

Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective

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Abstract

Non-locality seems to be a basic aspect of what it is to be living. Living system is elementary particle like coherent unit. The phenomenon of memory suggests temporal non-locality. Also remote mental interactions - if real - suggest non-locality. In fact, non-locality - both spatial and temporal - is the basic element of entire quantum TGD, and in particular, of its applications to quantum biology, neuroscience, theory of consciousness, and also of remote mental interactions.

In the sequel I make kind of pseudo deduction of the picture provided by Topological Geometroynamics (TGD) by starting from empirical findings loosely related to non-locality rather than problems of General Relativity or of particle physics. The hope is that this could make the basic ideas of TGD easier to grasp. Also the mathematical framework and its interpretation as they are now are briefly discussed and the some applications to TGD inspired theory of consciousness and quantum biology are discussed.

1 Introduction

Non-locality seems to be a basic aspect of what it is to be living. Living system is elementary particle like coherent unit. The phenomenon of memory suggests temporal non-locality. Also remote mental interactions - if real - suggest non-locality. In fact, non-locality - both spatial and temporal - is the basic element of entire quantum TGD, and in particular, of its applications to quantum biology, neuroscience, theory of consciousness, and also of remote mental interactions.

In the following I make kind of pseudo deduction of the picture provided by Topological Geometroynamics (TGD) by starting from empirical findings loosely related to non-locality rather than problems of General Relativity or of particle physics. The hope is that this could make the basic ideas of TGD easier to grasp.

1.1 What does non-locality mean physically?

Both spatial and temporal non-locality are possible and manifested as spatio-temporal coherence not expected on basis of classical and standard QM considerations.

There are many hints about the nature of non-locality.

1. Spatial non-locality manifest itself as a coherent behavior: organisms behave like independent coherent units. The idea about sacks of water containing some chemicals able to climb in trees and write poems does not look plausible. At the level of brain spatial coherence manifests itself as synchronous behavior of brain regions.
2. Temporal non-locality manifests itself as temporal synchrony, especially so in the dynamics of brain. Also memories suggest temporal non-locality. Also various functions/behavioral patterns meaning intentional goal-directed action reflect temporal non-locality. In EEG quasi-stationary segments separated by rapid transients appear [J4].
3. Libet's findings [J1] about anomalous time ordering of conscious decision and neural correlates of associated action suggest that signals can propagate backwards in time. Motor actions would involve signals propagating backwards in time and sensory-motor dichotomy could correspond to two arrows of time.
4. Fantappie [J8] suggested long time ago that the arrow of time is not always the same in living matter and christened the entropy increasing in reverse direction of time syntropy. Spontaneous self assembly could be example of process taking place in reverse direction of time as a decay process. This would however imply that experienced time having always the same direction cannot be equated with the geometric time. There are also other reasons for distinguishing between these two times.

Questions: Do we really understand the notion of time, in particular the relationship between geometric time and the experienced time? What experienced time is? Is the arrow of time always the standard one?

Temporal non-locality is very difficult if not impossible to understand in the standard physics framework, where 3-D snapshot of reality together with initial values for generalized positions and velocities determine everything. Are the basic objects 4-dimensional? Should one consider generalized positions at two values of time as basic data. Could kind of generalized Bohr orbits be in question. Could the basic entities be events - pairs of 3-D snapshot at different values of geometric time?

Should ordinary positive energy ontology (PEO) be replaced with something different, in which pairs of states - physical events - or equivalently the 4-dimensional space-time evolutions connecting them, are basic entities. One can think that these pairs of initial and final states are zero energy states in the sense that the values of various conserved quantum numbers for the positive and negative energy parts sum up to zero. This would allow to have deterministic dynamics for connecting time evolutions without loss of laws of physics. I call this ontology Zero Energy Ontology (ZEO). ZEO would be much more general than PEO but consistent with conservation laws and solve the to-be-or-not-to-be question of theoretician: why to see the pains of constructing a theory if only one particular solution of equations is realized in Nature: one cannot test the theory without additional assumptions. In ZEO based quantum theory any zero energy state could be created from vacuum.

1.2 Living systems have shape

Living organisms have shape, which is non-local property. All physical systems have shape. These shapes appear in all scales and in the case of fundamental biomolecules the shapes have crucial significance for the functioning of living matter. For instance, the dynamical folding of DNA double strand is essential for transcription.

In standard physics the shape is described in terms of densities of particles as something phenomenological. In the modelling the shape is fed in as a phenomenological geometric input and there is no attempt to really deduce the shape from microscopic physics as reductionism would demand. It is highly questionable whether this attempt could be even successful.

Could shape as something non-local be something real?

1. Geometry and topology provide two definitions of shape. Could the space-time topology and geometry - its shape - be non-trivial in even macroscopic scales? This idea does not conform with the general relativistic view according to which space-time would be topologically rather uninteresting above Planck scale. One would lose the energy momentum conservation as consequence of lost space-time symmetries (translations and Lorentz transformations). Also topology change for 3-space, which takes place routinely in living matter systems, is impossible in this framework.
2. How could one modify the general relativistic view? The hint comes from superstring models in which string world sheets are 2-D space-times represented as 2-D surfaces - sub-manifolds - in 10-D space-time. String models fail but one could perhaps modify them. The basic problem of string models is how to get the 4-D space-time from string models. Why not replace 2-D surfaces with 4-D ones in some higher-D space-time, which could be taken to be fixed because the dynamics of space-time would be coded by its geometric shape. One would avoid the notorious landscape problem and loss of predictivity.

The identification of space-time as 4-surface would change completely the view about what space-time is. The good news is that one does not lose classical conservation laws if the higher-dimensional space-time is chosen properly. Space-time surfaces can contain even Euclidian regions (time and space in the same role) without loss of basic conservation laws. This means huge flexibility.

3. The visible world is also hierarchical: shapes within shapes. Biological body consists of organs consists of cells consists of biomolecules consists of This fractal like structure should have counterpart as the structure of space-time surface. Space-time surface indeed turn out to have this kind of structure: ... space-time sheets glued to larger space-time sheets glued to.... I refer to this structure as many-sheeted space-time and we indeed see it directly!

Question: Could space-time be 4-D surface in some higher-D space-time - many-sheeted space-time. The shape of spacetime would have meaning also as shape in this higher-D space-time.

1.3 Does coherence in long spatial and temporal scales reduce to macroscopic quantum coherence?

Coherence could be understood as macroscopic quantum coherence if living systems are macroscopic quantum systems. But how?: Planck constant is too small? There are several hints suggesting that Planck constant could have actually a spectrum.

1.3.1 Effects of ELF em fields on living matter, macroscopic quantum coherence, and dark matter and energy

The effects of ELF em fields on vertebrate brain involving both physiology and behavior look like quantal appearing at multiples of basic frequency assignable to cyclotron transitions of biologically important ions such as Ca^{++} ion in endogenous magnetic field of $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ is the nominal value of Earth's magnetic field [J3] The problem is that cyclotron energies are extremely low: more than ten orders of magnitude below thermal energies.

Question: Could Planck constant have nonstandard values: say $h_{eff} = n \times h$.

If this were the case, quantum scales would be scaled up. Energy $E = h_{eff}f$ associated with given frequency is scaled up. Could EEG consist of photons with $h_{eff} = n \times h$ such that the energies of dark EEG photons are above thermal energies. These photons can transform to ordinary photons perhaps identifiable as bio-photons in the energy range of visible and UV photons.

What these phases of matter with non-standard Planck constants could be? Why we have not observed them? We know that dark energy and dark matter exist. Could they correspond to $h_{eff} = n \times h$ phases? If so, dark matter could be in key role in living matter. Two mysteries would find a common explanation.

