that roughly 750 million years ago, the earliest-known supercontinent Rodinia, began to break apart.

   Did the breaking apart of Rodinia initiate the expansion of Earth, which gradually accelerated? If so, the area covered by the analogues of oceans between continents was much smaller than on the recent Earth. The narrow fissures would have contained water which had bursted from the underground oceans and brough multicellular life forms.

   The analogues of continents would have later recombined to form Pannotia 600–540 Ma. Did the expansion involve a pulsation leading to the formation of Pannotia, which then split again to continents separated by narrow analogs of oceans. The multicellular lifeforms giving rise to 600 Ma old fossils could have emerged from underground oceans in the breaking apart of Pannotia.

Snowball Earth hypothesis from TGD point of view

The assumption is that snowball Earth dating back to 650 Ma, involving several large scale glaciations, preceded CE. The Earth would have suffered a global glaciation but evidence exists only for local glaciations.

What could be the TGD counterpart of the snowball Earth? Milankovitch cycles (`https://cutt.ly/12zkeoF`) with a period of order 100,000 years were present and could have caused local glaciations explaining the observed glaciations. The two large scale glaciations associated with snowball Earth could relate to the expansion of Earth. Did the glaciation take place for the oceans defined by the narrow fissures between the analogues of continents formed in the splitting of Rodinia?

The Great Oxygenation Event

The Great Oxygenation Event oxidized the atmosphere and made oxygen based life possible at the surface of Earth.

1. The oxygen content of the atmosphere and assumed oceans was very low before CE and could not support oxygen based life. During the Great Oxygenation Event (GOE) (see the Wikipedia article (`https://cutt.ly/K2jAxV9`), which started for about 2.45 Gy ago, the oxygenation of atmosphere proceeded very slowly (see the Wikipedia picture `https://cutt.ly/d2jAEd3`).

   In CE (CE) the oxygen content of the atmosphere increased very rapidly to the recent level of about 21 per cent. The oxidation is made manifest by the observed layers of oxidized iron. The absence of oxygen for more than 2.45 Gy ago is demonstrated by layers of iron based compounds, which are not oxidized.

2. Usually it is assumed that the oceans were present during the pre-Cambrian period and that the sea water was oxidized gradually. On Mars the situation is however different. There are local sources of oxygenated water such as lakes and rivers but no oceans. There is also evidence for underground life on Mars.

   Could the situation on Earth have been like in Mars during the pre-Cambrian Earth? Could the underground oceans, serving as a kind of womb shielding the evolving life from meteoric bombardment and cosmic rays, have made possible the evolution of the photosynthesizing life and multicellulars producing oxygen, which bursted to the surface of Earth in CE?

3. Suppose that the water from the underground oceans, containing highly developed multicellulars, bursted to the surface during the GOE. What could be the time scale of the process? Was GOE implied by this process and did it accelerate during CE? Did this increasing rate of bursts lead to oceans of increasing size so that the scale of glaciations was dramatically increased during the last two glaciations before CE.

Was CE a quantum phase transition in Earth scale?

The TGD view of CE explains the sudden appearance of multicellulars and also implies that the gravitation would have been 4 times stronger before CE so that the possible lifeforms surviving at the surface of Earth are expected to have a flat shape. The reduction of surface gravitation after CE in turn could in turn explain the emergence of giant plants and animals.

In the TGD framework the evolution of life would have involved quantum criticality and quantum phase transitions closely related to ordinary criticality and phase transitions [L98]. CE would be naturally a quantum phase transition in the scale of Earth involving in an essential manner gravitational Planck constant h_{gr} making possible dramatic reduction of gravitational binding energy in the scaling up of Earth radius by factor 2.

In the TGD framework the standard ontology of quantum theory is replaced with zero energy ontology (ZEO) solving the basic paradox of the quantum measurement theory [L69, L87, L85, L97].

Interesting questions relate to the proposal that a pair of "big" state function reductions (BSFRs) in astrophysical scales (counterpart for quantum tunnelling) changing the arrow of time was in question. Could one interpret the time reversed classical time evolution after the first BSFR, that is GOE, as a classical correlate for the pair of BSFR making the process effectively to look like deterministic and smooth classical process [L58] [L58]?

Oxygenation of oceans did not precede Cambrian Explosion as TGD strongly suggests and empirical study concludes

There was an interesting article in Futurism about the findings challenging the basic assumption related to the origin of life (`https://futurism.com/the-byte/textbooks-wrong-origin-life`). The research article "Widespread seafloor anoxia during generation of the Ediacaran Shuram carbon isotope excursion" [I89] can be found at
urlhttps://onlinelibrary.wiley.com/doi/10.1111/gbi.12557.

On the basis of empirical evidence it is claimed that the view of the gradual oxygenation of oceans is wrong. The abstract of the article explains the findings.

Reconstructing the oxygenation history of Earth's oceans during the Ediacaran period (635 to 539 million years ago) has been challenging, and this has led to a polarizing debate about the environmental conditions that played host to the rise of animals. One focal point of this debate is the largest negative inorganic C-isotope excursion recognized in the geologic record, the Shuram excursion, and whether this relic tracks the global-scale oxygenation of Earth's deep oceans.

To help inform this debate, we conducted a detailed geochemical investigation of two siliciclastic-dominated successions from Oman deposited through the Shuram Formation. Iron speciation data from both successions indicate formation beneath an intermittently anoxic local water column. Authigenic thallium (Tl) isotopic compositions leached from both successions are indistinguishable from bulk upper continental crust ($\epsilon^{205}Tl_A \simeq -2$) and, by analogy with modern equivalents, likely representative of the ancient seawater ϵ^{205} Tl value. A crustal seawater $\epsilon^{205}Tl$ value requires limited manganese (Mn) oxide burial on the ancient seafloor, and by extension widely distributed anoxic sediment porewaters.

This inference is supported by muted redox-sensitive element enrichments (V, Mo, and U) and consistent with some combination of widespread (a) bottom water anoxia and (b) high sedimentary organic matter loading. Contrary to a classical hypothesis, our interpretations place the Shuram excursion, and any coeval animal evolutionary events, in a predominantly anoxic global ocean.

The absence of oxygenation before the Expolosion is also the TGD based prediction. The TGD based model predicts that the mysterious Cambrian Explosion in which advanced multicellulars suddenly emerged involved an increase of Earth radius by factor 2 in a geologically short time scale [L46] [L93].

This view conforms with TGD inspired cosmology in which a smooth cosmological expansion is replaced with a serious rapid step-wise expansions, which are essentially quantum phase transitions involving astrophysical quantum coherence scales.

The Earth would have been like Mars now (not much water at surface, even the radius would have been very near to Mars radius) and life would have evolved in underground oceans (being shielded from cosmic rays and meteors), in the womb of Mother Gaia. The evidence for the underground life on Mars is accumulating. The water in underground oceans would have oxygenated by photosynthesizing life and the underground water would have bursted to the surface and give rise to the oxygenated oceans covering most of the Earth's surface since then.

The basic objection is that photosynthesis was not possible. The core of the Earth however produces radiation in the same wavelength range as the Sun and in the TGD framework this could allow the development of photosynthesis [L103]. Now Quanta Magazine article (`rebrand.ly/jbvkwtp`) told that in a research [I93] published last month in Nature Communications, researchers reported that in groundwater reservoirs 200 meters below the fossil fuel fields of Alberta, Canada, they discovered abundant microbes that produce unexpectedly large amounts of oxygen even in the absence of light. Photosynthesis is the standard way to produce oxygen. But how could photosynthesis work underground? This looks like a complete mystery in the standard physics framework.

Whether the interpretation of the article that life evolved in anoxic global ocean is consistent with the TGD view that this oceans was essentially absent, is not of course clear.

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What objections can one invent against the TGD view? The first objection against the TGD proposal is that fossils of complex multicellular life forms have been found with age of 600 million years to be compared with the fossils dating back to 550 years ago when Cambrian explosion could have started. The story of their discovery told in the popular article "How 2 Teens Accidentally Solved Charles Darwin's Most Vexing Problem" (`rebrand.ly/uk0ntuk`) is fascinating.

In 1956, a teenage girl by the name of Tina Negus found a strange looking fossil in Charnwood Forest in Leicestershire, England. The plant fossil should not have been there since the rock was 600 million years old and the Cambrian explosion started roughly 60 million years later. Tina Negus showed a pencil rubbing to his geography teacher but he didn't believe her.

A year later, in 1957, three teenage boys were playing near the same rock face when they, too, noticed the same fossil. One of these teens, fifteen-year-old Roger Mason, found the second fossil. Roger Mason contacted Trevor Ford, a local geologist, who wrote about the finding to the Journal of the Yorkshire Geological Society. The new plant was named Charnia Masoni. Charnia is a genus of frond-like life forms belonging to the Ediacaran biota. Charnia came from Charnwood Forest in Leicestershire, England where Tina Engus found it. Masoni is after Roger Mason.

Does the TGD based view survive these findings? Note first that the Charmia Masoni does not conform with the conclusion that the oceans that possibly existed at that time did not contain oxygen. Furthermore, Charnia Masoni does not change the basic facts: complex multicellular life forms emerged as if from nowhere. The time span from Charnia Masoni fossils about 600 billion years to the beginning of Cambrian Explosion about 538.8 million years ago is about 10 per cent.

Can one explain the finding in the TGD view of the Cambrian explosion?

1. If the surface of Earth did not contain much water before the Cambrian Explosion, one

can imagine that water leaked from the underground oceans locally at some places but not everywhere. Instead of oceans, there were oxygenated lakes, where multicellular life forms survived.

2. Another possibility is that the expansion of Earth involves periodic oscillation typical of resonances so that bursts of oxygenated water containing the highly evolved life forms emerged to the surface. I have considered this kind of explanation for the periodic oscillations found to be associated with the Cambrian explosion.

3. One can also imagine that the rock containing the fossil has emerged from the older of a sediment rock a the "bottom" underground water reservoir when a crack was formed in the geologically fast expansion.

There is also indirect evidence for the presence of life about 3.85 billion years ago (`rebrand.ly/ebz2q92`). The interaction of rocks with life forms lowers the C-13 ratio of rocks to a characteristic value serving as a signature for life. Any sedimentary rocks that formed before life appeared on Earth would have the high C-13 ratio of a volcanic origin. The discovery of rocks with the same C-13 ratio that serve as a signature of life support the view that very primitive microbial life existed already at that time. One can consider the possibility that very primitive life forms existed at the surface of Earth. Second possibility is that they leaked from underground oceans. Also in Mars there is evidence for the presence of water and it could have indeed leaked from underground water reservoirs.

Anomalously high rates of tectonic plate motion and the TGD view of Cambrian explosion

The popular Arstechnica article (see this) tells that the motion between plates was surprisingly fast. The rate of the tectonic motion as relative rate for the distance increase between plates was surprisingly fast: even about 4 times the recent one.

The TGD view of expanding Earth relies on the prediction of cosmic expansion as a sequence of fast periods of expansion for astrophysical objects.

1. The model predicts that the tectonic plates were created in rather fast radial expansion of Earth: radius increased by a factor 2. Cracks giving rise plates were formed because rock is not flexible material.

2. The model explains the Cambrian explosion: advanced photosynthesising multicellulars emerged from underground oceans as the oxygenated water bursted to the surface. The TGD view of dark matter allows to circumvent the obvious objections against the model and conforms with the recent surprising findings [L116] (see this) and this).

3. The fast radial expansion caused a fast increase of the distances between plates. The velocity v of this recession would have been $v = dR/dt \times \Delta\Phi$, where $\Delta\Phi$ is the angular distance between the plates and dR/dt is the radial expansion rate.

   The duration of Cambrian Explosion was roughly $\Delta T = 30$ million years. Using Earth radius $R = 6,371$ km, one obtains the estimate $dR/dt = R/\Delta T \simeq 20$ cm/year. v is obtained from this by multiplying with $\Delta\Phi < \pi$. The largest rate mentioned in the popular article is $v = 64$ cm/year. The order of magnitude is correct and the rate would have been higher than the average during the fastest periods.

   The estimate for v must involve a large enough angle $\Delta\Phi$ and a long enough time period so that $\Delta\Phi$ is expected to be a considerable fraction of π. For $\Delta\Phi$ slightly below π, the estimate is exact but this is probably an accident.

4. Note that the predicted contribution to v is always positive and could provide a test for the TGD view.

A fascinating, and admittedly frightening, question, which just now occurred to me, is whether the Cambrian explosion was gravitational expansion analogous to cosmic expansion in which the metric (!) distances between points doubled! This would have required the scaling of the induced metric by a factor about 4. Could this make sense or does it kill the basic idea?

1. In zero energy ontology (ZEO), light-cone proper time a serves in the role of the cosmic scale factor of either half-cone of the causal diamond (CD) having interpretation as empty cosmology. "Big" state function reductions (BSFRs), serving as TGD counterparts of the ordinary SFRs, change the arrow of time and a pair of BSFRs would be behind quantum tunnelling in the TGD Universe.

   In the TGD framework quantum coherence and BSFRs are possible even in astrophysical scales. Could the increase of the radius of Earth be quantum tunnelling be realized as a pair of BSFRs.

2. Can one imagine a local "mini" Big Bang for the CD inside which Earth's space-time surface belongs and a scaling of light-cone proper time a by a factor 2 in astrophysical quantum quantum tunnelling? The value of the light-cone proper time a, characterizing the cosmotemporal position of Earth in a double BSFR, would have increased by factor 2. The spatial scaling by a factor 2 conforms with the p-adic length scale hypothesis stating that p-adic length scales coming as powers of 2 are of special importance.

3. One can try to form a more quantitative view of the situation. Note that the size scale of the initial CD before explosion would be $T/2$, where T is the distance between the tips of the CD would be about 30 million years. The Cambrian explosion occurred about $T_i = 540$ million years ago. If T_i corresponds to the cm of CD, the future tip of the initial CD would be at 570 million years. CD size would be scaled by factor 2 and the end of the cm of CD would correspond to $T_f = 570$ million years.

   The quantum average space-time surface would be replaced by a new one in double BSFR and would be modified already 60 million years before T_f. This time would correspond to 630 million years. As explained, some multicellular plant fossils have been found with an age of about 600 million years. Could this replacement of geometric past explain them?

Does the existence of an underground ocean floor at the mantle-core boundary relate to underground life?

The popular article published in Futurism discussed an unexpected observation by the group led by Samantha Hansen published in Science [D6]. The mantle-core boundary in the Earth's interior contains a layer that looks like the crust of Earth in the sense that the seismic perturbations propagating through it have an ultralow velocity. There are mountains many times higher than Himalaya! How is this possible? Is this possible in standard physics?

The answer of the article to this question is based on the idea that subduction for continental plates implies that part of them sinks down because they are denser than the surrounding material and gradually gather to form a second sea floor at the mantle-core boundary. To me this idea looks rather plausible but need not be correct.

My first reaction was the question whether this second sea floor could be a genuine seafloor, the seafloor of an underground ocean! Could new physics predicted by TGD make this possible?

1. The basic prediction of the Expanding Earth hypothesis [L116] explaining Cambrian Explosion is that life evolved in underground oceans and bursted to the surface as the radius of Earth increased by factor 2 in a rapid expansion lasting about 30 million years (cosmic expansion would occurred as rapid jerks for astrophysical objects). During the last weeks several strange findings removing the most obvious objections against this vision have emerged.