Question: Should one generalize quantum theory so that dark matter/energy would be assignable to hierarchy of $h_{eff} = n \times h$ phases?

1.3.2 Where could the dark matter reside?

Where could the dark matter reside?

1. The first hint comes from quite recent finding that the brain hemispheres of persons having no corpus callosum are in synchrony (see <http://tinyurl.com/3gjhtgb>). What synchronizes the brain hemispheres in this kind of situation? The hint comes from spontaneous synchronization of clocks (penduli) involving generation of very weak periodic perturbation - "boss" - forcing the clocks in same phase. Is there a kind of "boss", which forces neurons to march in synchrony [K31]?
2. Second hint comes from the observation that EEG correlates strongly with the contents of consciousness. Why? Information costs energy. Why to construct information not used for any purpose? Could it be that EEG communicates information about brain state to some entity? Could this entity be the "boss" in turn using EEG to control the brain. The wavelength associated with EEG frequency 7.8 Hz is circumference of Earth. Could this entity be of this size or even larger?
3. There is a further hint: the effects of ELF radiation were at cyclotron frequencies in endogenous magnetic field with strength of .2 Gauss. For iron it corresponds to 10 Hz frequency for which wavelength is slightly larger than circumference of Earth. Could the "boss" be a magnetic field structure - magnetic body (MB) - assignable to the organism?
4. There is an objection against this idea. In Maxwell's electrodynamics magnetic fields of different organisms interfere to a random background so that the informations from separate organisms would be lost. Standard space-time concept is not enough. Should the very notion of space-time be such that the magnetic field structures of different organisms behave like separate entities without interference between them. The phases of matter with different values of h_{eff} would in some sense live in different worlds - they would be dark relative to each other - but also interact with matter visible to us. Generalization of space-time concept seems to be necessary. The guess is many-sheeted space.

Question: Do magnetic bodies carrying dark matter characterized by non-standard value of Planck constant carry serve as “bosses”? They should also effectively correspond to separate space-times.

1.3.3 How to create dark matter?

One eventually encounters the question how to test the theory. To achieve this one should be able to create dark matter by inducing phase transition of ordinary matter to dark matter or to do the opposite: ordinary matter would mysteriously disappear somewhere or pop up somewhere. This would serve as a signature for the dark matter. There are some hints.

1. Biosystems look like critical systems. Sensory systems have optimal sensitivity to small changes in environment. There is analogy with fundamental physics: in particle accelerators measurement instruments are critical systems to maximize the sensitivity and transform microscopic effects to macroscopic ones. Neural system is an excellent example of a control system in which small control signals give rise to large effects. Homeostasis can be understood in terms of positive and negative feedback keeping the system near criticality. Living systems are functional in rather narrow temperature range. There is also evidence for quantum criticality (QC) at molecular level [I14].
2. The appearance of $h_{eff} = n \times h$ dark matter should lead to a generation of long range coherence and non-locality. On the other hand, long range fluctuations are the tell-tale signature of criticality. Could dark phases with $h_{eff} = n \times h$ be created at quantum criticality (QC)?

Question: IS QC is essential for having non-locality manifesting itself as long range correlations, dark matter, and $h_{eff} = n \times h$ phases.

1.4 Summing up

To sum up: these propagandistic arguments suggest the following picture.

1. Temporal non-locality requires that PEO is replaced ZEO. The arrow of time is not always the same. The relationship between experienced and geometric time must be understood: they are not same although they are strongly correlated.
2. The importance of shape - a non-local concept - in biology suggests identification of space-time as 4-D surface in some higher-D space-time.
3. EEG contains information about the contents of consciousness: EEG communicates information to some entity identified as magnetic body serving as intentional agent receiving sensory input and controlling biological body. The organism-environment duality would be replaced with trinity involving also MB.
4. Coherence in long scales reduces to quantum coherence for $\rightarrow h_{eff} = n \times h$ dark matter hierarchy and dark matter at magnetic bodies is the quintessence of living matter.
5. Criticality of living matter reduces to long range correlations implied by QC. Dark matter is created at QC and implies also non-locality.

The challenge is to realize this picture mathematically. TGD does this although I ended up with it with motivations coming from General Relativity and particle physics. In the sequel I discuss the mathematical formulation and its physical interpretation. I also discuss briefly various applications of this picture.

2 TGD

General theory of relativity (GRT) plagued by the problem that the notions of energy and momentum are not well-defined for curved space-time. The proposal for overcoming the energy problem (made 1977, thesis came 1982) was that space-times are not abstract 4-D manifolds but representable as 4-D surfaces in certain 8-dimensional space-time $H = M^4 \times CP_2$, which is empty Minkowski space M^4 with points replaced with certain very small 4-D space CP_2 fixed uniquely from the condition that standard model symmetries and standard model fields can be geometrized. This choice of H is uniquely fixed both by twistorial considerations [K26, K47] or by the condition that theory is consistent with standard model symmetries.

It soon turned out that the modification can be seen also as a generalization of string model with strings in 10-D space-time replaced with 3-D surfaces in 8-D H , whose “orbits” are identifiable as space-time surfaces. Recently the connection with string model picture has become much deeper. By strong form of holography (SH) 2-D string world sheets and partonic 2-surfaces carry the data needed to construct quantum states and construct solutions of field equations (preferred extremals). 4-D space-time is however necessary for quantum-classical correspond necessary to describe measurements.

TGD Universe is predicted to be fractal: this replaces the naive Planck length scale reductionism with fractality for which the simplest realization would be p-adic length scale hypothesis emerging from p-adic thermodynamics and dark matter hierarchy. Non-trivial predictions emerge in all scales from Planck length to cosmology and this makes it very difficult to communicate TGD for colleagues believing firmly on naive length scales reductionism.

In what follows I will proceed from quantum TGD to classical TGD without starting from particle physics observations - it would be extremely boring to repeat same old arguments again and again and reader can find these arguments from [K39].

2.1 Quantum TGD

The basic idea is to generalize Einstein’s program as geometrization of classical physics to geometrization of the entire quantum theory so all notions of quantum theory except state function reduction which is identified as basic building brick of conscious experience would reduce to geometry.

2.1.1 Reduction of quantum theory to Kähler geometry and spinor structure of WCW

The condition that the entire quantum theory is geometrized requires infinite-dimensional geometric structure instead of space-time and the “world of classical worlds” (WCW) identified roughly as the space of space-time surfaces is the natural identification [K3, K8].

1. The construction of quantum TGD leads to a generalization of the notion of super-space of Wheeler and to construction of infinite-dimensional geometry that I call “World of Classical Worlds” (WCW) having rough mathematical identification as space of 3-surfaces in H (ZEO dictates the identification in more detail). The mere mathematical existence of WCW geometry fixes it essentially uniquely - this is true already for the loop spaces of string model [?] - and therefore physics. A huge generalization of the symmetries of super-string models emerges giving hopes of understanding the theory.

The geometrization of hermitian conjugation of quantum theory requires that WCW allows complex structure its metric is Kähler metric [K8] and coded by Kähler function identified in terms of Kähler action for a preferred extremal: this gives direct connection with classical physics since induced Kähler form define classical U(1) field, for the U(1) factor of electroweak gauge group assignable with weak hyper-charge. twistor lift implies the presence of a volume term identifiable in terms of cosmological constant. It would bring also Planck length into the theory as the radius of twistor sphere [K26].

2. Quantum states are identified as classical WCW spinor fields so that there is no need to perform quantization and state function reduction is the only genuinely quantal aspect of TGD [K30, K42]. Spinor structure requires identification of gamma matrices anticommuting

to WCW metric and if the metric is Kähler metric, the anti-commutation relations are completely analogous to those of fermionic oscillator operators and one can indeed express the gamma matrices as linear superpositions of fermionic oscillator operators at space-time surface. Second quantization at space-time level is a purely classical notion at WCW level and becomes geometrized in WCW context.

3. ZEO (Zero Energy Ontology) is an essential element of theory. Usually one assumes that in classical physics generalized positions and their time derivatives (generalized velocities) giving at given moment of time in 3-D snapshot of space-time dictated the time evolution. This has generalization to Schrödinger equation. One has initial value problem.

This Newtonian view does not work in TGD: boundary value problem provides a more natural formulation. The generalized positions at two moments of time are more natural data and the dynamical evolution connecting the two 3-D snapshots defines by holography more or less equivalent view about the situation. These pairs are analogous to classical events and one can construct as their quantum superpositions what I call zero energy states and quantum jumps are quantum events occurring between these classical events.

ZEO is much more flexible than ordinary ontology since any zero energy state can be created from vacuum whereas in standard classical ontology only one solution of field equations is realized and in principle it is not possible to test the theory without additional assumptions. ZEO is especially natural in biology and neuroscience: the notions like function, behavioral pattern, and habit are not easy to describe in terms of the state of organism as 3-D snapshot of time evolution.

The two time=constant snapshots are actually replaced with past and future boundaries of CD, which is the intersection of future and past directed light-cones of Minkowski space with each point replaced with CP_2 . The ends of space-time surfaces are at the these boundaries. Zero energy states have opposite conserved quantum numbers at the opposite boundaries of CD: this guarantees that conservation laws are satisfied and the system is consistent with standard laws of physics. CDs form a fractal hierarchy. There are CDs within CDs and CDs can also overlap.

In order to avoid confusion it must be made clear that since WCW spinor fields and zero energy states are formally purely classical entities. Only the state function reduction replacing zero energy state (classical event) would be genuinely quantal element of the theory. The Wheelerism for this would be “Quantization without quantization”.

4. The recent formulation for the notion of preferred extremal relies on strong form of General Coordinate Invariance (SGCI). SGCI states that two very different kinds of 3-surfaces can be identified as fundamental objects. Either the light-like 3-D orbits of partonic 2-surfaces defining boundaries between Minkowskian and Euclidian space-time regions or the space-like 3-D ends of space-time surfaces at boundaries of CD (both ends!). If both choices are equally good, partonic 2-surfaces and their tangent space-data at the ends of space-time should be the most economic choice.

This eventually led to the realization that partonic 2-surfaces and string world sheets should be enough for the formulation of WCW geometry and quantum TGD [K2]. Classical fields in the interior of space-time surface would be needed only in quantum measurement theory, which demands classical physics in order to interpret the experiments. The outcome is SH stating that quantum physics should be coded by string world sheets and partonic 2-surfaces inside given CD. SH is very much analogous to the AdS/CFT correspondence but is much simpler: the simplicity is made possible by much larger group of conformal symmetries. 2-dimensionality of space-time regions carrying fermion field can be deduce also from the condition that electromagnetic charge is well-defined for spinor modes: this requires that W boson fields vanish and this implies in the generic case 2-D string world sheets. Number theoretic vision suggests the interpretation of string world sheets and partonic 2-surfaces as commutative or co-commutative sub-manifolds of the space-time having quaternionic (associative) tangent space as a 4-surface in the imbedding space with octonionic (non-associative) tangent space [K24, K43].

If these 2-surfaces satisfy some consistency conditions one can continue them to 4-D space-time surface inside CD such that string world sheets are surfaces inside them satisfying the condition that charged (possibly all) weak gauge potentials identified as components of the induced spinor connection vanish at the string world sheets and also that energy momentum currents flow along these surfaces. String world sheets carry second quantized free induced spinor fields and fermionic oscillator operator basis is used to construct WCW gamma matrices.

5. The existence of WCW geometry requires maximal possible group of symmetries for the geometry of WCW. Essentially a union of infinite-dimensional symmetric spaces labelled by so called zero modes not contribution to the line element of WCW would be in question. The natural candidate for this infinite-dimensional isometry group is symplectic group acting in CP_2 and at 3-D light-cone. This group maps vacuum extremals to vacuum extremals but is not a symmetry of more general extremals: if this were the case WCW metric would be trivial.

2.1.2 Quantum Criticality and hierarchy of Planck constants as dark matter hierarchy

The Kähler coupling strength α_K appearing in Kähler action is analogous to temperature. In its original form [K8] QC stated that this coupling strength is analogous to critical temperature and therefore has discrete spectrum. This idea makes sense even if Kähler action is generalized to contain additional terms: all coupling constants would be analogous to critical thermodynamical parameters.

Indeed, the twistor lift of TGD [K26, K47] replacing space-time surfaces with their twistor spaces in 12-dimensional product of twistor spaces of M^4 and CP_2 indeed brings in cosmological constant Λ and Planck length as radius of the sphere S^2 serving as the fiber of twistor space. This lift makes sense only for $M^4 \times CP_2$ making this choice unique. If Planck length and cosmological constant emerge in this manner their spectrum would be fixed by QC condition. The negative pressure implying accelerated cosmic expansion can be also assigned to magnetic flux tubes with monopole flux so that the situation remains open.

The meaning of QC at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that QC [K40] is behind all of them. Behind QC are in turn number theoretic vision and strong forms of general coordinate invariance (GCI) and holography (SGCI and SH).

1. The hierarchy of Planck constants labelling a hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of the super-symplectic algebra assignable to the boundary of CD with points replaced with CP_2 . The conformal weights are n -ples of those for the entire algebra. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question. For $n > 1$ the hierarchy levels are interpreted in terms of dark matter. What is highly non-trivial that the conformal weights itself need not be integers or half integers as usually. The generators of algebra could have conformal weights which are proportional to zeros of zeta and poles of zeta so that the number of generating elements (finite for ordinary super-conformal algebras) would be infinite [K5]. Physical states would however have real conformal weights which would be half integers (conformal confinement).

Could n correspond to the value of effective Planck constant $h_{eff}/h = n$? Why n should correspond to the number of sheet for the space-time surface as covering space? It has become clear that there is no obvious reason why for this. Number theoretic vision provides much more feasible answer. Adelic hierarchy corresponds to a hierarchy of extensions of rationals and the Galois groups of extensions act as symmetry groups permuting number theoretic discretizations of space-time surface and combining them to single n -fold covering space, where n divides the the order of Galois group of the extension. These groups also act as automorphism groups of the dynamical Kac-Moody groups assignable to the hierarchy of sub-algebras of the super-symplectic algebra.

2. QC in turn reduces to the number theoretic vision about SH. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.

SH says that space-time surfaces are continuations of collections of string world sheets and partonic 2-surfaces to preferred extremals of Kähler action for which Noether charges in the sub-algebra of super-symplectic algebra vanish. This condition is the counterpart for the reduction of the 2-D criticality to conformal invariance. This eliminates huge number of degrees of freedom and makes SH possible. TGD does not reduce physics to that of strings since the fact that strings are surfaces inside 4-D space-time surfaces is an essential part of physics and also the experimental testing requires 4-D space-time as also the notion of 8-D imbedding space.

3. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic [K43].

p-Adic sectors serve as correlates for cognition and imagination. One can indeed have string world sheets and partonic 2-surfaces, which can be algebraically continued to preferred extremals in p-adic sectors by utilizing p-adic pseudo constants providing huge flexibility. If this is not possible in the real sector, a fragment of imagination is in question! It can also happen that only part of real space-time surface can be generated: this might relate to the fact that imaginations can be seen as partially realized motor actions and sensory perceptions.