2. Could these mountains at the core-mantle boundary correspond to mountains of underground ocean floor?

Could the underground oceans have existed and carried life? Could they reside even in the extremely hostile environement at the mantle-core boundary?

1. Underground oceans near the mantle-core boundary boundary could be imagined as a porous structure having water inside pores. Such structures are very common and if Earth's crust is formed from meteorites the water would be present from the beginning. Even biological matter is analogous to porous structure. When stone is heated it becomes a porous structure.

Maybe the enormous heat flux from the core could cause porosity. In accordance with the standard vision of self-organization, this could be understood as complexity developing induced by a constant heat flux. Self-organization takes place at boundaries.

2. It is known that huge reservoirs of water exist underground. The boundary between upper and lower mantle at a depth of about 500 km contains a porous structure carrying water (see this). If the size of the pores is large enough, considerably above cell size, advanced multicellulars could evolve in the underground oceans.

It is easy to invent lethal objections in the standard physics framework.

1. The temperature and pressure increase as one goes towards the core. The temperature of pores should be around 40 C for life to survive. Also the pressure should be normal.

2. Consider the crust first. The temperature reaches the values in the range 100-600 C at the crust-mantle boundary. The temperature increase is about 30 C per kilometer in the upper part of the crust and would be about 30 C at the depth of 1 km if it is 0 C at the surface. The underground water reservoirs should not be at depths much larger than 1 km if the standard physics applies and the largest depths would be possible near the poles.

3. In the underground ocean at the boundary of the upper and lower mantle at a depth of about 500 km, the temperature and pressure are quite too high. Temperature of the surrounding solid material varies from 500 K at the lower boundary of the crust to 1200 K at the boundary of upper and lower mantle. Densities would be several times higher than the normal density of water.

4. Temperature at the mantle-core boundary is about 3000 -4500 K and pressure 1.3 trillion times the atmospheric pressure. The density of mantle is by factor about 5-6 higher than the density of crust so that the pressure is really huge since water and solid matter are almost incompressible. Water in ordinary form cannot exist in this kind of environment if standard physics applies.

Could underground oceans allow some exotic phase of water at physiological temperature around 40 C and normal pressure? This is not possible for the water of standard physics. But the water in living matter is not normal!

1. The phase of water discovered by Pollack [**?**, **?**] called fifth phase of water by Pollack himself (also the term "ordered water" is used). Pollack proposed it to be fundamental for life. Gel phases would represent a basic example of this water.

   This phase of water plays a key role in the TGD based model of living matter. The model identifies dark matter based as phases of ordinary matter with non-standard values of Planck constant. The gravitational Planck constant indeed has huge values.

2. The underground life faces the same problem as the biological cell at the surface of Earth: how to isolate itself from the environment. The high temperatures and pressures make the problem orders of magnitudes more challenging. The fifth phase of water surrounding the system could provide the solution in the case of cell membrane and DNA double strand: develop a layer consisting of the fifth phase of water which thermally shields the volume of the ordinary water from the environment at a different temperature.

3. The negatively charged exclusion zones (EZs) generated in the Pollack effect as protons go to magnetic flux tubes as dark protons realizing the dark genetic code, are also able to get rid of various impurities in their interiors. This violates second law in its standard form and suggests that the arrow of time at the magnetic body of EZ controlling its dynamics has a non-standard arrow of time and induces an effective change of the arrow of time for ordinary biomater for long periods of time. This would isolate the system also chemically from the environment.

4. As a matter of fact, it has been discovered that ordinary water in air develops a thin molecular layer at its surface. This layer is neither water or ice and the identification as the fifth phase of water would be suggestive [L106]. This layer could also work at nanoscales and reduce the freezing temperature of the lattice water in materials like concrete to about -70 C. The mechanism could be essentially thermal isolation.

Could thermal isolation work also in high temperature environments, where underground life had to survive?

1. Could the darkness of the ordered water make possible a situation in which the interactions of the water inside pores with the hot high pressure environment are very weak and heat and matter are not transferred between the solid environment and water. Thermal equilibrium would be established very slowly and the temperature could and pressure could be much lower than otherwise for very long periods.

2. Magnetic bodies would carry the dark matter relevant for the biocontrol and would be shielded from the hot environment. They would be gradually heated and this would lead to biological death as it does in ordinary biology according to TGD. Zero energy ontology would however come in rescue and the change of arrow of time would reverse heating to cooling!

3. The unpaired and their chemically non-inert valence electrons of biologically important ions should be dark and reside at the flux tubes associated with very long dark valence bonds. This would generate long range quantum coherence. This would explain why living matter contains these ions although thermal ionization is not possible at physiological temperatures. Also the protons of hydrogen bonds would be dark. Only the chemically inert full electron shells would remain and the system would remain and since be effectively thermally isolated from the hot environment.

   As a matter of fact, electrolytes involve ions and the mechanism of ionization is not actually understood and TGD suggest a mechanism of ionization based on the generation of dark valence electrons and dark protons [L112, L88].

While preparing this text, I learned that the standard view of Cambrian explosion has a problem with the Cambrian ocean temperature.

1. If the oceans existed (not clear in the TGD framework before the Cambrian explosion!), their temperatures should have been around 60 C. Marine invertebrates do not however survive above 38 C.

2. Isotopic estimates for Cambrian phosphatic brachiopods [I96] (see) assuming no post-Cambrian O^{18} isotopic depletion relative to the recent concentration suggests that the temperatures of Cambrian oceans were in the range 35-41 C. This range is above the recent range 27-35 C. Assuming a O^{18} depletion of -3 promille of the early Cambrian sea water relative today, one can get Cambrian temperatures around 30 degrees.

3. The problem now is that the underground oceans should have been very near to the surface (unless one assumes the TGD inspired thermal insulation hypothesis). Faint Sun paradox comes to rescue here. The luminosity of the Sun should have been 30 per cent lower than now so that the temperature at the surface of Earth should have been below the freezing point. This has motivated the snowball Earth hypothesis. The paradox disappears if life evolved in the underground oceans in a warmer environment. The temperature deduced from the O^{18} fraction of fossils should be that for the underground ocean. Furthermore, the faint Sun makes it possible for the underground oceans to be located below 1 km depth without assuming the thermal insulation hypothesis.

4. What could have caused the O^{18} depletion of the Cambrian phosphatic brachiopods? A possible explanation is that there were non-oxygenated water reservoirs (presumably in a form of ice) at the surface of Earth and the oxygenated underground water was mixed with this water. Also the surface of Mars, to which the surface of Earth before the Cambrian explosion is analogous, contains some water.

To conclude, I am not suggesting that life developed at the mantle-core boundary: this might be quite too science-fictive an idea. Pole regions of the crust are the most conservative candidate for the seat of underground oceans. It is quite enough for the purposes of the Expanding Earth model that it developed in underground water reservoirs at depths of a few kilometers. Also in this case the thermal and chemical isolation from the environment could have played a key role. An interesting question is whether the critical temperature range 30-40 C of life could fix the depth for the underground oceans in which life most probably evolved.

What are the mysterious structures observed in the lower mantle?

I learned of very interesting results related to geology. The Dailymail popular article (see this) tells about massive structures in the Earth's deep mantle below Pacific Ocean near the mantle-core boundary. The article "Full-waveform inversion reveals diverse origins of lower mantle positive wave speed anomalies" of Schouten et al published in Scientific reports [F45] (see this) describes the findings.

There are cold regions deep within the Earth where seismic waves behave in unexpected ways. These regions, located 900 to 1,200 kilometers beneath the Pacific Ocean, defy expectations based on conventional plate tectonics theories. These kinds of structures can result from the subduction of continental plates leading to the sinking of a plate to the mantle. There are however no subduction records in the Ocean regions so that the mechanism must be different.

It seems that the recent view of the dynamics of the Earth's mantles is in a need of a profound updating. It has been proposed that the structures could be the remnants of ancient, silica-rich materials from the early days of the Earth when the mantle was formed billions of years ago. Alternatively, they may be areas where iron-rich rocks have accumulated over time due to the constant movement of the mantle. However, researchers are still unsure about the exact composition of these deep Earth structures.

Here is the abstract of the article of Schouten et al.

> it Determining Earth's structure is paramount to unravel its interior dynamics. Seismic tomography reveals positive wave speed anomalies throughout the mantle that spatially correlate with the expected locations of subducted slabs. This correlation has been widely applied in plate reconstructions and geodynamic modelling. However, global travel-time tomography typically incorporates only a limited number of easily identifiable body wave phases and is therefore strongly dependent on the source-receiver geometry.
>
> Here, we show how global full-waveform inversion is less sensitive to source-receiver geometry and reveals numerous previously undetected positive wave speed anomalies in the lower mantle. Many of these previously undetected anomalies are situated below major oceans and continental interiors, with no geologic record of subduction, such as beneath the western Pacific Ocean. Moreover, we find no statistically significant correlation positive anomalies as imaged using full-waveform inversion and past subduction. These findings suggest more diverse origins for these anomalies in Earth's lower mantle, unlocking full-waveform inversion as an indispensable tool for mantle exploration.

Here some terminology is perhaps in order. Seismic waves are acoustic waves and their propagation in the mantle is studied. Positive speed anomaly means that sound speed is higher than expected. The lowering of temperature or increase of density such as presence of iron can cause this kind of anomalies. The Pacific ocean and the interior regions of plates do not have any subduction history so that the slabs cannot be pieces ofcontinental plates, which have sunk to the mantle.

I have not earlier considered what happened in the lower mantle in the sudden expansion of Earth increasing its radius by factor 2 and giving rise to the Cambrian Explosion. Did these kinds of cracks occur also in the mantle-core boundary and lead to the formation of the recently observed structures also below regions where there is no geologic record for subduction? Could at least some regions which are believed to be caused by the sinking of parts of continental plates have such structure?

Could the Cambrian explosion be a mini Big Bang that happened in the lower mantle and forced the motion of the upper layers leading to the increase of the radius of Earth? The

longstanding problem has been the identification of the energy needed to overcome the gravitational force. The order of magnitude of the gravitational binding energy per nucleon is about 1 eV at the surface of the Earth and decreases like $M(R)/M_E)/R \propto R^2$ below it. How did the matter above the monopole flux tube layers get this energy?

1. Since the monopole flux tubes are the key actors, a natural first guess is that there was a layer of dark protons at monopole flux tubes in the lower mantle, say above the core, and that the gravitational energy is compensated by the cyclotron energy of dark proton with gravitational Planck constant $\hbar_{gr}(M(below))$ at monopole flux tube carrying a magnetic field of order of magnitude of endogenous magnetic field. The value of B_{end} need not be the same as its value $B_{end} = .2$ Tesla at the surface of the Earth.

2. If the monopole flux behaves like $1/R^3$, as the dipole character of the Earth's magnetic field suggests, and the mass appearing in the gravitational Planck constant is the mass $M(R) = (R/R_E)^3 M_E$ below the monopole flux tube layer is used, the cyclotron energy is the same as at the surface of the Earth. In the explosion, the value of $\hbar_{gr}$ would be reduced dramatically, perhaps to $\hbar$ and the cyclotron energy would be liberated.

   In the interior of the Earth, the gravitational potential energy for mass m is of form $E_{gr} = GM_E m V_{gr}(R)$, $V_{gr}(R) = R^2/2R_E^3 - (3/2)/R_E$ and approaches in the center of the Earth the value $-(3/2)GM_E m/R_E$ and at the surface of the Earth to the value $-GM_E m/R_E$.

3. All nuclei must receive the cyclotron energy compensating the gravitational binding energy and a larger fraction should therefore be dark before the explosion. The gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ of a nucleus is proportional to its mass number so that the cyclotron energy $\propto ZeB/m$ does not depend on the mass number A of the ion of mass $m \simeq Am_p$. For $1/\beta_0 = 1$, the extreme option is that the entire Earth's interior contains gravitationally dark nuclei meaning that there is a large negatively charged exclusion zone created in the Pollack effect, perhaps giving rise to the electric body assignable to the Earth. Can this be consistent with what is known about the Earth's history? For $1/\beta_0 = 2^{-11}$ assignable with the magnetic body of the Sun-planet system, the value of cyclotron energy would be about 10 keV, which happens to be the energy scale of "cold fusion" identified as dark fusion in the TGD framework [**?**]. Could the formation of dark nuclei with nucleon radius of order electron Compton length and with a dark nuclear binding energy of order 10 keV involve the formation of the monopole flux tubes with this dark cyclotron energy?

11.3.4 A possible mechanism of radiative energy transfer from the Earth's core to underground oceans near the surface of Earth

The recent observations [D6] strongly suggest that there is an ancient seabed on top of the Earth's core, and there are also mountains with a height of about 10 km. The proposed model, in which convection moves the sea floor to the region above the mantle, is probably correct.

This finding combined with the discovery of the so-called superionic ice [D9], which could exist above the Earth's core, allows to develop a proposal for a mechanism of metabolic energy transfer from the Earth's core to the underground oceans near the surface of Earth. This would make possible the development of photosynthesizing life forms in underground oceans. The generalization of the Pollack effect [I101, L13, I143, I123] would play a key role in the mechanism.

Ultralow velocity zones

The following abstract of the article (see this) published by a group led by Dr. Samantha Hansen [D6] gives an overall view of what has been observed.

Ultralow velocity zones (ULVZs) are the most anomalous structures within the Earth's interior; however, given the wide range of associated characteristics (thickness and composition) reported by previous studies, the origins of ULVZs have been debated for decades. Using a recently developed seismic analysis approach, we find widespread, variable ULVZs along the core-mantle boundary (CMB) beneath a largely unsampled portion of the Southern Hemisphere. Our study region is not beneath current or recent subduction zones, but our mantle convection simulations demonstrate how heterogeneous accumulations of previously subducted materials could form on the

CMB and explain our seismic observations. We further show that subducted materials can be globally distributed throughout the lowermost mantle with variable concentrations. These subducted materials, advected along the CMB, can provide an explanation for the distribution and range of reported ULVZ properties.

So called S waves (see this) are transversal acoustic waves caused by the shear force parallel to the propagation. This force is proportional to viscosity and is negligible in liquids but much larger in solid phase waves reflected at mantle-core boundary. The core of Earth is in a liquid phase. Therefore sound waves from the surface of Earth are reflected back at the mantle-core boundary.

This makes it possible to deduce information from the structure of the mantle-core boundary and it has turned out that it has a highly complex structure. First of all, these waves propagate very slowly. This allows us to conclude that there is a relatively thin layer with a high density, which could consist of the same material as the seabed. This layer contains mountains with heights of order 10 km.

The TGD inspired view of the evolution life, inspired by the Cambrian Explosion and TGD based view of cosmology, is that photosynthesizing life evolved in underground oceans and that the expansion of the Earth radius by about factor 2 bursted these oceans to the surface of Earth in Cambrian Explosion [L46, L93, L83, L116, L115].

Could the ancient seabed above the mantle be assigned to the ocean immediately above the mantle? This is not possible. The existence of an underground ocean immediately above the mantle is impossible due to the high pressure and temperature so that the convection remains the natural explanation for the presence of seabed.

The second objection is that life in the underground oceans is not possible because solar energy needed by photosynthesis is not available. How could photosynthesis have developed in the underground oceans? The key observation is that energies of the photons of thermal radiation coming from the core are of the same order as the metabolic energy currency with nominal value of .5 eV: could this radiation have served as a source of metabolic energy.