4. The assignment of the hierarchy of Planck constant to a hierarchies of inclusions of hyperfinite factors of type II_1 is natural. Also the interpretation in terms of finite measurement resolution makes sense. As n increases the sub-algebra acting as conformal gauge symmetries is reduced so that some gauge degrees of freedom are transformed to physical ones. The transitions increasing n occur spontaneously since criticality is reduced. A good metaphor for TGD Universe is as a hill at the top of a hill at the top.... In biology this interpretation is especially interesting since living systems can be seen as systems doing their best to stay at criticality using metabolic energy feed as a tool to achieve this. Ironically, the increase of \hbar would mean increase of measurement resolution and evolution!
5. If twistor lift is not performed, the only coupling constant of the theory is Kähler coupling constant $\alpha_K = g_K^2/4\pi\hbar$, which appears in the definition of the Kähler function K characterizing the geometry of WCW. In the most general case α_K has a spectrum of critical values and this conjecture seems at this moment the most reasonable one. It has indeed turned out that the discrete spectrum could have interpretation in terms of discretized coupling constant evolution for U(1) coupling constant of standard model. The identification of the spectrum in terms of zeros of so called fermionic zeta function expressible in terms of Riemann zeta is attractive [K5]. The exponent of K defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed values of $\alpha_K = g_K^2/4\pi\hbar_{eff}$ should be analogous to critical temperatures and determined by QC requirement.

2.2 Classical TGD

In TGD framework classical physics is an exact part of quantum physics rather than being only an approximate limit of quantum theory emerging from the stationary phase approximation to path integral, which would in TGD allow all space-time surfaces. Now one does not have path integral but functional integral over the pairs of 3-surfaces at boundaries of CD. Only preferred extremals of Kähler are allowed in the functional integral so they satisfy classical field equations and even more: effective 2-dimensionality holds by SH. Stationary phase approximation can be made also now but selects "preferred preferred extremals". The reason is that for real value of α_K the Minkowskian space-time regions give imaginary exponent to the action exponential whereas Euclidian space-time regions give real exponent identifiable as exponent of Kähler function. In fact, the value of α_K can be also complex but this does not affect this picture.

2.2.1 Space-time surfaces as preferred extremals of Kähler action

Preferred extremal of Kähler action have remained for a long time one of the basic poorly defined notions of TGD. There are pressing motivations for understanding what “preferred” really means. For instance, the conformal invariance of string models naturally generalizes to 4-D invariance defined by quantum Yangian of quantum affine algebra (Kac-Moody type algebra) characterized by two complex coordinates and therefore explaining naturally the effective 2-dimensionality [K26].

In ZEO preferred extremals are space-time surfaces connecting two space-like 3-surfaces at the ends of space-time surfaces at boundaries of CD. A natural looking condition is that the symplectic Noether charges associated with a sub-algebra of symplectic algebra with conformal weights n -multiples of the weights of the entire algebra vanish for preferred extremals. These conditions would be classical counterparts the condition that super-symplectic sub-algebra annihilates the physical states.

What is needed is the association of a unique space-time surface to a given 3-surface defined as union of 3-surfaces at opposite boundaries of CD. One can imagine many manners to achieve this. “Unique” is probably too much to demand: for the proposal unique space-time surface is replaced with finite number of conformal gauge equivalence classes of space-time surfaces. This would bring in finite number of discrete degrees of freedom. In any case, it is better to talk just about preferred extremals of Kähler action and accept as the fact that there are several proposals for what the precise meaning of this notion.

2.2.2 Many-sheeted space-time and topological field quantization

At classical level the basic is the notion of many-sheeted space-time which can be visualized in 2-D situation as a structure consisting of space-time sheets extremely near to each other and connected by wormhole contacts. General Relativity becomes approximate description obtained by replacing the sheets with single slightly curved region of Minkowski space. The sheets correspond to material objects that one can say that we directly see them. The experimental tests distinguishing TGD from GRT relate to many-sheetedness.

Preferred extremal property implies extremely powerful quantization conditions as is clear from the fact that the 2-D data should fix the preferred extremal by SH.

The quantum field theory limit of TGD - GRT plus standard model - is obtained when the sheets are compressed to single region of slightly curved piece of M^4 by identifying gauge potentials as sums of induced gauge potentials for the spinor connection of CP_2 and gravitational field as sum for the deviations of the induced metrics from Minkowski metric. This corresponds to the vision that the force experienced by a test particle - small 4-surface - is sum of those induced as it touches various space-time sheets. One gets rid of topological complexity but the extreme simplicity of space-time dynamics is lost in this replacement.

The compactness (finite size) CP_2 implies topological field quantization: the classical electric fields, magnetic fields, and radiation fields decompose to topological field quanta, space-time sheets, and one can say that physical systems have field identity, field body. This is not true in Maxwell’s theory.

The notion of magnetic body carrying dark matter identified as macroscopically quantum coherent $h_{eff} = n \times h$ phases has become central in TGD inspired quantum biology [K32, K31]. Magnetic body becomes intentional agent using biological body as a sensory receptor and motor instrument. Communication and control would be based EEG and its fractally scaled variants consisting of dark photons. The size of magnetic body is rather large, at EEG frequency range the size scale is defined by the wave length of photons involved and is of the order of the size scale of Earth. The proposal is that bio-photons are created in a phase transition transforming dark photons to ordinary photons [K35]: since bio-photons have energies are in the range of visible and UV photons, this requires that the value of h_{eff}/h is roughly the ratio of the frequency of EEG photon with the frequency of visible photon and rather large.

I have called radiation quanta “massless extremals” (MEs) or topological light rays. For MEs the signals propagate at maximal signal velocity (for general space-time sheet light velocity is reduced since the paths along curved space-time sheet is general longer) and thanks to the tubular structure of ME they represent precisely target communications. A further property is that the shape of signal is preserved since positive frequency can propagate in one direction only.

2.2.3 New ontology

TGD leads to a new ontology at both space-time level and quantum level.

1. At space-time level many-sheeted space-time represents new piece of ontology. Single space-time sheet is extremely simple objects and the information needed to construct it is by SH 2-dimensional. Complexity emerges at quantum field theory limit when the sheets of the many-sheeted space-time are replaced with single slightly curved region of M^4 .
2. The hierarchy of Planck constants identified in terms of dark matter as phases of ordinary matter represents second new ontological element. Dark matter is assumed to reside at magnetic body which also represents a new ontological element.
3. A further modification of ontology is the replacement of the usual positive energy ontology (PEO) with what I call ZEO already described. In ZEO quantum states are superpositions of quantum evolutions connecting the positive and negative energy parts of the states. Zero energy states are essentially 4-D and only the positive and negative energy parts are 3-D. Quantum jumps/state function reductions re-create the zero energy states with new ones and this allows to solve the basic paradox of ordinary quantum measurement theory due to the fact that non-determinism of state function reduction is in conflict with the determinism of unitary time evolution. One also ends up with identification of "self" as conscious entity: self corresponds to generalized Zeno effect: to a sequence of state function reduction to say positive (positive) energy part of zero energy state [K1] [L15]. Self dies when the first reduction to negative (positive) part occurs. Also the origin for the flow of experienced time can be understood.

2.2.4 Hierarchies

TGD Universe is characterized by various hierarchies. At space-time level there is a hierarchy of space-time sheets labelled by a hierarchy of p-adic length scales coming as primes near powers of two and probably generalizing to primes near powers of prime [K37, K43]. In ZEO and at imbedding space level there is a hierarchy of CDs labelled by their size scales coming as integer multiples of CP_2 scales. The fractal hierarchy of symplectic sub-algebras leads to a generalization of quantum theory based on a hierarchy of Planck constants characterizing hierarchy of dark matters [K6, K40], hierarchies of inclusions of hyper-finite factors [K29], hierarchies of breakings of super-symplectic gauge symmetry [K30, K42] associated with a hierarchy of quantum criticalities [K40]. There is also a number theoretic hierarchy of algebraic extensions of rationals accompanied by those of p-adic number fields [K43] allowing to see evolution as a gradual increase of the complexity for extensions of rationals assignable to the parameters characterizing string world sheets and partonic 2-surfaces. In TGD inspired theory of consciousness [K11] self hierarchy emerges.

At the basic level the fundamental hierarchy seems to be the hierarchy of breakings of super-symplectic symmetry as gauge symmetry. Super-symplectic algebra and its Yangian generalization have the structure of conformal algebra and is naturally associated with critical systems which are now 4-dimensional. There are also other conformal algebras involved.

By SH implied by the SGCI the core of the mathematical description of quantum TGD reduces to that for 2-D systems associated with partonic 2-surfaces and string world sheets. Although space-time is 4-D, all that can be said mathematically about quantum physics can be reduced to these 2-D "space-time genes". 4-D space-time surfaces are however necessary for the classical description of TGD necessary to interpret quantum measurements in terms of frequencies and wavelengths classical space-time picture about particles. This reduction implies that the representations of charges of super-symplectic Yangian [K26, K47] are in terms of fermionic strings connecting partonic 2-surfaces, which means enormous simplification of the theory. This representation also involves a generalization of AdS/CFT duality to TGD framework as manifestation of SGCI basically [K2].

2.3 Number theoretical physics

Number theoretical physics involves several threads [K43].

1. p-Adic physics as correlate for cognition, imagination, and intentionality [K23] p-Adic physics was originally inspired by the challenge of understanding the mass scales of elementary particles but it soon turned that the interpretation in terms of mathematical correlates of cognition and imagination is very natural. This in turn forced the conclusion that cognition is probably present in all length scales, rather than only at the level of brain. The eventual outcome was a fusion of real and p-adic physics in terms of adelic physics.
2. Classical number fields emerge very naturally in TGD framework [K24]. For instance, the conjecture is that space-time surfaces as preferred extremals of Kähler action are quaternionic sub-manifolds of imbedding space endowed with octonionic structure. Also quaternion analyticity [?, ?] as a generalization of complex analyticity central in string models is very attractive conjecture [K26] in accordance with the original vision that 2-D analyticity in some sense generalizes to its 4-D variant.
3. Infinite primes [K22] are constructed by a repeated second quantization of arithmetic quantum field theory and could be essential for understand of quantum TGD.

In the sequel I discuss only the p-adic physics and the fusion of real physics and various p-adic physics to adelic physics as proposal for the physics of matter and mind or correlates of sensory and cognitive consciousness.

2.3.1 p-Adic physics as physics of cognition, imagination and intentionality

1. The attempt to understand elementary particle mass spectrum led to the hypothesis that p-adic number fields - one for each prime $p = 2, 3, 5, \dots$, which are completions of rationals like real numbers, allow to construct what I called p-adic thermodynamics allowing to understand particle masses as kind of thermal masses resulting when massless particles suffer slight thermal mixing with particles with mass scale given by CP_2 mass of order 10^{-4} Planck masses.
2. The failure of well-orderedness property for p-adic numbers brings in the corresponding failure due to a finite measurement resolution and leads to the vision that p-adic numbers are ideal for describing the effects of finite measurement resolution and cognitive resolution.
3. The failure of strict determinism for the partial differential equations suggest strongly that it serves as a correlate for cognition, imagination, and maybe also intention is closely related.
4. The fusion of real physics and various p-adic physics (identified as correlates for cognition, imagination, and intentionality) to single coherent whole leads to adelic physics [K43]. Adeles associated with given extension of rationals are Cartesian product of real number field with all p-adic number fields extended by the extension of rationals. Besides algebraic extensions also the extension by any root of e is possible since it induces finite-dimensional p-adic extension. One obtains hierarchy of adeles and of corresponding adelic physics interpreted as an evolutionary hierarchy.

An important restriction is that p-adic Hilbert spaces exist only if one restricts the p-adic numbers to an algebraic extension of rationals having interpretation as numbers in any number field. This is due to the fact that sum of the p-adic valued probabilities can vanish for general p-adic numbers so that the norm of state can vanish. One can say that the Hilbert space of states is universal and is in the algebraic intersection of reality and various p-adicities.

5. One can define the p-adic counterparts of Shannon entropy for all finite-dimensional extensions of p-adic numbers, and the amazing fact is that these entropies can be negative and thus serve as measures for information rather than for lack of it. The formula is simple:

$$S = - \sum_k P_k \log(P_k) \rightarrow \sum_k P_k \log(N_p(P_k)) . \quad (2.1)$$

Here $N_p(x)$ is the p-adic norm, which for n -D extension is defined as n :th root of the determinant of the matrix of the linear map defined by multiplication with x . The change of sign is dictated by the fact that converging Boltzmann weights $e^{-E/kT}$ must in be TGD proportional to positive powers p^k with increasing k by the properties of p-Adic norm.

p-Adic entropy can have both signs bit NMP suggests that the sign tends to become negative so that interpretation as a measure for conscious information is possible. Furthermore, all non-vanishing p-adic negentropies are positive and the number of primes contributing to negentropy is finite since any algebraic number can be expressed using a generalization of prime number decomposition of rational number. These p-adic primes characterize given system, say elementary particle.

The possibility of NE together with NMP [K12] implies that the reduction does not always lead to an unentangled state but can generate NE. Living systems would be systems generating NE and biological evolution could be seen as a gradual generation of negentropic resources - I have called them Akashic Records. For rational probabilities entanglement negentropy equals to real entropy [L11]. This might relate to the Jeremy Englands vision that high entropy is relevant for living matter.

What is important that entanglement negentropy and thermodynamical entropy are *not* negatives of each other. Hence NMP is not in conflict with the second law but predicts it for the ordinary matter as a consequence of non-determinism of state function reduction. It is however true that large entropic resources realized as a large number of states with the same energy makes possible both large thermodynamical entropy and NE with large negentropy.

2.3.2 The extension of real physics to adelic physics

In TGD framework cognition is described in terms of p-adic number fields and has led to a fusion of real and various p-adic physics to what I call adelic physics [K43]. Real physics corresponds to sensory experience and p-adic physics to cognition and imagination. Originally I talked about p-adic physics as physics of cognition and intentionality but I have become ambivalent about intentionality: this issue remains unsettled.

Real-p-adic correspondence has been a longstanding problem. Continuous correspondence at space-time level does not respect symmetries. Algebraic correspondence respects symmetries but not continuity. Also GCI has been a problem. In the proposed framework real-p-adic correspondence can be realized in elegant manner without conflict with fundamental symmetries and achieving continuity only for discretization.

1. The naive idea is that rationals belong to the intersection of reals and p-adics. More generally, points in algebraic extension of rationals would be common to realities and p-adicities which correspond to “thought bubbles” or imaginations. This hierarchy defines a hierarchy of adeles having interpretation in terms of evolution leading to increasingly complex algebraic extensions of rationals.
2. The first guess was that this means at space-time level that imbedding space points with rational valued coordinates (or values in the extension of rationals) correspond to common points of real and p-adic space-time surfaces. This picture however leads to problems with both GCI and key symmetries of TGD. What are the preferred coordinates of space-time surface which would be in algebraic extension of rationals in the intersection? Should one restrict symmetry groups to their discrete subgroups?
3. A partial resolution of the problem came from the realization that the intersection of realities and p-adicities corresponds to space-time surfaces, whose representation is such that they make sense both in real and p-adic sense [K43]. This requires that the WCW coordinates of these surfaces are invariant under various symmetries and general coordinate transformations of space-time belong to the extension of rationals in question. At the level of WCW the coordinates are highly unique on basis of symmetries and by GCI at space-time level. This also means discretization of the infinite-dimensional WCW and together with huge isometry group of WCW gives hopes about computability of TGD.