How would this energy be transferred? The Pollack effect [I101, L13, I143, I123] and its reversal, whose TGD based understanding [L13, L114, L121, L124, L122] has increased considerably during this year, could provide a fast energy transfer mechanism, but in its standard form the Pollack effect requires liquid water. Could the so-called superionic ice [D9], which has been speculated to be found even near the mantle of Earth, make possible the analogy of the Pollack effect?

Ordinary water cannot survive near mantle

Although it is obvious that ordinary liquid water cannot exist at temperatures and pressures prevailing near the mantle, it is useful to look at the situation more quantitatively.

In mechanical equilibrium, pressure gradient and the gravitational force, expressible in terms of the gradient of gravitational potential, cancel each other in good approximation. One can estimate the change of pressure as $\Delta p = \rho\Delta\Phi_{gr} = \rho GM\Delta(\frac{1}{R})$. The equation of state allows an estimate for ΔT.

Pressure is estimated to increase from 100 MPa at the surface of the Earth to 139 GPa above the mantle, that is by a factor 1000. Temperature, converted to thermal energy $E = kT$, is estimated to increase from .03 eV$\rightarrow$ to 0.42 eV. The increase is by a factor of 10. Ordinary water cannot survive in this kind of environment so that underground water is possible only sufficiently near to the surface of Earth.

Could one imagine a phase of water allowing the analog of Pollack effect so that the transformation of protons to dark protons at the gravitational MB could make it possible to transfer metabolic energy to the higher heights, where underground liquid water can exist. This would have made possible the development of photosynthesizing life and would also solve the "faint Sun" paradox (`https://rb.gy/mfhavz`) [L116] meaning that the solar energy feed was not enough for the metabolic needs of life at the surface of Earth.

Pollack effect for superionic water and metabolic energy feed from the core of Earth

Superionic ice [D9] (see this and this) existing at extreme pressures. The density of superionic ice is slightly less than 4 times the density of ordinary ice. In superionic ice O^{2-} ions form a lattice whereas H^+ ions float freely. This phase is conductor with H^+ ions serving as charge carriers. Superionic ice is proposed to appear in the mantles of giant planets such as Uranus and Neptune and in [**?**]he possibility that it could occur in the Earth's mantle was considered.

Could water appear as superionic ice above the Earth's core and allow Pollack effect and its reversal so that gravitational flux tubes would carry dark protons. Could dark photons emitted in the reverse Polack effect transfer the energy along gravitational flux tubes to the underground oceans near the surface of the Earth?

Let's assume that there exists superionic ice above the mantle.

1. Could the radiation from the core kick part of the protons of the superionic water to the gravitational magnetic body? The gravitational binding energy of protons at the surface of Earth is about .5 eV and now roughly by a factor 4 larger, that is 2 eV, at the top of the mantle. At the gravitational magnetic flux tubes the reduction of gravitational binding energy is therefore below 2 eV. The temperature of the core corresponds to the metabolic energy currency of about .4 eV so that the radiation could have played the same role as the solar radiation in photosynthesis.

2. If the reverse Pollack effect occurs, dark photons are emitted and they propagate to the MBs of water volumes near the surface of Earth and could provide energy for photosynthesis. Also time reversal can occur for the water near the surface of Earth and the proton can gain the energy required by darkness by emitting a negative energy dark photon propagating to the MB near the mantle. I have called this mechanism remote metabolism or quantum credict card and asked whether it could play a key role also in the ordinary biology.

3. If the temperatures of the lower part of the mantle and the core are the same, the energy input from the core could feed protons to gravitational MB, maintain the superionic water phase and compensate for the energy loss due to the reverse Pollack effect. The transfer of energy near the earth's surface would take place at the speed of light and dissipation would be very small.

4. The number of ordinary-to-dark transitions of protons per unit time determines the energy flow to the MB and the energy flow to the uppermost layers of the mantle. In a steady state, this flow must be the same as the radiative heat flow from the core. This transfer rate is determined by the rate for the photon absorptions kicking protons to the MB. The energy flow of energy coming as radiation is proportional to T^4.

A mechanism of photosynthesis which does not involve biomolecules

Standard biology teaches us that photosynthesis is needed to produce oxygen, which is the basic prerequisite of life. Besides complex biological apparatus this requires photons, which provide the needed energy. At the bottom of the ocean there is very dark and this might form a bottleneck for the evolution of life. Now it has been found that at the bottom of ocean mineral deposits known as polymetallic nodules can generate oxygen in absence of photons (see). They contain combinations of cobalt, copper, lithium, and manganese and the size of the nodule can be that of a human hand. The initiation of electrolysis splitting water to hydrogen and oxygen needs only 1.5 eV voltage in seawater. This means that one has a battery. It was found that the nodules involve voltage as high as .95 eV.

The nodules could make possible electrolysis and splitting of water. They could make it possible to overcome the hen and egg problem due the fact that a complex biomolecular apparatus is needed for photosynthesis but this apparatus cannot exist in primordial biology.

In the TGD Universe, multicellular life would have evolved in underground oceans and bursted to the surface in the Cambrian explosion for about 450 million years ago [L116], which in the TGD Universe was caused by the expansion of the Earth radius by a factor 2 in a rather short period of time. TGD indeed predicts that the cosmic expansion of astrophysical objects occurs as

short bursts. This explains why the astrophysical objects comove in expansion but do not expand themselves .

A heavy objection against this vision is that there are no photons in underground oceans so that photosynthesis is not possible. I have proposed that the light arriving as dark photons - ordinary photons but with a large value of effective Planck constant h_{eff} - from the Earth's core (the temperature is nearly the same as in the solar corona) could have provided the metabolic energy. Also solar photons arriving as dark photons along monopole flux tubes could have provided the energy.

It seems that also the polymetallic nodules could generate photons and make possible the splitting of water. What could be the mechanism making this possible? It must be added that also electrolysis, thought to represent ancient physics, is not a well-understood phenomenon. Remarkably, "cold fusion" was discovered in electrolytes [L30, L76]. The voltages used in electrolysis are in eV range and in atomic physics length scales they correspond to ridiculously weak electric fields. How can they cause the ionization essential for electrolysis?

1. In the Pollack effect [I101, L13, I143, I123], the irradiation of water in the presence of the gel phase generates a voltage, and therefore produces a battery. This battery also makes possible electrolysis and the splitting of water producing oxygen. Pollack effect is not understood in the framework of standard chemistry.

2. The TGD explanation is that in the Pollack effect one fourth of the protons of water are transformed to dark photons and kicked to monopole flux tubes. This creates a negatively charged region called exclusion zone (EZ). This would generate a charge separation giving rise to the voltage. Photons would provide the needed energy to transform ordinary protons to dark protons with a larger value of h_{eff} and therefore larger energy.

   It has become gradually clear that what matters is energy. Therefore the Pollack effect can be realized in several ways. In particular, the formation of molecules as bound states of atoms can provide the needed energy: no photons would be needed [L113, L128].

   In particular, the reverse Pollack effect, that is dropping of dark protons from the monopole flux tubes back to ordinary protons, is also possible and would liberate ordinary photons needed in the splitting of water. This could also provide the photonic energy needed in photosynthesis and could provide a temporary storage of metabolic energy needed in photosynthesis and in the storage of energy to ATP [L114](see ¡A HREF="https://tgdtheory.fi/public$_h$tml/*articles/photosynth.pdf*"
   this $<$ /A $>$).

3. If this can happen in the nodules, the photosynthesis could have evolved in underground oceans via the fusion of atoms to molecules and completely without external light source.

11.3.5 Did Earth have a ring before the Cambrian Expolosion and did the rapidly expanding Earth catch the ring?

I encountered a link to a very interesting popular article "Did Earth have a ring like Saturnus?" (see this) telling about the article "Evidence suggesting that earth had a ring in the Ordovician" of Tomkins et al published in Earth and Planetary Science Letters [E17].

The proposal is that the ring would have formed as a large asteroid was caught by the Earth. The tidal forces of Earth would have destroyed the asteroid so that it became a ring along the equator of the Earth. The ring created a shadow. If it formed along the equator, it could have initiated global cooling about 465 years ago: the so-called Hirnantian Icehouse followed 20 million years later. There are as many as 21 meteor strikes along the equator and this is very implausible if the meteors would have arrived from random directions.

This is a highly interesting finding from the point of view of the Expanding Earth hypothesis inspired by TGD [L116, L115]. About 524 million years ago the so-called Cambrian Explosion occurred. Highly evolved multicellular life forms suddenly emerged. A possible explanation of this mystery could be a fast expansion of the Earth: radius would have increased by about factor 2: these fast expansions could be the TGD counterpart of smooth cosmic expansion. This would have led to the bursting of underground oceans containing the multicellular life to the surface of the Earth. It is not difficult to invent objections against the idea but the new physics predicted

by TGD allows to circumvent them and the model explains a large number of anomalies to the evolution of Earth.

The ring would have formed about 60 million years later and existed for a time measured 10 million years as a natural unit. Could one think that Earth had already before this time a ring and the Expanding Earth caught the ring? This could explain why the ring was along the equator, something not obvious if the ring was formed by the asteroid rotating around the Earth. This would have produced the 21 meteor strikes along the equator, a phenomenon which is extremely implausible if the meteors did not originate from the same source. The expansion of the Earth would have gradually increased the width of the shadow and the collision with the ring would have generated dust in the atmosphere and caused an additional shadowing effect causing the cooling of the climate.

11.3.6 Could the proposed Expansion of Earth during Cambrian Explosion have lead to the formation of Moon?

The discussions related to the Expanding Earth hypothesis stimulated interesting questions. How planets and Moons would have been born in TGD-based astrophysics and could the formation of Moon relate to the Expanding Earth hypothesis explaining also Cambrian Explosion [L116] and whether the gradual growth of Moon's orbit might relate to it?

During the last year, I wrote two articles about the birth of stars and planets and also Moons in TGD Universe last year [L118, L119].

The first basic idea is the fractality of TGD-based cosmology, which follows from the TGD view of space-time as a 4-D surface in $H = M^4 \times CP_2$. Another key idea is the replacement of a smooth continuous expansion with a sequence of fast explosions.

1. The scaled down versios of Big Bang would occur on different scales. For example, a star would produce shells of mass ejected in an explosion that would condense into planets.

2. The planets could also do the same and this would lead to the birth of shells, from these the rings would be born and from these the Moons would be born.

There are many theories about the formation of the Moon. One of them is that for about 4.5 Gy years ago a planet christened as Theia (see this) and having a mass about the mass of Mars collided with Earth and was evaporated in the process, and that the vapour condensed to form Moon (see this). 10-30 percent of Theia's mass formed Moon which is roughly 1 per cent of the mass of Earth and 70-90 per cent of mass contributed to the mass of Earth: this makes less than 10 per cent of the mass of the Earth. This would have led to the increase of the radius of the Earth and the rough estimate gives that the radius increased by a factor 2. Expanding Earth hypothesis in turn proposes that the radius of Earth increased in Cambrian explosion by factor 2.

A possibility suggested by TGD is that Moon was created by the same mechanism as a planets, that is by an explosion creating a spherical layer, which condensed to form a Moon. The condition $4\Delta R/R_E \simeq M_{Moon}M_E$ gives $\Delta R \simeq 22$ km. Intriguingly, the group led by Weigang Liang has presented strong evidence that the Moon has turned inside out [E8]. The heavy elements, which should be in the core are at the surface. For a popular summary see this. Can this model explain this mysterious looking finding? During the condensation of the spherical layer to the Moon, the gravitational acceleration experienced by the outer parts of the shell was stronger than that experienced by the inner parts. Therefore turning inside out of the shell before the condensation to Moon.

A more precise calculation shows that the turning inside out is suggestive even if the shell has a constant density.

1. Let the outer and inner radii of the spherical shell be r_{out} and r_{in} respectively. The $r_{out}-r_{in} = \Delta_{out}$ gives the thickness of the shell. Since the shell is thin, one can write $r = r_{in} + \Delta$ and perform a Taylor approximation. One can write in a good approximation for the mass of the part of the shell extending from rin to $r = r_{in} + \Delta$ as

$$M_S(r = r_{in} + \Delta) = \rho 4\pi r_{in}^2 \Delta \simeq \frac{3(M_E - M_{shell})}{R_E^3} \quad .$$

where the approximation

$$\rho = \frac{3(M_E - M_{shell})}{4\pi R_E^3} \quad .$$

has been used.

2. The total gravitational mass affecting a particle at distance r is the sum of that caused by Earth without the shell and the portion of the shell below it and given by the sum of $M_E - M_{shell} = M_E - M(\Delta_{out})$ and $M(r)$.

3. One can write the gravitational potential as $V_{gr} = GV(r)$,where $V(r)$ is given by

$$V(r) = \frac{M_E - M_(shell) + M_S(r)}{r}$$

By expanding $V(r)$ as second order Taylor polynomial, one obtains

$$V(r) = (\frac{M_E - M_{shell}}{r_{in}} + [-\frac{M_E}{r_{in}^2} + \frac{3(M_E - M_{shell})}{R_E^3}(r_{in}\Delta - \Delta^2] \quad .$$

4. The radial gravitational acceleration is given by

$$\frac{a(r)}{G} = \frac{dV}{dr} = -[\frac{M_E}{r_{in}^2} - \frac{3(M_E - M_{shell})}{R_E^3}](r_{in} + 2\Delta)$$

The first term gives constant acceleration, which cannot cause inversion. The second term gives inwards directed acceleration and can force the inversion even in the case that the density of the shell is constant.

The the radial gravitational acceleration was proportional to $d(M(r)/r)/dr = -M(r)/r^2) + (dM(r)/dr)/2 = M(-(r/d)^3 - 1)/r^2 + (4\pi(r/d)^2)/r$

In condensation the spherical shell developed a hole and contracted along the surfae of the shell to form Moon. This preserved the reverted decomposition. The outer parts containing originally lighter stuff went to the core and the heavier stuff on the inner boundary of the shell remained on the surface.

The Cambrian explosion is also an explosion. The composition of the Moon is known to be the same as that of the Earth (see this). The crazy question that comes to mind (I can already hear my colleague's laughter in my ears) is whether the Moon was born this way in the Cambrian explosion about .5 Gy ago (instead of 4.5 Gy ago). This of course does not exclude the possibility that Moon was formed in a similar explosion for 4.5 billion years ago.

Can the Cambrian option be ruled out by comparing the ages of the Earth's Moon? Radiometric age determinations give the matter making up the Earth and the Moon (not the Earth or the Moon itself!!) age estimates of 4.543 Gy and 4.46 Gy. The age difference is 80 million years.

1. The age of the material composing Moon has been deduced from the radioactive decay of Zirconium and in the latest determination the estimate increased by 40 million years (see this). This inaccuracy is of the same order as the difference in the ages of the substances! So can the Moon consiste of matter, which has the same radio-active age as the Earth?

   One can also critically ask why the Moon's and Earth's matter would be of different ages when the composition is the same? The most natural explanation would that the substance is the same and therefore of the same age.

2. Radioactive age determinations would therefore not rule out the hypothesis of the formation of the Moon in the Cambrian explosion. In such an explosion, a layer with a thickness of about 6 km would have been thrown out and taken with it both the life on the surface and the fossils if there were any! .5 billion years old fossils would be products of underground life!