4. As often happens, also the original idea about points of given algebraic extension of rationals as common to real and p-adic space-time surfaces makes sense: one can say that these discrete points define cognitive representations in the real world. The point is that space-time surfaces can be identified as 4-surfaces in H and discretization is induced by that of H . At the first step, the pieces of hyperboloids inside CD and CP_2 can be replaced with their discrete variants making sense both in real and p-adic sense [L14].

The discretization of space-time surface is *induced* by the discretization at the level of $CD \times CP_2$ in terms of algebraic points of space-time surface and one avoids problem with p-adic version of general coordinate invariance and various space-time symmetries because for coset spaces the coordinate choice is unique apart from isometries: angles or hyperbolic angles serve as coordinates. Angles do not exist in p-adic context. The phases $\exp(i\phi)$ - and therefore the values of trigonometric functions - exist in algebraic extensions of p-adic numbers as roots of unity associated with angles $\phi_{m,n} = m2\pi/n$. Also the roots $e^{m/n}$ define finite-D extension of p-adic numbers since e^p is ordinary p-adic number.

The outcome is a precise mathematical formulation for the p-adic counterparts of space-time surfaces as preferred extremals of Kähler action. The p-adic variants of coset spaces can be seen as discretizations of real coset spaces with discrete points replaced by p-adic continua analogous to the monads of Leibniz [L14]. This would make possible discretization without losing differentiability central for field equations. One can define p-adic field equations inside these monads and strong SH makes sense in both real and p-adic sector.

The same algebraic expressions would describe real and p-adic solutions of field equations locally when restricted to string world sheets and partonic 2-surfaces (maybe also their light-like orbits). Inside monads real-p-adic correspondence would respect algebraic structures and symmetries. In the intersections symmetry groups would be replaced with discrete subgroups and continuity would be respected in the approximation provided by discretization and would confirm with the idea about finite measurement resolution.

5. This procedure is unique for given choice of discrete subgroups G and H . One can however take any discrete subgroup with matrix elements in algebraic extension of rationals and its subgroup and form a discrete analog of coset space: there is infinite hierarchy of measurement/cognitive resolutions. For instance, in the case of $SU(2)$ these discrete approximations of $SU(2)$ containing finite set of points correspond to the discrete subgroups labelling inclusions of hyperfinite factors of type II_1 and include only Platonic solids as genuinely 3-D approximations of sphere. This is discrete structure in real world.

2.3.3 p-Adic physics as physics of imagination

A further step in the progress came from the discovery of SH [K2]. 2-dimensional surfaces (string world sheets and partonic 2-surfaces) are fundamental objects and 4-D physics is a kind of algebraic continuation from this intersection of reality and various p-adicities in both real and p-adic sectors of the adelic Universe. 4-D space-time surfaces are preferred extremals of Kähler action making them effectively 2-D in the sense that the 2-D surfaces serve as “space-time genes”. Also the quantum states assignable to the 2-D surfaces can be algebraically continued to the entire 4-D space-time.

It is however quite possible that the continuation in the real sector to a preferred extremal of Kähler action fails. In p-adic sectors the possibility of p-adic pseudo constants, which are piecewise constant functions with vanishing derivative, makes the continuation much easier. This inspires the idea that imagination corresponds to these p-adic continuations. p-Adic continuation might be possible whereas real continuation could fail: one would have imagined world, which cannot be realized as often happens!

This argument becomes more precise as one realizes that SH is slightly broken: even information theoretically one has only effective 2-dimensionality [K43]. This means that 4-surfaces as preferred extremals are dictated by the data at string world sheets and possibly also partonic 2-surfaces and by data discrete set of points with preferred imbedding space coordinates in the extension of rationals defining the adelic structure by inducing the extensions of p-adic number fields. For p-adic number fields pseudo-constants make it easy to construct the algebraic continuation to a

preferred extremal containing the discretization. For reals this is possible only in special cases. These discretizations correspond to realizable imaginations.

Note that Galois group acts as symmetries in the space of space-time discretizations and under certain conditions gives rise to a space-time surface, which is a covering space with n sheets, n a factor of the order of Galois group. The identification $h_{eff}/h = n$ is natural and reduces the hierarchy of Planck constants and dark matter to adelic physics. Ramified primes for the extension of rationals involved are preferred for extension and if the extension allows especially many realizable imaginations, it is survivor in the number theoretic fight for survival. Ramified primes for these extensions should be winners in the number theoretic evolution. Whether p-adic length scale hypothesis and its generalization follow from this conjecture, remains an open question.

2.3.4 Negentropic entanglement (NE)

In a given p-adic sector the entanglement entropy is defined by replacing the logarithms of probabilities in Shannon formula by the logarithms of their p-adic norms as already described. The resulting entropy satisfies the same axioms as ordinary entropy but makes sense only for probabilities, which are rational valued or in an algebraic extension of rationals. The algebraic extensions corresponds to the evolutionary level of system and the algebraic complexity of the extension serves as a measure for the evolutionary level. p-Adically also extensions determined by roots of e can be considered. What is so remarkable is that the number theoretic entropy can be negative.

A simple example allows to get an idea about what is involved. If the entanglement probabilities are rational numbers $P_i = M_i/N$, $\sum_i M_i = N$, then the primes appearing as factors of N correspond to a negative contribution to the number theoretic entanglement entropy and thus to information. The factors of M_i correspond to negative contributions. For maximal entanglement with $P_i = 1/N$ in this case the entanglement entropy is negative. The interpretation is that the entangled state represents quantally concept or a rule as superposition of its instances defined by the state pairs in the superposition. Identity matrix means that one can choose the state basis in arbitrary manner and the interpretation could be in terms of “enlightened” state of consciousness characterized by “absence of distinctions”. In general case the basis is unique.

Metabolism is a central concept in biology and neuroscience. Usually metabolism is understood as transfer of ordered energy and various chemical metabolites to the system. In TGD metabolism could be basically just a transfer of NE from nutrients to the organism. Living systems would be fighting for NE to stay alive (NMP is merciless!) and stealing of NE would be the fundamental crime.

TGD has been plagued by a longstanding interpretational problem: can one apply the notion of number theoretic entropy in the real context or not. If this is possible at all, under what conditions this is the case? How does one know that the entanglement probabilities are not transcendental as they would be in generic case? There is also a second problem: p-adic Hilbert space is not a well-defined notion since the sum of p-adic probabilities defined as moduli squared for the coefficients of the superposition of orthonormal states can vanish and one obtains zero norm states.

These problems disappear if the reduction occurs in the intersection of reality and p-adicities since here Hilbert spaces have some algebraic number field as coefficient field. By SH the 2-D states states provide all information needed to construct quantum physics. In particular, quantum measurement theory.

1. The Hilbert spaces defining state spaces has as their coefficient field always some algebraic extension of rationals so that number theoretic entropies make sense for all primes. p-Adic numbers as coefficients cannot be used and reals are not allowed. Since the same Hilbert space is shared by real and p-adic sectors, a given state function reduction in the intersection has real and p-adic space-time shadows.
2. State function reductions at these 2- surfaces at the ends of CD take place in the intersection of realities and p-adicities if the parameters characterizing these surfaces are in the algebraic extension considered. It is however not absolutely necessary to assume that the coordinates of WCW belong to the algebraic extension although this looks very natural.
3. Does NMP apply to the sum of real and p-adic entropies (Option 1) or only to the sum of p-adic entanglement entropies (which can be negative) (Option 2). The situation is not settled yet.

- (a) For Option 1 the total entropy vanishes identically for *rational* probabilities and NMP would say nothing about the situation [L11]. NMP would not prevent or favor state function reduction. It is not clear whether this situation corresponds to that in the physics of ordinary matter as opposite to that of living matter. For algebraic probabilities there would be a competition between real and p-adic sectors and p-adic sectors would win for algebraic extensions in the sense that p-adic entropy would be larger than real entropy.
- (b) For Option 2 NMP would stabilize NE also for rational probabilities. One can wonder whether one obtains the ordinary state function reduction at all for this option. In ZEO state function reductions to the opposite boundary of CD would be however forced to occur and second law would be the outcome also in this case.

For both options it could quite well happen that NMP for the sum of real and p-adic entanglement entropies does not allow the ordinary state function reduction to take place since p-adic negative entropies for some primes would become zero and net negentropy would be lost.

In both cases mind would have causal power: it can stabilize quantum states against state function reduction and tame the randomness of quantum physics in absence of cognition! Can one interpret this causal power of cognition in terms of intentionality? If so, p-adic physics would be also physics of intentionality as originally assumed.

A fascinating question is whether the p-adic view about cognition could allow to understand the mysterious looking ability of idiot savants (not only of them but also of some greatest mathematicians) to decompose large integers to prime factors. One possible mechanism is that the integer N represented concretely is mapped to a maximally entangled state with entanglement probabilities $P_i = 1/N$, which means NE for the prime factors of P_i or N . The factorization would be experienced directly.

One can also ask, whether the other mathematical feats performed by idiot savants could be understood in terms of their ability to directly experience - “see” - the prime composition (adelic decomposition) of integer or even rational. This could for instance allow to “see” if integer is - say 3rd - power of some smaller integer: all prime exponents in it would be multiples of 3. If the person is able to generate an NE for which probabilities $P_i = M_i/N$ are apart from normalization equal to given integers M_i , $\sum M_i = N$, then they could be able to “see” the prime compositions for M_i and N . For instance, they could “see” whether both M_i and N are 3rd powers of some integer and just by going through trials find the integers satisfying this condition.

3 ZEO and generalization of quantum measurement theory to a theory of consciousness

TGD inspired theory of consciousness can be seen as a generalization of the quantum measurement theory by making observer part of physical system as conscious entity subject to laws of quantum physics. I will talk about this conscious entity as self and pose no a priori restrictions what self can be. The basic vision is that quantum measurement theory must be generalized so that observer ceases to be an outsider and is described by the quantum physics. ZEO plays a key role in this generalization and makes highly non-trivial predictions. Raising quantum measurement to a universal physical phenomenon requires the identification of the density matrix of subsystem as a universal observable and introduction of Negentropy Maximization Principle (NMP) [K12] as the fundamental variational principle of consciousness.

3.1 ZEO

One must generalize ontology in order to solve the contradiction between deterministic time evolution and the evolution by state function reductions. This requires understanding the notion of subjective time and its relationship to the geometric time. The new ontology must allow to see selves as something unchanged in some aspects and continually changing in some other aspects. Also the experience about the flow of subjective time must be explained.

1. In TGD framework the answer is ZEO [K12]. The concept of quantum state is generalized. States are now analogs for physical events characterized by initial and final quantum state that is pairs of positive and negative energy states. The conserved quantum numbers of the members are opposite so that zero energy states can be created from vacuum. This is a radical generalization of the physicalist world of view but entirely consistent with conservation laws: there is no need to give laws of physics in order to have free will. Positive and negative energy parts of the zero energy states can be assigned to opposite light-like boundaries of CDs, which are intersections of future and past directed light-cones multiplied by CP_2 . CDs form a fractal scale hierarchy. They can be seen as imbedding space correlates for the 4-D perceptive fields of selves.
2. CD is a central notion in ZEO and serves as imbedding space correlate for self. State function reduction can occur to either boundary of CD (“upper” or “lower”). Self can be seen as a generalized Zeno effect - a sequence of state function reductions to either boundary of CD. These two kinds of selves can be said to be time reversals of each other. The period of non-boiling pot corresponds to the passive boundary of CD not changing in the reductions: also the parts of zero energy states at this boundary remain unaffected. The opposite - active - boundary is shifted towards future reduction by reduction and states at it are changed. The shifting the geometric future gives rise to the experienced time flow. This is the analog of unitary time evolution.

3.2 NMP as variational principle of consciousness

One must generalize standard quantum measurement theory to a theory of consciousness. The notions of NMP, entanglement negentropy and negentropic entanglement (NE) are the key notions.

1. Negentropy Maximization Principle (NMP) [K12] is the variational principle of consciousness in TGD framework reducing to quantum measurement theory in Zero Energy Ontology assuming adelic physics. Negentropy Maximization Principle or something akin to it should be consistent with the standard rules of quantum measurement theory and possibly generalize them. In particular, NMP should tell which observables are measured in given entangled situation. The density matrix defined by the entanglement is the unique candidate for the universal observable. All systems could be said to give rise to quantum measurements. NMP must decide how long the self “lives”: self lives as long as repeated state function reductions at the same boundary give the maximal negentropy gain.
2. One must have a mathematical definition of negentropy [K12]. When NE is possible and what is the measure for the negentropy? Shannon entropy is the natural starting point but it cannot have negative values in real context. One could define information as a reduction of entropy as conscious observer learns the state of the system under consideration: the IIT approach of Tononi [J9], [L17, K48] relies on this notion and leads to a circular definition of conscious information. Now however the conscious entity would be this system and this definition of information does not apply. One must find a genuine measure of information assignable to entanglement as entanglement negentropy rather than lack of information about the state of either entangled member of entangled by identifiable as entanglement entropy (ordinary Shannon entropy).

Here one cannot avoid number theory and I can only apologize. The p-adic generalization of Shannon entropy by replacing the logarithms of probabilities with the logarithms of their p-adic norms provides a possible solution of the problem [K12, K1]. It is well defined for algebraic entanglement probabilities belonging to the algebraic extension of rationals defining also the extensions of various various p-adic number fields) [L11].

Adelicity (roughly: adeles correspond to Cartesian product of positive real numbers and all p-adic number fields) holds true in the sense that the sum of real and p-adic information measures (finite number of primes contribute) over all primes vanishes for rational entanglement probabilities. This is not the case for the algebraic extensions of adeles induced by those of rationals [L11].

It is not quite clear whether NMP applies to the sum of p-adic entropies or to the sum of real and p-adic entropies providing alternative definitions of information. Both options conform with the fact that large entropy seems to be prerequisite for life as proposed Jeremy England [I10] [K41] [L6].

3. NE (negentropic entanglement) is a further key notion and entanglement negentropy identified as number theoretic entanglement entropy, which can be negative. NE can only increase in state function reductions and this brings in evolution forced by NMP.

In the formulation of NMP in terms of maximal negentropy gain one considers divisions of the system into subsystem and complement and finds the pair for which the reduction of entanglement would give maximum reduction of entropy. If the system is irreducible this kind of pair characterized by entropic entanglement cannot be found. The eigenstates of density matrix for negentropically entangled subsystems are in 1-1 correspondence. An interesting question is whether associations in the sense of neuro science corresponds to NE between the states of associated systems.

State function reduction cascade is a key notion. State function reduction sequences is a top down cascade propagating downwards to smaller system sized. First the reduction in CD scale occurs. The resulting two subsystems decompose to two parts and so on until decomposition is not possible anymore because it would not generate negentropy.