Is there any empirical evidence that the age of the Moon *cannot* be on the order of .5 billion years. Is there any evidence for the explosive origin of the Moon? Could one compare Theia hypothesis and the two variants of TGD proposal? Could the dynamics of the Moon-Earth system help here?

1. It is known that the distance of the Moon from the Earth increases slowly: $v = 3.78$ cm per year (see this). Could the recent rate for the increase of the orbital radius be interpreted in terms of cosmic expansion? The Hubble constant is about $H = 70$ km/sMpc, where parsec (pc) is 3.26 ly. This gives for the cosmic recession velocity of Moon $v(now) = HR \simeq 2.8$ cm/y. This is 74 per cent of the observed velocity of increase for the orbital radius. This suggests that the velocity due to the explosion has gradually decreased and is approaching the cosmic recession velocity (, which increases linearly with the distance: this effect has been observed but surprisingly, has not been interpreted in terms of the cosmic recession velocity!).

   Could the deviation $v - v(now)$ be a remnant of the rapid increase in the orbital radius associated with the Cambrian explosion?

2. If Moon was born in about .5 billion years ago and the velocity would have been *constant* $v = 3.78$ cm/y, the Moon would have reached a distance of about 1.9×10^7 m, which is about $2.97R_E$ (three Earth radii) from the Earth and conserably smaller than $R = 60R_E$ so that the speed should have been significantly faster at the beginning.

3. If the Moon was born in such an explosion 4.5 Gy ago, the same rough estimate assuming constant velocity $v = 3.78$ cm/y would give for the distance of the Moon $R = 26.7R_E$, $R_E = 6,357$ km. This is roughly by a factor 1/2 smaller than the recent distance $R = 60R_E$ of the Moon. This option looks more reasonable than the Cambrian option.

   Cosmic expansion cannot explain the increase of the Moon's orbital radius. One would have $dR/dt = HR$ giving the estimate $R(t) = R_E exp(v(now)t/R)$ and $R(now) = eR_E$, which is much smaller than $R = 60R_E$.

4. Could Theia hypothesis explain the growth of the distance of the Moon's to its recent in terms of the recoil momentum gained by the evaporated fragment giving rise to the Moon? This should have made the orbit elliptic. The orbit of the Moon is slightly elliptic: the eccentricity is .055 (see this). One should also understand the mechanism, which distributed the remaining matter evenly along the surface of the Earth.

   What is intriguing from the TGD point of view is that the radius of Earth could have increased by a factor 2 in the collision with Theia. This would explain the findings motivating the Expanding Earth hypothesis if the continents were formed already in the collision with the Theia.

How quickly did the ejected crust condense to form the Moon? Surprisingly, this can happen very quickly. It is estimated that the Moon could have been born within hours after the impact of Thea (see this)!

11.4 Some mysteries of the biological evolution from the TGD point of view

Biological evolution involves several deep mysteries. In this article 3 such mysteries are discussed.

11.4.1 Three mysteries

The mystery of life's origin deepens

Sabine Hossenfelder told about new study, which deepens the mystery of life's origin (see this). The key notion is LUCA, life's universal common ancestor, whose genome should be common to all life forms, which in the most general case involves both archaea, prokaryotes (bacteria), and eucaryotes (plants, fungi and animals).

The newest study gives a considerably larger number than the previous estimates.

1. LUCA would have 2,657 genes. Luca would have had 2.7 million bps to be compared with about 3 billion bps of humans. LUCA would have lived about 4.2 billion years ago.

2. The proteins coded by the genes of LUCA suggest that hydrogen was important in the metabolism of LUCA. Presumably LUCA lived near volcanoes. LUCA also had a rather complex metabolic circuitry and the genome suggests that it was a part of an ecosystem. The size of LUCA is 10 μm in size, which is also the size of cell nucleus, and it has a genome but no nucleus.

3. An interesting side observation is that 2,657 is prime and forms a twin prime together with 2659. Maybe number theory is deeply involved with the genome.

4. The earlier estimate for the gene number of LUCA by Bill Martin's team (see this) left only 355 genes from the original 11,000 candidates, and they argue that these 355 definitely belonged to LUCA and can tell us something about how LUCA lived.

The problem is that there are two widely different candidates for the LUCA and the new candidate seems to be too complex if one assumes a single evolutionary tree.

The mystery of Cambrian Explosion

Cambrian Explosion represents a long standing mystery [I133] of evolutionary biology. The basic mystery is that highly evolved multicellular life forms emerged suddenly in the Cambrian explosion about .5 billion years ago. There are much older fossils of monocellular life forms archaea and prokaryotes and they would have lived at the surface of Earth as separate evolutionary lineages.

The TGD based solution of the mystery mystery of Cambrian Explosion does not involve ETs bringing multicellular life to the Earth [L46] [L93, L83, L116].

1. In the TGD Universe, quantum gravitation is possible in arbitrarily long scales and cosmic expansion is replaced by a sequence of quantum phase transitions occurring in astrophysical scales as very rapid local expansions between which there is no expansion.

2. The life on Earth could have evolved in two ways and as three separate evolutionary trees. Multicellular life forms possible for sexually reproducing eukaryotes would have evolved in the underground oceans, where they were shielded from meteor bombardments and cosmic rays. There are indications that underground oceans and underground life are present on Mars and possibly also some other places in the solar system.

3. In the Cambrian Explosion, identified as a short lasting rapid local cosmic expansion, the radius of Earth would have increased by a factor of two. This hypothesis was originally inspired by the observation of Adams [F1] that the continents seem to fit nicely together if the radius of Earth is taken to be 1/2 of its recent radius. This hypothesis would generalize the continental drift theory of Wegener. Rather highly developed photosynthesizing multicellular life forms would have bursted to the surface of Earth from underground oceans and oceans were formed [L46] [L93, L83, L116].

The TGD proposal for the solution of the LUCA mystery relies on the solution of the mystery of the Cambrian explosion. Bacteria and archaea would have evolved at the surface of the Earth and eukaryotes having a cell nucleus and reproducing sexually in the underground oceans. Bacteria and archaea would have evolved from a counterpart of LUCA having a much smaller genome and eukaryotes would have evolved from an archaea with maximum size, which became the nucleus of the first eukaryote, LUCA.

Perplexing findings about asteroid Ryugu

Anton Petrov told in in Youtube video (see this) "Shocking Discovery of Earth Bacteria Inside Ryugu Asteroid Samples + Other Updates" of highly interesting recent discoveries, which might provide very strong direct evidence for the TGD view of quantum biology. Ryugu was found to contain basic amino acids and also RNA and microorganisms bacteria and microfossils resembling those living at Earth were found.

The motivation for studying asteroids is that they could have been very important in the planetary formation. The Panspermia hypothesis suggests that asteroids and similar objects could have also brought life to the Earth and the findings about Ryugu could at first be seen as a support for this hypothesis.

One question raised by the study is whether the microorganisms living at the Earth managed somehow to colonize the Ryugu asteroid sample. In standard biology this should not be possible. The alternative possibility is that the evolution in Earth and Ryugu has been very similar: Ryugu indeed orbits the Sun at an on orbit for which the distance from the Sun is smaller than the orbital radius of Mars.

This would however require that the biological evolution is dictated by physics in a much longer length scale than the Earth size scale. This is just what TGD predicts. These findings provide a test for the TGD view of life which suggests a very general basic mechanism for the emergence of life [L98, L113, L127].

11.4.2 LUCA from the TGD perspective

In the following the explanation for the perplexing findings about LUCA are discussed from the TGD point of view.

Some basic facts about evolution

Let us relate the proposed identification of LUCA with 2657 genes to basic facts about biology.

1. It is known that parasitic bacteria have 500–1200 genes, free-living bacteria have 1500–7500 genes, and archaea have 1500–2700 genes. Prokaryotes and archaea are monocellular organism and do not have cell nucleus. Eukaryotes differ from Archaea and prokaryotes in that they can sexually reproduce: this means huge evolutionary step.

2. Archaea (see this) are often thought to be more primitive than prokaryotes (see this) and eukaryotes (see this but it seems that they resemble eukaryotes more than prokaryotes. It should be noticed that mitochondria (see this) responsible for the metabolism have their own genome having only 37 genes to that one could (just for fun) argue that mitochondria are a natural identification of LUCA!

3. The lower bound for the gene number of free living bacteria and archaea is 1500 and smaller than 2657. It is however known that ancient bacteria had more genes than their recent forms. This might be due to the fusion of the genes to longer genes. They could be also predecessors of LUCA in some sense.

The number of genes for LUCA is upper bound for the genes of archaea: what does this mean?

Intriguingly, 2657 is near the upper limit 2700 for the gene number of archaea. This raises questions.

1. Could the branches of the evolutionary tree have genuine dead ends, and are archaea and bacteria such dead ends? Could prokaryotes and archaea correspond to separate lineages of the evolutionary tree and did eukaryotes evolve from archaea as the cell nucleus emerged?

2. Was the gene number 2657 a critical gene number distinguishing between archaea and higher life forms? Could this be the critical gene number above which the cell nucleus possessed by eukaryotes becomes possible and makes possible sexual reproduction and explosive evolution of new life forms. Did the maximally complex archaea with 2657 genes become the first eukaryote nucleus, LUCA?

   If this was the case, did prokaryotes really share the genes of LUCA? Also prokaryotes and archaea with shorter genomes exist. Are these predecessors of the nucleus of LUCA? Did prokaryotes with gene number larger than 2657 evolve from prokaryotes separately?

3. Do prokaryotes and archaea have a common predecessor analogous to LUCA having much lower number of genes and is it the previous candidate for the LUCA having 355 genes.

Two mysteries with a common solution: Cambrian Explosion and the complexity of LUCA

The complexity of the genome of LUCA looks like a mystery as also the existence of two widely different candidates for LUCA. One possible solution of the mystery relies on the Panspermia hypothesis. Most life forms would have arrived to the Earth from elsewhere and only sufficiently complex organisms, whose genomes contained the LUCA genome, survived in the new environment. The TGD based solution of the mystery does not involve ETs but relies on the TGD inspired solution of the mystery of Cambrian Explosion [L46] [L93, L83, L116].

In this framework, one can imagine three separate evolutionary lineages.

1. Archaea and prokaryotes such as cyanobacteria, about which there are fossils much before the Cambrian Explosion, would have evolved at the surface of Earth. Note that cyanobacteria have about 559 core-genes (see this).

2. More complex multicellular eukaryotes, having a cell nucleus and reproducing sexually, would have evolved in the underground ocean oceans. The basic evolutionary step would have been the emergence of the cell nucleus, perhaps as a fusion of two monocellulars. This step could have led from LUCA as a maximally complex archaea to eukaryotes. For some reason, eukaryotes would have survived only in underground oceans. Cosmic rays causing damage to the genes inside it might have made sexual reproduction too risky.

3. Eukaryotes would have had the proposed LUCA as a common ancestor as the maximally complex archaea whereas the earlier candidate for LUCA would be the common ancestor of archaea and prokaryotes.

4. Either all the organisms of the underground oceans contained the maximally complex archaea genome or only the organisms of the underground oceans having a genome not sorter than the LUCA genome were sufficiently complex to survive besides the prokaryotes present from the beginning at the surface of Earth.

   LUCA as the first eukaryote, having the maximally evolved archaea as cell nucleus, would have had just the minimum number of genes needed to survive at the surface of the Earth. The archaea and bacteria having a genome shorter than LUCA genome would have emerged in the evolution at the surface of the Earth before the Cambrian Explosion.

5. A fusion of two unicellulars took place in the formation of LUCA and outer cell membrane emerged. An archaea with the genes of LUCA became the nucleus of the first eukaryote cell. The minimal choice for the second unicellular is mitochondria with 37 genes: this would give 2694 genes, almost the upper bound of 2700 for archaea. If cell membranes are an outcome of self-organization rather than being coded, this system might have been able to code itself.

11.4.3 The perplexing findings about the asteroid Ryugu from the TGD perspective

The TGD perspective about Ryugu is based on the notion of long range quantum coherence predicting the notions of gravitational and electric magnetic body carrying phases of ordinary matter with a very large value of Planck constant [L101, L98, L113, L127]. These field bodies with sizes in astrophysical scales are predicted to be fundamental for life and its evolution and imply that the evolution of the chemical life is predicted to be induced by the evolution at the level of the field bodies. In this framework one can understand why Ryugu can contain life forms resembling those on Earth.

Some facts about Ryugu

Some basic facts about Ryugu are in order. Consider first the origin of Ryugu.

1. The surface of Ryugu is very young and has an age of 8.9 ± 2.5 million years. The composition of Ryugu shows that its material has been at a rather high temperature about 1000 C and presumably near the Sun. Eventually Rygu would have left the inner solar system and its composition suggests that it has been very near to the Kuiper belt with distance 30-55 AU.

2. The asteroid that arrived near the Earth from outer space must have been for a long period in complete darkness. The object giving rise to Ryugu could have originated far from Jupiter, possibly near the Kuiper belt. Some compounds in Ryugu can only form near the Kuiper belt. A larger object of radius about 100 km could have suffered a collision near Earth and produced Ryugu with a size of 10 km near Earth.

3. Recently Ryugu orbits the Sun at a distance of 0.96-1.41 AU once every 16 months (474 days (16 months); semi-major axis of 1.19 AU). Note that the distance of Mars from the Sun is about 1.5 AU. Its orbit has an eccentricity of 0.19 and an inclination of 6 degrees with respect to the ecliptic.

The circumstances at Ryugu are favorable for life.

1. The highest temperature on the Ryugu asteroid reaches 100 degrees C, while the coldest regions sit at about room temperature. Temperatures also change depending on the solar distance of the asteroid, lowering as Ryugu moves further away from the Sun. This would mean that the circumstances at Ryugu become favourable for life as it passes Earth. The lowering of the temperature at a large distance would not be fatal.

   Hydration is essential for life. The required range of dehydration reaction temperature decreases with increasing substitution of the hydroxy-containing carbon: Primary alcohols: 170–180 degrees C; secondary alcohols: 100–140 degrees C; tertiary alcohols: 25 degrees-–80 degrees C. Primary/secondary/tertiary refers to the position of -OH substitution in Carbon atom.

2. Ryugu contains liquid water and also carbonated water. Coral-like inorganic crystals are present. The sample contained carbon rich molecules, amino acids and components of RNA and hydrated compounds! Ammonium.

3. It has also been found that Ryugu contains phosphorus rich samples. Phosphorus plays a central role in metabolism and in the "dark" realization of the genetic code in TGD. The abstract of the article [I91] summarizes the findings.

   Parent bodies of C-type asteroids may have brought key volatile and organic-rich compounds to the terrestrial planets in the early stages of the Solar System. At the end of 2020, the JAXA Hayabusa2 mission successfully returned samples from Ryugu, providing access to a primitive matter that has not suffered terrestrial alteration. Here we report the discovery of a peculiar class of grains, up to a few hundreds of micrometres in size, that have a hydrated ammonium–magnesium–phosphorus (HAMP)-rich composition. Their specific chemical and physical properties point towards an origin in the outer Solar System, beyond most snow lines, and their preservation along Ryugu history. These phosphorus-rich grains, embedded within an organic-rich phyllosilicate matrix, may have played a major role when immersed in primitive terrestrial water reservoirs. In particular, in contrast to poorly soluble calcium-rich phosphates, HAMP grains favour the release of phosphorus-rich and nitrogen-rich ionic species, to enter chemical reactions. HAMP grains may have thus critically contributed to the reaction pathways of organic matter towards a biochemical evolution.

Objections against the Panspermia hypothesis as explanation of the findings about Ryugu

The panspermia hypothesis states that Ryugu and similar objects could have served as a source of life on Earth.

1. Overpopulation problem is the theoretical objection against the Panspermia hypothesis. No new forms of life are possible since no niches are left untouched.

2. There is also a second objection against the panspermia hypothesis as an explanation of these findings about Ryugu. It has been claimed that the Ryugu sample was contaminated by terrestrial microorganisms [I74] (see this). Nitrogen dioxide NO_2 is used in sterilization meant to remove, kill, or deactivate all forms of life present in fluid or on a specific surface.

Life forms of Earth should not be able to colonize samples under extremely sterile conditions. If contamination occurred, its mechanism is unknown.

The Ryugu samples contained terrestrial microbes and they evolved with time. Their DNA has not yet been identified. They resemble bacilles, which are everywhere on the Earth.

3. Microfossils have been found in meteorites [I92]. They have been found also in Ryugu but only at the surface of Ryugu and were reported to be new fossils. The reason could be that microbes have survived only at the surface of Ryugu where they receive solar light necessary for photosynthesis. The proposal of [I74] is that terrestrial organisms might by some unknown mechanism have contaminated the surface of Ryugu and produced the microfossils.

The TGD view of Ryugu

Neither panspermia hypothesis nor contamination look plausible in the TGD framework. Life would have evolved by the same basic mechanism both at the Earth and the asteroids and other similar objects.

1. Ryugu stays relatively near the Earth at its orbit. This could have also made possible the generation of organic matter inside the sample during the period that Ryugu has spent at its orbit around the Sun. This requires a model for how this happens and standard physics does not provide such a model.

2. The notion of the field body is central in the TGD inspired quantum biology and would act as controller of the biological body [L98, L113]. Ordinary genetic code is proposed to be accompanied by its dark variant realized at the field body for ordinary particles at it having a very large value of effective Planck constant and behaving like dark matter. Could the field body of the Earth and Sun have induced the generation of organic molecules and even bacterial life forms in the same way as they did this at the Earth?

3. The notion of the gravitational magnetic body, characterized by gravitational Planck constant introduced by Nottale [E5], containing protons behaving like dark matter, represents new quantum physics relevant to the TGD inspired quantum biology. OH-O^- + dark proton qubits and their generalizations based on biologically important ions formed by salts would be the key element of life [L127] suggesting besides chemical life also other forms of life.

   Any cold plasma (plasmoids as life forms) and even quartz crystals could give rise to these qubits at temperatures near the room temperature around which the flips of these qubits are possible. The difference of OH bonding energy and O^- binding energy determines the relevant energy. Its nominal value is .33 eV and is near the metabolic energy quantum of about .5 eV and near to the thermal energy .15 eV at physiological temperatures.

4. These qubits would make the matter living and life in this sense is universal. Dark genetic code is predicted and corresponds to the ordinary chemical genetic code. Basic biomolecules would give rise to analogs of topological quantum computers.

   The flipping of these qubits would make quantum computation like information processing possible? Pollack effect by photon absorption can induce OH$\rightarrow$ O$-$ +dark proton transition and the reversal of this process and the reversal of this process can take place spontaneously. If O^-+dark proton has a lower energy than OH, it can be also induced by a presence of electric field or absorption of photons by O^- so that OH becomes the minimum energy state.

Could one understand the findings about Ryugu in this framework?

1. The presence of gravitational magnetic bodies of Earth and Sun could have induced the formation of OH-O^- qubits and more general qubits, not only at the Earth but also at Ryugu. The presence of OH bonds requires hydration and hydration is indeed possible at Ryugu.

   Therefore the same mechanism could have led to the emergence of the basic organic molecules at the Earth, at Mars and inside the Ryugu asteroid and meteorites. Since the minimal distance of the Earth and Ryugu from the Sun is nearly the same, the temperature of Ryugu

is near its maximal value when it is near the Earth so that the temperature would never get too hot.

2. Ryugu is under the influence of the gravitational bodies of both the Earth and the Sun. Ryugu passesnear the Earth repeatedly with a period of 4 years. The organic molecules and various hydrated compounds could have gradually formed during about 10 million years as it passed near the Earth. Also bacterial life could have emerged in this way. Therefore contamination need not be in question.

Acknowledgements: I want to thank my friend Heikki Haila for enlightening discussions concerning glaciations.

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 [L34, L35]. In the recent view of quantum TGD [L109], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L73, L74] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L69] [K102] 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) [L69, L87] [K102] 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 [A16] so that $H = M^4 \times CP_2$ is twistorially unique.

One can loosely say that quantum states in a given sector of "world of classical worlds" (WCW) are superpositions of space-time surfaces inside CDs and that positive and negative energy parts of zero energy states are localized and past and future boundaries of CDs. CDs form a hierarchy. One can have CDs within CDs and CDs can also overlap. The size of CD is characterized by the proper time distance between its two tips. One can perform both translations and also Lorentz boosts of CD leaving either boundary invariant. Therefore one can assign to CDs a moduli space and speak about wave function in this moduli space.

In number theoretic approach it is natural to restrict the allowed Lorentz boosts to some discrete subgroup of Lorentz group and also the distances between the tips of CDs to multiples of CP_2 radius defined by the length of its geodesic. Therefore the moduli space of CDs discretizes. The quantization of cosmic recession velocities for which there are indications, could relate to this quantization.

A-2.1 Basic facts about CP_2

CP_2 as a four-manifold is very special. The following arguments demonstrate that it codes for the symmetries of standard models via its isometries and holonomies.

CP_2 as a manifold

CP_2, the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-2.1}$$

Here λ is any non-zero complex number. Note that CP_2 can be also regarded as the coset space $SU(3)/U(2)$. The pair z^i/z^j for fixed j and $z^i \neq 0$ defines a complex coordinate chart for CP_2. As j runs from 1 to 3 one obtains an atlas of three coordinate charts covering CP_2, the charts being holomorphically related to each other (e.g. CP_2 is a complex manifold). The points $z^3 \neq 0$ form a subset of CP_2 homoeomorphic to R^4 and the points with $z^3 = 0$ a set homeomorphic to S^2. Therefore CP_2 is obtained by "adding the 2-sphere at infinity to R^4".

Besides the standard complex coordinates $\xi^i = z^i/z^3$, $i = 1, 2$ the coordinates of Eguchi and Freund [A12] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it \ , \\ \xi^2 &= x + iy \ . \end{aligned} \tag{A-2.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= rexp(i\frac{(\Psi+\Phi)}{2})cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= rexp(i\frac{(\Psi-\Phi)}{2})sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-2.3}$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number Euler number 3, Pontryagin number 3 and second $b = 1$.

Fig. 4. CP_2 as manifold. `http://tgdtheory.fi/appfigures/cp2.jpg`

Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2, observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \to exp(i\alpha)z^i$ on the sphere S^5: $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5.

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-2.5}$$

where the function K, Kähler function, is defined as

$$\begin{aligned} K &= log(F) \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-2.6}$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-2.7}$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-2.8}$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A \ , \tag{A-2.9}$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , \quad e^1 = \frac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} \ , \quad e^3 = \frac{r\sigma_3}{F} \ . \end{aligned} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\ e^2 &= \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 &= \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \ . \end{aligned} \tag{A-2.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \ . \tag{A-2.12}$$

From this expression one finds that at coordinate infinity $r = \infty$ line element reduces to $\frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2)$ of S^2 meaning that 3-sphere degenerates metrically to 2-sphere and one can say that CP_2 is obtained by adding to R^4 a 2-sphere at infinity.

The vierbein connection satisfying the defining relation

$$de^A = -V^A_B \wedge e^B \ , \tag{A-2.13}$$

is given by

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\ V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\ V_{03} &= (r - \tfrac{1}{r})e^3 \ , & V_{12} &= (2r + \tfrac{1}{r})e^3 \ . \end{aligned} \tag{A-2.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{aligned} R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3 \ , & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1 \ , & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1 \ , \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ . \end{aligned} \tag{A-2.15}$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$J = -is_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-2.16}$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$J^k_{\ r} J^{rl} = -s^{kl} \ . \tag{A-2.17}$$

The condition states that J and g give representations of real unit and imaginary units related by the formula $i^2 = -1$.

Kähler form is expressible locally in terms of Kähler gauge potential

$$J = dB \ , \tag{A-2.18}$$

where B is the so called Kähler potential, which is not defined globally since J describes homological magnetic monopole.

$dJ = ddB = 0$ gives the topological half of Maxwell equations (vanishing of magnetic charges and Faraday's induction law) and self-duality $*J = J$ reduces the remaining equations to $dJ = 0$. Hence the Kähler form can be regarded as a curvature form of a $U(1)$ gauge potential B carrying a magnetic charge of unit $1/2g$ (g denotes the gauge coupling).

The magnetic flux of J through a 2-surface in CP_2 is proportional to its homology equivalence class, which is integer valued. The explicit representations of J and B are given by

$$\begin{aligned} B &= 2re^3 \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F} sin\Theta d\Theta \wedge d\Phi \ . \end{aligned} \tag{A-2.19}$$

The vierbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type (1, 1).

Useful coordinates for CP_2 are the so called canonical (or symplectic or Darboux) coordinates in which the Kähler potential and Kähler form have very simple expressions

$$\begin{aligned} B &= \sum_{k=1,2} P_k dQ_k \ , \\ J &= \sum_{k=1,2} dP_k \wedge dQ_k \ . \end{aligned} \tag{A-2.20}$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$\begin{aligned} P_1 &= -\frac{1}{1+r^2} \ , \\ P_2 &= -\frac{r^2 cos\Theta}{2(1+r^2)} \ , \\ Q_1 &= \Psi \ , \\ Q_2 &= \Phi \ . \end{aligned} \tag{A-2.21}$$

Spinors In CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A9]. 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 [B11] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H-chirality $e = \pm 1$, CP_2-chirality l, r and M^4-chirality L, R are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi \ , \\ e &= \pm 1 \ , \end{aligned} \tag{A-2.23}$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \otimes \gamma_5$, $1 \otimes \gamma_5$ and $\gamma_5 \otimes 1$ respectively. Clearly, for a fixed H-chirality CP_2- and M^4-chiralities are correlated.

The spinors with H-chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite H-chirality one can identify the vielbein group of CP_2 as the electro-weak group: $SO(4)$ having as its covering group $SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.24}$$

Here V and B denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor H-chirality $+(-)$. The integers $n_\pm$ are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection V and of B are given by the equations

$$\begin{array}{lllllll} V_{01} & = & -\frac{e^1}{r} \ , & & V_{23} & = & \frac{e^1}{r} \ , \\ V_{02} & = & -\frac{e^2}{r} \ , & & V_{31} & = & \frac{e^2}{r} \ , \\ V_{03} & = & (r - \frac{1}{r})e^3 \ , & & V_{12} & = & (2r + \frac{1}{r})e^3 \ , \end{array} \tag{A-2.25}$$

and

$$B = 2re^3 \ , \tag{A-2.26}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.27}$$

where one have defined

$$\begin{array}{lll} I_L^1 & = & \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\ I_L^2 & = & \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ . \end{array} \tag{A-2.28}$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^\pm = \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.29}$$

where $W^\pm$ denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$\begin{array}{l} R_{01} = -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ R_{02} = -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 \ , \\ R_{03} = 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , \\ R_{12} = 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ . \end{array} \tag{A-2.30}$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$\begin{aligned} W_{03} = W_{12} \equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ W_{01} = W_{23} \equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ W_{02} = W_{31} \equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 \ . \end{aligned} \tag{A-2.31}$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$\begin{aligned} X &= re^3 \ , \\ Y &= \frac{e^3}{r} \ , \end{aligned} \tag{A-2.32}$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$\begin{aligned} \bar{\gamma} &= aX + bY \ , \\ \bar{Z}^0 &= cX + dY \ , \end{aligned} \tag{A-2.33}$$

where the normalization condition

$$ad - bc = 1 \ ,$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$\begin{aligned} A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\ &+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \ . \end{aligned} \tag{A-2.34}$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5\Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$c = -d \ . \tag{A-2.35}$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.36}$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$\begin{aligned} Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \ , \\ I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \ . \end{aligned} \tag{A-2.37}$$

The fields γ and Z^0 are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) \ , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) \ . \end{aligned} \tag{A-2.38}$$

The value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{3b}{2(a+b)} \ , \tag{A-2.39}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of the Weinberg angle is a dynamical problem. The original approach was based on the assumption that it makes sense to talk about electroweak action defined at fundamental level and introduce a symmetry breaking by adding an additional term proportional to Kähler action. The recent view is that Kähler action plus volume term defines the fundamental action.

The Weinberg angle is completely fixed if one requires that the electroweak action contains no cross term of type γZ^0. This leads to a definite value for the Weinberg angle.

One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle. As a matter fact, color gauge action identifying color gauge field as proportional to $H^A J_{\alpha\beta}$ is proportional to Kähler action. A possible interpretation would be as a sum of electroweak and color gauge interactions.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+ 1_+ + n_- 1_-) \ , \tag{A-2.40}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \end{aligned} \tag{A-2.41}$$

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.42}$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \tag{A-2.43}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \ . \tag{A-2.44}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} \ , \\ L_{sym} &= \frac{1}{4g^2} Tr(F^{\alpha\beta} F_{\alpha\beta}) \ , \end{aligned} \tag{A-2.45}$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$\begin{aligned} X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\ K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ , \end{aligned} \tag{A-2.46}$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient K is given by

$$K = \sum_i \left[-\frac{(18 + 2n_i^2)sin^2\theta_W}{9} \right] \ , \tag{A-2.47}$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18 + n_i^2))} \ . \tag{A-2.48}$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} \ . \tag{A-2.49}$$

The bare value of the Weinberg angle is 9/28 in this scenario, which is not far from the typical value 9/24 of GUTs at high energies [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.

1. The supersymplectic symmetries form isometries of the world of classical worlds (WCW) and they act in CP_2 degrees of freedom as symplectic transformations leaving the CP_2 symplectic form J invariant and therefore also its contribution to the electromagnetic field since this part is the same for all space-time surfaces in the superposition of space-time surfaces as a representation of supersymplectic isometry group (as a special case a representation of color group).

2. In TGD, color and electroweak symmetries acting as holonomies are not independent and for the $SU(2)_L$ part of induced spinor connection the symplectic transformations induces $SU(2)_L \times U(1)_R$ gauge transformation. This suggests that the quantum expectations of the induced weak fields over the space-time surfaces vanish above the quantum coherence scale. The averages of W and of the left handed part of Z^0 should therefore vanish.

3. $\langle Z^0 \rangle$ should vanish. For $U(1)_R$ part of Z^0, the action of gauge transformation is trivial in gauge theory. Now however the space-time surface changes under symplectic transformations and this could make the average of the right-handed part of Z^0 vanishing. The vanishing of the average of the axial part of the Z^0 is suggested by the partially conserved axial current hypothesis.

One can formulate this picture quantitatively.

1. The electromagnetic field [L123] contains, besides the induced Kähler form, also the induced curvature form R_{12}, which couples vectorially. Conserved vector current hypothesis suggests that the average of R_{12} is non-vanishing. One can express the neutral part of the induced gauge field in terms of induced spinor curvature and Kähler form J as

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 \quad , \end{aligned} \tag{A-2.50}$$

2. The induced fields γ and Z^0 (photon and Z- boson) can be expressed as

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \ , \\ Z^0 &= 2R_{03} = 2(J + 2e^0 \wedge e^3) \end{aligned} \tag{A-2.51}$$

$$per. \tag{A-2.52}$$

The condition $\langle Z^0 \rangle = 0$ gives $2\langle e^0 \wedge e^3 \rangle = -2J$ and this in turn gives $\langle R_{12} \rangle = 4J$. The average over γ would be

$$\langle \gamma \rangle = (3 - 4sin^2\theta_W)J \ .$$

For $sin^2\theta_W = 3/4$ $langle\gamma\rangle$ would vanish.

The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

1. One expects that the correlators of classical weak fields as color invariants, and perhaps even symplectic invariants, are non-vanishing below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as hadron.

2. The intuitive picture is that in longer length scales one has disjoint 3-surfaces with a size scale of Compton length. If the states associated with two disjoint 3-surfaces are separately color invariant there are no correlations in color degrees of freedom and correlators reduce to the products of expectations of classical weak fields and vanish. This could also hold when the 3-surfaces are connected by flux tube bonds.

   Below the Compton length weak bosons would thus behave as correlated massless fields. The Compton lengths of weak bosons are proportional to the value of effective Planck constant h_{eff} and in living systems the Compton lengths are proposed to be even of the order of cell size. This would explain the mysterious chiral selection in living systems requiring large parity violation.

3. What about the averages and correlators of color gauge fields? Classical color gauge fields are proportional to the products of Hamiltonians of color isometries induced Kähler form and the expectations of color Hamiltonians give vanishing average above Compton length and therefore vanishing average. Correlators are non-vanishing below the hadron scale. Gluons do not propagate in long scales for the same reason as weak bosons. This is implied by color confinement, which has also classical description in the sense that 3-surfaces have necessarily a finite size.

   A large value of h_{eff} allows colored states even in biological scales below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as dark hadron.

Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:

1. Symmetries must be realized as purely geometric transformations.

2. Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [B2] .

   The action of the reflection P on spinors of is given by

$$\Psi \quad \rightarrow \quad P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.53}$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) \ , \\ \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \gamma^1\gamma^3 \otimes 1\Psi \ . \end{aligned} \tag{A-2.54}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \Psi^\dagger \gamma^2\gamma^0 \otimes 1 \ . \end{aligned} \tag{A-2.55}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Induction procedure and many-sheeted space-time

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has U(1) holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber if embedding space at their image points. In the recent case the embedding of space-time surface to embedding space defines the induction procedure. The induced gauge potentials and gauge fields are projections of the spinor connection of the embedding space to the space-time surface (see `http://tgdtheory.fi/appfigures/induct.jpg`).

Induction procedure makes sense also for the spinor fields of embedding space and one obtains geometrization of both electroweak gauge potentials and of spinors. The new element is induction of gamma matrices which gives their projections at space-time surface.

As a matter fact, the induced gamma matrices cannot appear in the counterpart of massless Dirac equation. To achieve super-symmetry, Dirac action must be replaced with Kähler-Dirac action for which gamma matrices are contractions of the canonical momentum currents of Kähler action with embedding space gamma matrices. Induced gamma matrices in Dirac action would correspond to 4-volume as action.

Fig. 9. Induction of spinor connection and metric as projection to the space-time surface. `http://tgdtheory.fi/appfigures/induct.jpg`.

A-3.2 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0. This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0, and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

Fig. 10. Illustration of many-sheeted space-time of TGD. `http://tgdtheory.fi/appfigures/manysheeted.jpg`

Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of M^4 (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields.This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through then so that the throats look like Kähler magnetic monopoles.

Fig. 11. Wormhole contact. `http://tgdtheory.fi/appfigures/wormholecontact.jpg`

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in H although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of M^4 and providing it with an effective metric obtained as sum of M^4 metric and deviations of the induced metrics of various space-time sheets from M^4 metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

Fig. 12. The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. `http://tgdtheory.fi/appfigures/fieldsuperpose.jpg`

Space-time surfaces of TGD are considerably simpler objects that the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating

with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the generi case. There are also magnetic flux quanta and electric flux quanta. The deformations of cosmic strings with 2-D string orbit as M^4 projection gives rise to magnetic flux tubes carrying monopole flux made possible by CP_2 topology allowing homological Kähler magnetic monopoles.

Fig. 13. Topological quantization for magnetic fields replaces magnetic fields with bundles of them defining flux tubes as topological field quanta. `http://tgdtheory.fi/appfigures/field.jpg`

The imbeddability condition for say magnetic field means that the region containing constant magnetic field splits into flux quanta, say tubes and sheets carrying constant magnetic field. Unless one assumes a separate boundary term in Kähler action, boundaries in the usual sense are forbidden except as ends of space-time surfaces at the boundaries of causal diamonds. One obtains typically pairs of sheets glued together along their boundaries giving rise to flux tubes with closed cross section possibly carrying monopole flux.

These kind of flux tubes might make possible magnetic fields in cosmic scales already during primordial period of cosmology since no currents are needed to generate these magnetic fields: cosmic string would be indeed this kind of objects and would dominated during the primordial period. Even superconductors and maybe even ferromagnets could involve this kind of monopole flux tubes.

A-3.4 Embedding space spinors and induced spinors

One can geometrize also fermionic degrees of freedom by inducing the spinor structure of $M^4 \times CP_2$.

CP_2 does not allow spinor structure in the ordinary sense but one can couple the opposite H-chiralities of H-spinors to an $n = 1$ ($n = 3$) integer multiple of Kähler gauge potential to obtain a respectable modified spinor structure. The em charges of resulting spinors are fractional (integer valued) and the interpretation as quarks (leptons) makes sense since the couplings to the induced spinor connection having interpretation in terms electro-weak gauge potential are identical to those assumed in standard model.

The notion of quark color differs from that of standard model.

1. Spinors do not couple to color gauge potential although the identification of color gauge potential as projection of $SU(3)$ Killing vector fields is possible. This coupling must emerge only at the effective gauge theory limit of TGD.

2. Spinor harmonics of embedding space correspond to triality $t = 1$ ($t = 0$) partial waves. The detailed correspondence between color and electroweak quantum numbers is however not correct as such and the interpretation of spinor harmonics of embedding space is as representations for ground states of super-conformal representations. The wormhole pairs associated with physical quarks and leptons must carry also neutrino pair to neutralize weak quantum numbers above the length scale of flux tube (weak scale or Compton length). The total color quantum numbers or these states must be those of standard model. For instance, the color quantum numbers of fundamental left-hand neutrino and lepton can compensate each other for the physical lepton. For fundamental quark-lepton pair they could sum up to those of physical quark.

The well-definedness of em charge is crucial condition.

1. Although the embedding space spinor connection carries W gauge potentials one can say that the embedding space spinor modes have well-defined em charge. One expects that this is true for induced spinor fields inside wormhole contacts with 4-D CP_2 projection and Euclidian signature of the induced metric.

2. The situation is not the same for the modes of induced spinor fields inside Minkowskian region and one must require that the CP_2 projection of the regions carrying induced spinor field is such that the induced W fields and above weak scale also the induced Z^0 fields vanish in order to avoid large parity breaking effects. This condition forces the CP_2 projection to be 2-dimensional. For a generic Minkowskian space-time region this is achieved only if the

spinor modes are localized at 2-D surfaces of space-time surface - string world sheets and possibly also partonic 2-surfaces.

3. Also the Kähler-Dirac gamma matrices appearing in the modified Dirac equation must vanish in the directions normal to the 2-D surface in order that Kähler-Dirac equation can be satisfied. This does not seem plausible for space-time regions with 4-D CP_2 projection.

4. One can thus say that strings emerge from TGD in Minkowskian space-time regions. In particular, elementary particles are accompanied by a pair of fermionic strings at the opposite space-time sheets and connecting wormhole contacts. Quite generally, fundamental fermions would propagate at the boundaries of string world sheets as massless particles and wormhole contacts would define the stringy vertices of generalized Feynman diagrams. One obtains geometrized diagrammatics, which brings looks like a combination of stringy and Feynman diagrammatics.

5. This is what happens in the the generic situation. Cosmic strings could serve as examples about surfaces with 2-D CP_2 projection and carrying only em fields and allowing delocalization of spinor modes to the entire space-time surfaces.

A-3.5 About induced gauge fields

In the following the induced gauge fields are studied for general space-time surface without assuming the preferred extremal property (Bohr orbit property). Therefore the following arguments are somewhat obsolete in their generality.

Space-times with vanishing em, Z^0, or Kähler fields

The following considerations apply to a more general situation in which the homologically trivial geodesic sphere and extremal property are not assumed. It must be emphasized that this case is possible in TGD framework only for a vanishing Kähler field.

Using spherical coordinates (r, Θ, Ψ, Φ) for CP_2, the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta) d\Phi) + \frac{r^2}{2F} sin(\Theta) d\Theta \wedge d\Phi \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-3.1}$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3+2p)\frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta) d\Phi) + (3+p)\frac{r^2}{2F} sin(\Theta) d\Theta \wedge d\Phi \ , \\ p &= sin^2(\Theta_W) \ , \end{aligned} \tag{A-3.2}$$

where Θ_W denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi \ , \\ (3+2p)\frac{1}{r^2 F}(d(r^2)/d\Theta)(k + cos(\Theta)) &+ (3+p) sin(\Theta) = 0 \ , \end{aligned} \tag{A-3.3}$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} \ , \\ X &= D\left[|\frac{k+u}{C}|\right]^{\epsilon} \ , \\ u &\equiv cos(\Theta) \ , \ C = k + cos(\Theta_0) \ , \ D = \frac{r_0^2}{1+r_0^2} \ , \ \epsilon = \frac{3+p}{3+2p} \ , \end{aligned} \tag{A-3.4}$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r. $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u + k| = [(1 + r_0^2)/r_0^2)]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \ ,$$

where $sign(x)$ denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi \ , \\ Z^0 &= -\frac{6}{p} J \ . \end{aligned} \tag{A-3.5}$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range Z^0 vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

2. The vanishing of Z^0 fields is achieved by the replacement of the parameter ϵ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that Z^0 field vanishes identically. Also the relationship $F_{em} = 3J = -\frac{3}{4}\frac{r^2}{F} du \wedge d\Phi$ is useful.

3. The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2} Z^0 \ . \end{aligned} \tag{A-3.6}$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em,Z^0, or Kähler field is of practical value in the case of vacuum extremals and is given by

$$\begin{aligned} ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\ s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\ s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ , \end{aligned} \tag{A-3.7}$$

and is useful in the construction of vacuum embedding of, say Schwartchild metric.

Topological quantum numbers

Space-times for which either em, Z^0, or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \ , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \ . \end{aligned} \tag{A-3.8}$$

m^0,m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i,k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0. At $r = \infty$ surfaces n_2,ω_2 and m can change since all values of Ψ correspond to the same point of CP_2: at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2, too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global embedding for, say a constant magnetic field. Although global embedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate u in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ , \tag{A-3.9}$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

A-4 The relationship of TGD to QFT and string models

The recent view of the relationship of TGD to QFT and string models has developed slowly during years and it seems that in a certain sense TGD means a return to roots: instead of QFT like description involving path integral one would have wave mechanics for 3-surfaces.

A-4.1 TGD as a generalization of wave mechanism obtained by replacing point-like particles with 3-surfaces

The first vision of TGD was as a generalization of quantum field theory (string models) obtained by replacing pointlike particles (strings) as fundamental objects with 3-surfaces.

The later work has revealed that TGD could be seen as a generalization of the wave mechanism based on the replacement of a point-like particle with 3-D surface. This is due to holography implied by general coordinate invariance. The definition of the metric of the "world of classical worlds" (WCW) must assign a unique or at least almost unique space-time surface to a given 3-surface. This 4-surface is analogous to Bohr orbit so that also Bohr orbitology becomes an exact part of quantum physics. The failure of strict determinism forces to replace 3-surfaces with 4-surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K49, K26, K82] [L90, L109].

Fig. 5. TGD replaces point-like particles with 3-surfaces. `http://tgdtheory.fi/appfigures/particletgd.jpg`

A-4.2 Extension of superconformal invariance

The fact that light-like 3-surfaces are effectively metrically 2-dimensional and thus possess generalization of 2-dimensional conformal symmetries with light-like radial coordinate defining the analog of second complex coordinate suggests that this generalization could work and extend the super-conformal symmetries to their 4-D analogs.

The boundary $\delta M^4_+ = S^2 \times R_+$- of 4-D light-cone M^4_+ is also metrically 2-dimensional and allows extended conformal invariance. Also the group of isometries of light-cone boundary and of light-like 3-surfaces is infinite-dimensional since the conformal scalings of S^2 can be compensated by S^2-local scaling of the light-like radial coordinate of R_+. These simple facts mean that 4-dimensional Minkowski space and 4-dimensional space-time surfaces are in a completely unique position as far as symmetries are considered.

In fact, this leads to a generalization of the Kac-Moody type symmetries of string models. $\delta M^4_+ \times CP_2$ allows huge supersymplectic symmetries for which the radial light-like coordinate of δM^4_+ plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

A-4.3 String-like objects and strings

String like objects obtained as deformations of cosmic strings $X^2 \times Y^2$, where X^2 is minimal surface in M^4 and Y^2 a holomorphic surface of CP_2 are fundamental extremals of Kähler action having string world sheet as M^4 projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D M^4 projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of induces spinor fields is well-defined requires in the generic case the localization of the modes at 2-D surfaces -string world sheets and possibly also partonic 2-surfaces. This in Minkowskian space-time regions.

Fig. 6. Well-definedness of em charge forces the localization of induced spinor modes to 2-D surfaces in generic situations in Minkowskian regions of space-time surface. `http://tgdtheory.fi/appfigures/fermistring.jpg`

A-4.4 TGD view of elementary particles

The TGD based view about elementary particles has two key aspects.

1. The space-time correlates of elementary particles are identified as pairs of wormhole contacts with Euclidean signature of metric and having 4-D CP_2 projection. Their throats behave effectively as Kähler magnetic monopoles so that wormhole throats must be connected by Kähler magnetic flux tubes with monopole flux so that closed flux tubes are obtained.

2. At the level of H Fermion number is carried by the modes of the induced spinor field. In space-time regions with Minkowski signature the modes are localized at string world sheets connecting the wormhole contacts.

Fig. 7. TGD view about elementary particles. a) Particle orbit corresponds to a 4-D generalization of a world line or b) with its light-like 3-D boundary (holography). c) Particle world lines have Euclidean signature of the induced metric. d) They can be identified as wormhole contacts. e) The throats of wormhole contacts carry effective Kähler magnetic charges so that wormhole contacts must appear as pairs in order to obtain closed flux tubes. f) Wormhole contacts are accompanied by fermionic strings connecting the throats at the same sheet: the strings do not extend inside the wormhole contacts. `http://tgdtheory.fi/appfigures/elparticletgd.jpg`

Particle interactions involve both stringy and QFT aspects.

1. The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of "long" string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their superconformal invariance behave like "short" strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.

2. Wormhole contact defines basic stringy interaction vertex for fermion-fermion scattering. The propagator is essentially the inverse of the superconformal scaling generator L_0. Wormhole contacts containing fermion and antifermion at its opposite throats behave like virtual bosons so that one has BFF type vertices typically.

3. In topological sense one has 3-vertices serving as generalizations of 3-vertices of Feynman diagrams. In these vertices 4-D "lines" of generalized Feynman diagrams meet along their 3-D ends. One obtains also the analogs of stringy diagrams but stringy vertices do not have the usual interpretation in terms of particle decays but in terms of propagation of particles along two different routes.

Fig. 8. a) TGD analogs of Feynman and string diagrammatics at the level of space-time topology. b) The 4-D analogs of both string diagrams and QFT diagrams appear but the interpretation of the analogs stringy diagrams is different. `http://tgdtheory.fi/appfigures/tgdgraphs.jpg`

A-5 About the selection of the action defining the Kähler function of the "world of classical worlds" (WCW)

The proposal is that space-time surfaces correspond to preferred extremals of some action principle, being analogous to Bohr orbits, so that they are almost deterministic. The action for the preferred extremal would define the Kähler function of WCW [K49, K82].

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 [L36] [L90, L95, L96] 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 [A16] so that TGD would be unique. Dimensional reduction is forced by the condition that the 6-surface has S^2-bundle structure characterizing twistor spaces and the base space would be the space-time surface.

1. Dimensional reduction of 6-D Kähler action implies that at the space-time level the fundamental action can be identified as the sum of Kähler action and volume term (cosmological constant). Other choices of the action do not look natural in this picture although they would have the same preferred extremals.

2. Preferred extremals are proposed to correspond to minimal surfaces with singularities such that they are also extremals of 4-D Kähler action outside the singularities. The physical analogue are soap films spanned by frames and one can localize the violation of the strict determinism and of strict holography to the frames.

3. The preferred extremal property is realized as the holomorphicity characterizing string world sheets, which generalizes to the 4-D situation. This in turn implies that the preferred extremals are the same for any general coordinate invariant action defined on the induced gauge fields and induced metric apart from possible extremals with vanishing CP_2 Kähler action.

   For instance, 4-D Kähler action and Weyl action as the sum of the tensor squares of the components of the Weyl tensor of CP_2 representing quaternionic imaginary units constructed from the Weyl tensor of CP_2 as an analog of gauge field would have the same preferred extremals and only the definition of Kähler function and therefore Kähler metric of WCW would change. One can even consider the possibility that the volume term in the 4-D action could be assigned to the tensor square of the induced metric representing a quaternionic or octonionic real unit.

Action principle does not seem to be unique. On the other hand, the WCW Kähler form and metric should be unique since its existence requires maximal isometries.

Unique action is not the only way to achieve this. One cannot exclude the possibility that the Kähler gauge potential of WCW in the complex coordinates of WCW differs only by a complex gradient of a holomorphic function for different actions so that they would give the same Kähler form for WCW. This gradient is induced by a symplectic transformation of WCW inducing a U(1) gauge transformation. The Kähler metric is the same if the symplectic transformation is an isometry.

Symplectic transformations of WCW could give rise to inequivalent representations of the theory in terms of action at space-time level. Maybe the length scale dependent coupling parameters of an effective action could be interpreted in terms of a choice of WCW Kähler function, which maximally simplifies the computations at a given scale.

1. The 6-D analogues of electroweak action and color action reducing to Kähler action in 4-D case exist. The 6-D analog of Weyl action based on the tensor representation of quaternionic imaginary units does not however exist. One could however consider the possibility that only the base space of twistor space $T(M^4)$ and $T(CP_2)$ have quaternionic structure.

2. Kähler action has a huge vacuum degeneracy, which clearly distinguishes it from other actions. The presence of the volume term removes this degeneracy. However, for minimal surfaces having CP_2 projections, which are Lagrangian manifolds and therefore have a vanishing induced Kähler form, would be preferred extremals according to the proposed definition. For these 4-surfaces, the existence of the generalized complex structure is dubious.

   For the electroweak action, the terms corresponding to charged weak bosons eliminate these extremals and one could argue that electroweak action or its sum with the analogue of color action, also proportional Kähler action, defines the more plausible choice. Interestingly, also the neutral part of electroweak action is proportional to Kähler action.

Twistor lift strongly suggests that also M^4 has the analog of Kähler structure. M^8 must be complexified by adding a commuting imaginary unit i. In the E^8 subspace, the Kähler structure of E^4 is defined in the standard sense and it is proposed that this generalizes to M^4 allowing also

generalization of the quaternionic structure. M^4 Kähler structure violates Lorentz invariance but could be realized at the level of moduli space of these structures.

The minimal possibility is that the M^4 Kähler form vanishes: one can have a different representation of the Kähler gauge potential for it obtained as generalization of symplectic transformations acting non-trivially in M^4. The recent picture about the second quantization of spinors of $M^4 \times CP_2$ assumes however non-trivial Kähler structure in M^4.

A-5.2 Two paradoxes

TGD view leads to two apparent paradoxes.

1. If the preferred extremals satisfy 4-D generalization of holomorphicity, a very large set of actions gives rise to the same preferred extremals unless there are some additional conditions restricting the number of preferred extremals for a given action.

2. WCW metric has an infinite number of zero modes, which appear as parameters of the metric but do not contribute to the line element. The induced Kähler form depends on these degrees of freedom. The existence of the Kähler metric requires maximal isometries, which suggests that the Kähler metric is uniquely fixed apart from a conformal scaling factor Ω depending on zero modes. This cannot be true: galaxy and elementary particle cannot correspond to the same Kähler metric.

Number theoretical vision and the hierarchy of inclusions of HFFs associated with supersymplectic algebra actings as isometries of WcW provide equivalent realizations of the measurement resolution. This solves these paradoxes and predicts that WCW decomposes into sectors for which Kähler metrics of WCW differ in a natural way.

The hierarchy subalgebras of supersymplectic algebra implies the decomposition of WCW into sectors with different actions

Supersymplectic algebra of $\delta M^4_+ \times CP_2$ is assumed to act as isometries of WCW [L109]. There are also other important algebras but these will not be discussed now.

1. The symplectic algebra A of $\delta M^4_+ \times CP_2$ has the structure of a conformal algebra in the sense that the radial conformal weights with non-negative real part, which is half integer, label the elements of the algebra have an interpretation as conformal weights.

   The super symplectic algebra A has an infinite hierarchy of sub-algebras [L109] such that the conformal weights of sub-algebras $A_{n(SS)}$ are integer multiples of the conformal weights of the entire algebra. The superconformal gauge conditions are weakened. Only the subalgebra $A_{n(SS)}$ and the commutator $[A_{n(SS)}, A]$ annihilate the physical states. Also the corresponding classical Noether charges vanish for allowed space-time surfaces.

   This weakening makes sense also for ordinary superconformal algebras and associated Kac-Moody algebras. This hierarchy can be interpreted as a hierarchy symmetry breakings, meaning that sub-algebra $A_{n(SS)}$ acts as genuine dynamical symmetries rather than mere gauge symmetries. It is natural to assume that the super-symplectic algebra A does not affect the coupling parameters of the action.

2. The generators of A correspond to the dynamical quantum degrees of freedom and leave the induced Kähler form invariant. They affect the induced space-time metric but this effect is gravitational and very small for Einsteinian space-time surfaces with 4-D M^4 projection.

   The number of dynamical degrees of freedom increases with $n(SS)$. Therefore WCW decomposes into sectors labelled by $n(SS)$ with different numbers of dynamical degrees of freedom so that their Kähler metrics cannot be equivalent and cannot be related by a symplectic isometry. They can correspond to different actions.

Number theoretic vision implies the decomposition of WCW into sectors with different actions

The number theoretical vision leads to the same conclusion as the hierarchy of HFFs. The number theoretic vision of TGD based on M^8-H duality [L109] predicts a hierarchy with levels labelled by the degrees $n(P)$ of rational polynomials P and corresponding extensions of rationals characterized by Galois groups and by ramified primes defining p-adic length scales.

These sequences allow us to imagine several discrete coupling constant evolutions realized at the level H in terms of action whose coupling parameters depend on the number theoretic parameters.

1. Coupling constant evolution with respect to $n(P)$

The first coupling constant evolution would be with respect to $n(P)$.

1. The coupling constants characterizing action could depend on the degree $n(P)$ of the polynomial defining the space-time region by M^8-H duality. The complexity of the space-time surface would increase with $n(P)$ and new degrees of freedom would emerge as the number of the rational coefficients of P.

2. This coupling constant evolution could naturally correspond to that assignable to the inclusion hierarchy of hyperfinite factors of type II_1 (HFFs). I have indeed proposed [L109] that the degree $n(P)$ equals to the number $n(braid)$ of braids assignable to HFF for which super symplectic algebra subalgebra $A_{n(SS)}$ with radial conformal weights coming as $n(SS)$-multiples of those of entire algebra A. One would have $n(P) = n(braid) = n(SS)$. The number of dynamical degrees of freedom increases with n which just as it increases with $n(P)$ and $n(SS)$.

3. The actions related to different values of $n(P) = n(braid) = n(SS)$ cannot define the same Kähler metric since the number of allowed space-time surfaces depends on $n(SS)$.

   WCW could decompose to sub-WCWs corresponding to different actions, a kind of theory space. These theories would not be equivalent. A possible interpretation would be as a hierarchy of effective field theories.

4. Hierarchies of composite polynomials define sequences of polynomials with increasing values of $n(P)$ such that the order of a polynomial at a given level is divided by those at the lower levels. The proposal is that the inclusion sequences of extensions are realized at quantum level as inclusion hierarchies of hyperfinite factors of type II_1.

   A given inclusion hierarchy corresponds to a sequence $n(SS)_i$ such that $n(SS)_i$ divides $n(SS)_{i+1}$. Therefore the degree of the composite polynomials increases very rapidly. The values of $n(SS)_i$ can be chosen to be primes and these primes correspond to the degrees of so called prime polynomials [L99] so that the decompositions correspond to prime factorizations of integers. The "densest" sequence of this kind would come in powers of 2 as $n(SS)_i = 2^i$. The corresponding p-adic length scales (assignable to maximal ramified primes for given $n(SS)_i$) are expected to increase roughly exponentially, say as 2^{r2^i}. $r = 1/2$ would give a subset of scales $2^{r/2}$ allowed by the p-adic length scale hypothesis. These transitions would be very rare.

   A theory corresponding to a given composite polynomial would contain as sub-theories the theories corresponding to lower polynomial composites. The evolution with respect to $n(SS)$ would correspond to a sequence of phase transitions in which the action genuinely changes. For instance, color confinement could be seen as an example of this phase transition.

5. A subset of p-adic primes allowed by the p-adic length scale hypothesis $p \simeq 2^k$ defining the proposed p-adic length scale hierarchy could relate to n_S changing phase transition. TGD suggests a hierarchy of hadron physics corresponding to a scale hierarchy defined by Mersenne primes and their Gaussian counterparts [K61, K62]). Each of them would be characterized by a confinement phase transition in which n_S and therefore also the action changes.

2. Coupling constant evolutions with respect to ramified primes for a given value of $n(P)$

For a given value of $n(P)$, one could have coupling constant sub-evolutions with respect to the set of ramified primes of P and dimensions $n = h_{eff}/h_0$ of algebraic extensions. The action would only change by U(1) gauge transformation induced by a symplectic isometry of WCW. Coupling parameters could change but the actions would be equivalent.

The choice of the action in an optimal manner in a given scale could be seen as a choice of the most appropriate effective field theory in which radiative corrections would be taken into account. One can interpret the possibility to use a single choice of coupling parameters in terms of quantum criticality.

The range of the p-adic length scales labelled by ramified primes and effective Planck constants h_{eff}/h_0 is finite for a given value of $n(SS)$.

The first coupling constant evolution of this kind corresponds to ramified primes defining p-adic length scales for given $n(SS)$.

1. Ramified primes are factors of the discriminant $D(P)$ of P, which is expressible as a product of non-vanishing root differents and reduces to a polynomial of the n coefficients of P. Ramified primes define p-adic length scales assignable to the particles in the amplitudes scattering amplitudes defined by zero energy states.

   P would represent the space-time surface defining an interaction region in $N-$-particle scattering. The N ramified primes dividing $D(P)$ would characterize the p-adic length scales assignable to these particles. If $D(P)$ reduces to a single ramified prime, one has elementary particle [L99], and the forward scattering amplitude corresponds to the propagator.

   This would give rise to a multi-scale p-adic length scale evolution of the amplitudes analogous to the ordinary continuous coupling constant evolution of n-point scattering amplitudes with respect to momentum scales of the particles. This kind of evolutions extend also to evolutions with respect to $n(SS)$.

2. According to [L99], 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 [L99].

3. p-Adic length scale hypothesis [L110] in its basic form states that there exist preferred primes $p \simeq 2^k$ near some powers of 2. A more general hypothesis states that also primes near some powers of 3 possibly also other small primes are preferred physically. The challenge is to understand the origin of these preferred scales.

   For polynomials P with a given degree $n(P)$ for which discriminant $D(P)$ is prime, there exists a maximal ramified prime. Numerical calculations suggest that the upper bound depends exponentially on $n(P)$.

   Could these maximal ramified primes satisfy the p-adic length scale hypothesis or its generalization? The maximal prime defines a fixed point of coupling constant evolution in accordance with the earlier proposal. For instance, could one think that one has $p \simeq 2^k$, $k = n(SS)$? Each p-adic prime would correspond to a p-adic coupling constant sub-evolution representable in terms of symplectic isometries.

Also the dimension n of the algebraic extension associated with P, which is identified in terms of effective Planck constant $h_{eff}/h_0 = n$ labelling different phases of the ordinary matter behaving like dark matter, could give rise to coupling constant evolution for given $n(SS)$. The range of allowed values of n is finite. Note however that several polynomials of a given degree can correspond to the same dimension of extension.

Number theoretic discretization of WCW and maxima of WCW Kähler function

Number theoretic approach involves a unique discretization of space-time surface and also of WCW. The question is how the points of the discretized WCW correspond to the preferred extremals.

1. The exponents of Kähler function for the maxima of Kähler function, which correspond to the universal preferred extremals, appear in the scattering amplitudes. The number theoretical approach involves a unique discretization of space-time surfaces defining the WCW coordinates of the space-time surface regarded as a point of WCW.

   In [L109] it is assumed that these WCW points appearing in the number theoretical discretization correspond to the maxima of the Kähler function. The maxima would depend on the action and would differ for ghd maxima associated with different actions unless they are not related by symplectic WCW isometry.

2. The symplectic transformations of WCW acting as isometries are assumed to be induced by the symplectic transformations of $\delta M^4_+ \times CP_2$ [K49, K26]. 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 [L105].

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 [K65, K56, K24]. The fusion of the various p-adic physics leads to what I call adelic physics [L34, L35]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K29, K30, K31, K32].

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 [L73, L74] 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 [L99, L105]. 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 sub-space. This makes it possible to assign to this surface space-time surface in $H = M^4 \times CP_2$.

At the level of H the space-time surfaces are by holography preferred extremals and are assumed to be determined by the twistor lift of TGD [L36] 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 [A8]. p-Adic numbers are representable as power expansion of the prime number p of form

$$x = \sum_{k \geq k_0} x(k) p^k, \; x(k) = 0, ..., p-1 \; . \tag{A-6.1}$$

The norm of a p-adic number is given by

$$|x| \;=\; p^{-k_0(x)} \;. \tag{A-6.2}$$

Here $k_0(x)$ is the lowest power in the expansion of the p-adic number. The norm differs drastically from the norm of the ordinary real numbers since it depends on the lowest pinary digit of the p-adic number only. Arbitrarily high powers in the expansion are possible since the norm of the p-adic number is finite also for numbers, which are infinite with respect to the ordinary norm. A convenient representation for p-adic numbers is in the form

$$x \;=\; p^{k_0}\varepsilon(x) \;, \tag{A-6.3}$$

where $\varepsilon(x) = k + ...$ with $0 < k < p$, is p-adic number with unit norm and analogous to the phase factor $exp(i\phi)$ of a complex number.

The distance function $d(x,y) = |x-y|_p$ defined by the p-adic norm possesses a very general property called ultra-metricity:

$$d(x,z) \;\leq\; max\{d(x,y), d(y,z)\} \;. \tag{A-6.4}$$

The properties of the distance function make it possible to decompose R_p into a union of disjoint sets using the criterion that x and y belong to same class if the distance between x and y satisfies the condition

$$d(x,y) \;\leq\; D \;. \tag{A-6.5}$$

This division of the metric space into classes has following properties:

1. Distances between the members of two different classes X and Y do not depend on the choice of points x and y inside classes. One can therefore speak about distance function between classes.

2. Distances of points x and y inside single class are smaller than distances between different classes.

3. Classes form a hierarchical tree.

Notice that the concept of the ultra-metricity emerged in physics from the models for spin glasses and is believed to have also applications in biology [B10]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

1. Basic form of the canonical identification

There exists a natural continuous map $I : R_p \to R_+$ from p-adic numbers to non-negative real numbers given by the "pinary" expansion of the real number for $x \in R$ and $y \in R_p$ this correspondence reads

$$\begin{aligned} y \;&=\; \sum_{k>N} y_k p^k \to x = \sum_{k<N} y_k p^{-k} \;, \\ y_k \;&\in\; \{0,1,..,p-1\} \;. \end{aligned} \tag{A-6.6}$$

This map is continuous as one easily finds out. There is however a little difficulty associated with the definition of the inverse map since the pinary expansion like also decimal expansion is not unique ($1 = 0.999...$) for the real numbers x, which allow pinary expansion with finite number of pinary digits

$$\begin{aligned} x &= \sum_{k=N_0}^{N} x_k p^{-k} \ , \\ x &= \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,..} p^{-k} \ . \end{aligned} \tag{A-6.7}$$

The p-adic images associated with these expansions are different

$$\begin{aligned} y_1 &= \sum_{k=N_0}^{N} x_k p^{k} \ , \\ y_2 &= \sum_{k=N_0}^{N-1} x_k p^{k} + (x_N - 1)p^{N} + (p-1)p^{N+1} \sum_{k=0,..} p^{k} \\ &= y_1 + (x_N - 1)p^N - p^{N+1} \ , \end{aligned} \tag{A-6.8}$$

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval $[p^k, p^{k+1})$ (see **Fig. A-6.1**) and is equal to the usual real norm at the points $x = p^k$: the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of p is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

Fig. 14. The real norm induced by canonical identification from 2-adic norm. `http://tgdtheory.fi/appfigures/norm.png`

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition $x +_p y < max\{x, y\}$ holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of p. Moreover one has $x \times_p y < x \times y$ in general. The p-Adic negative -1_p associated with p-adic unit 1 is given by $(-1)_p = \sum_k (p-1)p^k$ and defines p-adic negative for each real number x. An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$\begin{aligned} (x+y)_R &\leq x_R + y_R \ , \\ |x|_p|y|_R \leq (xy)_R &\leq x_R y_R \ , \end{aligned} \tag{A-6.9}$$

where $|x|_p$ denotes p-adic norm. These inequalities can be generalized to the case of $(R_p)^n$ (a linear vector space over the p-adic numbers).

$$\begin{aligned} (x+y)_R &\leq x_R + y_R \ , \\ |\lambda|_p|y|_R \leq (\lambda y)_R &\leq \lambda_R y_R \ , \end{aligned} \tag{A-6.10}$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$(x_R)^2 = (\sum_n x_n^2)_R \ . \tag{A-6.11}$$

These inequalities resemble those satisfied by the vector norm. The only difference is the failure of linearity in the sense that the norm of a scaled vector is not obtained by scaling the norm of the original vector. Ordinary situation prevails only if the scaling corresponds to a power of p.

These observations suggests that the concept of a normed space or Banach space might have a generalization and physically the generalization might apply to the description of some non-linear systems. The nonlinearity would be concentrated in the nonlinear behavior of the norm under scaling.

3. Modified form of the canonical identification

The original form of the canonical identification is continuous but does not respect symmetries even approximately. This led to a search of variants which would do better in this respect. The modification of the canonical identification applying to rationals only and given by

$$I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \tag{A-6.12}$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$. It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of r and s mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for I and I_Q but I_Q is theoretically preferred since the real probabilities obtained from p-adic ones by I_Q sum up to one in p-adic thermodynamics.

4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals n-dimensional space R^n must be covered by 2^n copies of the p-adic variant R_p^n of R^n each of which projects to a copy of R_+^n (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field Q_p satisfying $e^p \ mod \ p = 1$.

Fig. 15. Various number fields combine to form a book like structure. `http://tgdtheory.fi/appfigures/book.jpg`

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that M^4 projections for the rational points of space-time surface X^4 are related by a direct identification whereas CP_2 coordinates of X^4 at these points are related by I, I_Q or some of its variants implying long range correlates for CP_2 coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, "thought bubbles".

Fig. 16. The basic idea between p-adic manifold. `http://tgdtheory.fi/appfigures/padmanifold.jpg`

There are some problems.

1. Canonical identification does not respect symmetries since it does not commute with second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map arithmetic operations which requires pinary cutoff below which chart map takes rationals to rationals so that commutativity with arithmetics and symmetries is achieved in finite resolution: above the cutoff canonical identification is used

2. Canonical identification is continuous but does not map smooth p-adic surfaces to smooth real surfaces requiring second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map requiring completion of the image to smooth preferred extremal of Kähler action so that chart map is not unique in accordance with finite measurement resolution

3. Canonical identification violates general coordinate invariance of chart map: (cognition-induced symmetry breaking) minimized if p-adic manifold structure is induced from that for p-adic embedding space with chart maps to real embedding space and assuming preferred coordinates made possible by isometries of embedding space: one however obtains several inequivalent p-adic manifold structures depending on the choice of coordinates: these cognitive representations are not equivalent.

A-6.2 Hierarchy of Planck constants and dark matter hierarchy

Hierarchy of Planck constants was motivated by the "impossible" quantal effects of ELF em fields on vertebrate cyclotron energies $E = hf = \hbar \times eB/m$ are above thermal energy is possible only if $\hbar$ has value much larger than its standard value. Also Nottale's finding that planetary orbits migh be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierachy of Planck constant would mean that the values of Planck constant come as integer multiples of ordinary Planck constant: $h_{eff} = n \times h$. The particles at magnetic flux tubes characterized by h_{eff} would correspond to dark matter which would be invisible in the sense that only particle with same value of h_{eff} appear in the same vertex of Feynman diagram.

Hierarchy of Planck constants would be due to the non-determism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manfolds of any $M^4 \times Y^2$, where Y^2 is Lagrangian sub-manifold of CP_2. For agiven Y^2 one obtains new manifolds Y^2 by applying symplectic transformations of CP_2.

Non-determinism would mean that the 3-surface at the ends of causal diamond (CD) can be connected by several space-time surfaces carrying same conserved Kähler charges and having same values of Kähler action. Conformal symmetries defined by Kac-Moody algebra associated with the embedding space isometries could act as gauge transformations and respect the light-likeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskianb space-time region transforms to wormhole contact say). The number of conformal equivalence classes of these surfaces could be finite number n and define discrete physical degree of freedom and one would have $h_{eff} = n \times h$. This degeneracy would mean "second quantization" for the sheets of n-furcation: not only one but several sheets can be realized.

This relates also to quantum criticality postulated to be the basic characteristics of the dynamics of quantum TGD. Quantum criticalities would correspond to an infinite fractal hierarchy of broken conformal symmetries defined by sub-algebras of conformal algebra with conformal weights coming as integer multiples of n. This leads also to connections with quantum criticality and hierarchy of broken conformal symmetries, p-adicity, and negentropic entanglement which by consistency with standard quantum measurement theory would be described in terms of density matrix proportional $n \times n$ identity matrix and being due to unitary entanglement coefficients (typical for quantum computing systems).

Formally the situation could be described by regarding space-time surfaces as surfaces in singular n-fold singular coverings of embedding space. A stronger assumption would be that they are expressible as as products of n_1 -fold covering of M^4 and n_2-fold covering of CP_2 meaning analogy with multi-sheeted Riemann surfaces and that M^4 coordinates are n_1-valued functions and CP_2 coordinates n_2 -valued functions of space-time coordinates for $n = n_1 \times n_2$. These singular coverings of embedding space form a book like structure with singularities of the coverings localizable at the boundaries of causal diamonds defining the back of the book like structure.

Fig. 17. Hierarchy of Planck constants. `http://tgdtheory.fi/appfigures/planckhierarchy.jpg`

A-6.3 $M^8 - H$ duality as it is towards the end of 2021

The view of $M^8 - H$ duality (see Appendix **??**) has changed considerably towards the end 2021 [L90] 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 [L90] 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 [L90] 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 [L73, L74]. 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 $X^4 \subset M^8$ [L64]. 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 [L90]. 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 [L79] 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 [L90]. 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 [L69] [K102].

1. In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution. One can say that in the TGD framework general coordinate invariance implies holography and the slight failure of its determinism in turn forces ZEO.

   Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L69].

2. To avoid getting totally confused it is good to emphasize some aspects of ZEO.

   (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.

   (b) ZEO means two times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.

3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.

   (a) The findings of Minev et al [L58] in atomic scale can be explained by the same mechanism [L58]. In BSFR a final zero energy state as a superposition of classical deterministic time evolutions emerges and for an observer with a standard arrow of time looks

like a superposition of deterministic smooth time evolutions leading to the final state. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution in which case the process does not lead to anywhere: the interpretation would be that BSFR back to the initial state occurs!

(b) Libets' experiments about active aspects of consciousness [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.

(c) Earthquakes involve a strange anomaly: they are preceded by ELF radiation. One would expect that they generate ELF radiation. The identification as BSFR would explain the anomaly [L62]. 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 [L65, L131].

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 [L65, L131]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

   Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n.

   MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

A-8 Some notions relevant to TGD inspired consciousness and quantum biology

Below some notions relevant to TGD inspired theory of consciousness and quantum biology.

A-8.1 The notion of magnetic body

Topological field quantization inspires the notion of field body about which magnetic body is especially important example and plays key role in TGD inspired quantum biology and consciousness theory. This is a crucial departure fromt the Maxwellian view. Magnetic body brings in third level to the description of living system as a system interacting strongly with environment. Magnetic body would serve as an intentional agent using biological body as a motor instrument and sensory receptor. EEG would communicated the information from biological body to magnetic body and Libet's findings from time delays of consciousness support this view.

The following pictures illustrate the notion of magnetic body and its dynamics relevant for quantum biology in TGD Universe.

Fig. 18. Magnetic body associated with dipole field. `http://tgdtheory.fi/appfigures/fluxquant.jpg`

Fig. 19. Illustration of the reconnection by magnetic flux loops. `http://tgdtheory.fi/appfigures/reconnect1.jpg`

Fig. 20. Illustration of the reconnection by flux tubes connecting pairs of molecules. `http://tgdtheory.fi/appfigures/reconect2.jpg`

Fig. 21. Flux tube dynamics. a) Reconnection making possible magnetic body to "recognize" the presence of another magnetic body, b) braiding, knotting and linking of flux tubes making possible topological quantum computation, c) contraction of flux tube in phase transition reducing the value of h_{eff} allowing two molecules to find each other in dense molecular soup. `http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg`

A-8.2 Number theoretic entropy and negentropic entanglement

TGD inspired theory of consciousness relies heavily p-Adic norm allows an to define the notion of Shannon entropy for rational probabilities (and even those in algebraic extension of rationals) by replacing the argument of logarithm of probability with its p-adic norm. The resulting entropy can be negative and the interpretation is that number theoretic entanglement entropy defined by this formula for the p-adic prime minimizing its value serves as a measure for conscious information. This negentropy characterizes two-particle system and has nothing to do with the formal negative negentropy assignable to thermodynamic entropy characterizing single particle. Negentropy Maximization Principle (NMP) implies that number theoretic negentropy increases during evolution by quantum jumps. The condition that NMP is consistent with the standard quantum measurement theory requires that negentropic entanglement has a density matrix proportional to unit matrix so that in 2-particle case the entanglement matrix is unitary.

Fig. 22. Schrödinger cat is neither dead or alive. For negentropic entanglement this state would be stable. `http://tgdtheory.fi/appfigures/cat.jpg`

A-8.3 Life as something residing in the intersection of reality and p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the "mind stuff" of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of "world of classical worlds" (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients with are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

Fig. 23. The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of though, cognitive representation. Its reversal would correspond to a transformation of intention to action. `http://tgdtheory.fi/appfigures/padictoreal.jpg`

A-8.4 Sharing of mental images

The 3-surfaces serving as correlates for sub-selves can topologically condense to disjoint large space-time sheets representing selves. These 3-surfaces can also have flux tube connections and this makes possible entanglement of sub-selves, which unentangled in the resolution defined by the size of sub-selves. The interpretation for this negentropic entanglement would be in terms of sharing of mental images. This would mean that contents of consciousness are not completely private as assumed in neuroscience.

Fig. 24. Sharing of mental images by entanglement of subselves made possible by flux tube connections between topologically condensed space-time sheets associated with mental images. `http://tgdtheory.fi/appfigures/sharing.jpg`

A-8.5 Time mirror mechanism

Zero energy ontology (ZEO) is crucial part of both TGD and TGD inspired consciousness and leads to the understanding of the relationship between geometric time and experience time and how the arrow of psychological time emerges. One of the basic predictions is the possibiity of negative energy signals propagating backwards in geometric time and having the property that entropy basically associated with subjective time grows in reversed direction of geometric time. Negative energy signals inspire time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig.** 24 in the appendix of this book) providing mechanisms of both memory recall, realization of intentational action initiating action already in geometric past, and remote metabolism. What happens that negative energy signal travels to past and is reflected as positive energy signal and returns to the sender. This process works also in the reverse time direction.

Fig. 25. Zero energy ontology allows time mirror mechanism as a mechanism of memory recall. Essentially "seeing" in time direction is in question. `http://tgdtheory.fi/appfigures/timemirror.jpg`

Acknowledgements: I am grateful for Dainis Zeps for enlightnening discussions concerning CP_2 geometry.

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