There is an obvious analogy with the Integrated Information Theory (IIT) of Tononi and Koch. The quantity Φ postulated by Tononi and Koch [J9] resembles negentropy in TGD [L17]. The basic objection against IIT is that the notion of conscious information is circular being based on entropy as fundamental notion. Information is defined as reduction of entropy when conscious entity learns what the state of system is. The notion of conscious information cannot involve this kind of dependence. The outcome is a paradox: printer printer text is conscious if no-one knows about the contents of the file, not if some-one already knows since the definition of conscious information reduces it to conscious information gained by the outsider. This is not surprising, since entropy as a notion belongs to the physics of outsider about object rather than subject.

In TGD framework negentropy for entanglement does not involve this kind of assumption since conscious information represents abstraction or rule with the superposed state pairs (a_i, b_i) representing the instances of a rule (A, B) and A and B representing concepts.

3.3 Details related to NMP

What happens in state function reduction and what NMP really says is still far from being completely clear. The basic condition is that standard measurement theory emerges as a special case and is forced by NMP [K12]. This does not however fix the NMP completely.

1. *Adelic NMP as the only reasonable option*

I have considered two options for NMP.

1. In the original approach to NMP it was assumed that both generic entanglement with real entanglement probabilities and entanglement with algebraic entanglement probabilities are possible. Real entanglement is entropic and demands standard measurement theory leading to a 1-D eigen-space of the density matrix. Algebraic entanglement can be negentropic in number theoretic sense for some p-adic primes, and in this case state function reduction occurs only if it increases negentropy. It takes place to N-dimensional eigen-space of the density matrix. The basic objection is that real entanglement is transcendental in the generic case reducing to algebraic entanglement only as a special case. Algebraic entanglement is also extremely rare without additional physical assumptions.
2. In the adelic approach entanglement coefficients and therefore also entanglement probabilities are always algebraic numbers from the condition that the notion of p-adic Hilbert space makes sense. Also extensions of rationals defining finite-dimensional extension of p-adic numbers (roots of e can appear in extension) must be allowed. Same entanglement can be seen from both real (sensory) and p-adic perspectives (cognitive). The entanglement is always entropic in the real sector but can be negentropic in some p-adic sectors. It is now clear that the adelic option is the only sensible one.

2. Variants of the adelic NMP

The adelic option allows to consider several variants.

1. Negentropy could correspond **a)** to the sum $N = N_R + \sum_p N_p$ of real and various p-adic negentropies or **b)** to the sum $N = \sum N_p$ of only p-adic negentropies. N_p is non-vanishing for a finite number of p-adic primes only as is easy to find. In both cases $\sum_p N_p$ could be interpreted as negentropy assignable to cognition. N_R might have interpretation as a measure of ignorance of one of the entangled systems about the state of other.
2. NMP implies that state function reduction (measurement of density matrix leading to its eigen-space) occurs if negentropy **1)** is not reduced or **2)** increases. This means that NE is stable against NMP.

Can one select between these options?

1. For option **a)** NMP becomes trivial for rational entanglement probabilities as is easy to find: one has $N = N_R + \sum_p N_p = 0$. NMP does not force state function reduction to occur but it could occur and imply ordinary state function reduction as a special case for option **1)** (when eigen-spaces are 1-dimensional). Therefore one would have option **1a)**.
2. If option **1a)** is unrealistic, only the options **1b)** and **2b)** with $N = \sum_p N_p$ are left. For option **2b)** state function necessarily occurs for $N = \sum_p N_p < 0$ but not for $N = 0$ - not even in rational case. For option **2b)** the state function reduction could occur also for $N = 0$. However, since N_p is proportional to $\log(p)$ and the numbers $\log(p)$ are algebraically independent, $N = 0$ is not actually possible so that **1b)** and **2b)** are equivalent. Therefore NMP states that $N = \sum_p N_p$ must increase for $N < 0$: this forces state function reduction to an eigen-space of density matrix.

But is it really possible to have $\sum N_p < 0$ making possible ordinary state function reduction? For rational entanglement probabilities this is not possible by $S_R = \sum_p N_p$ and one might even speculate that for algebraic extensions one has $\sum_p N_p \geq S_R$. Mathematician could probably check the situation. $\sum_p N_p \geq S_R$ holds true, entanglement is stable against NMP and ordinary state function reduction is not possible. This would leave only the option **1a)** and NE with $N > 0$ would be stable also now. $N = 0$ entanglement (possibly rational always) would allow ordinary state function reduction.

This leaves still two options. Negentropy gain is **A)** maximal or **B)** non-negative but not necessarily maximal: I have considered the latter option earlier. For option **1a)** reduction is possible only for $N = 0$ and in this case negentropy gain is zero for all possible eigen-spaces of density matrix and maximality condition does not say anything.

1. For option **1a)** reduction is possible only for $N = 0$ and in this case negentropy gain is zero for all possible eigen-spaces of density matrix and **A)** and **B)** are equivalent. One obtains ordinary state function reductions.
2. Consider next the equivalent options **1b)** and **2b)** making sense if $\sum_p N_p < 0$ is possible. For option **A)** negentropy gain is maximal and the reduction occurs to an eigen-space with maximum dimension $N = N_{max}$. There can be several eigen-spaces with the same maximal dimension. As a special case one obtains ordinary state function reduction. The reduction probability is same as in standard quantum measurement theory.

For option **B)** the reduction could occur also to any N -dimensional eigen-space or its sub-space. The idea would be that NMP allows something analogous to a choice between good and evil: the negentropy gain could in this case be also smaller than the maximal one corresponding to $\log(N_{max})$. This would conform with the intuition that we do not seem to live in best possible world. On the other hand, negentropy transfer between systems could be also seen as stealing in some situations and metabolism identified as negentropy transfer could be seen as the fundamental "crime" to which all other forms of reduce.

To sum up, the only option which guarantees without additional assumptions (possibility of $\sum N_p < 0$) ordinary state function reduction and stability of NE is option **1a**).

3. *Could quantum measurement involve also adelic localization?*

For option **B**) there is still one possible refinement involved. p-Adic mass calculations lead to the conclusion that elementary particles are characterized by p-adic primes and that p-adic length scale hypothesis $p \simeq 2^k$ holds true: a more general form of hypothesis allows also to consider primes near powers q^n of some small prime such as $q = 3$.

Could state function reduction imply also adelic/cognitive localization in the sense that the negentropy is nonzero and positive for only single p-adic prime in the final state? The reduction would occur to p^k -dimensional eigen-space with p^k dividing N : any divisor would be allowed. Note that Hilbert spaces with prime dimension are prime with respect to the decomposition to tensor product so that reduction would select prime power factor of the eigen-space. This would in general reduce negentropy gain.

The information theoretic meaning would be that prime-dimensional Hilbert spaces are stable against decomposition to tensor products so that the notion of entanglement would not make sense and therefore also the change of the state by the reduction of entanglement would be impossible. I have considered the possibility that prime-dimensional state spaces could make possible stable storage of quantum information [L18]. The prime-dimensional state when imbedded to higher-dimensional space - say space representing N qubits - could be interpreted as an entangled state and would be unstable with respect to state function reduction.

This hypothesis would provide considerable insights to the origin of p-adic length scale hypothesis. To get a contact with physics consider electron as an example.

1. In the case of electron one would have $p = M_{127} = 2^{127} - 1 \sim 10^{38}$. Could electron decompose to two entangled subsystems with density matrix equal to $p \times p$ identity matrix? The dimension of eigen-space would be huge and electron would carry negentropy of 127 bits: also p-adic mass calculations combined with a generalization of Hawking-Bekenstein formula suggest that electron carries entropy of 127 bits: in adelic picture these views are mutually consistent.

The recent view indeed is that all elementary particles correspond to closed monopole magnetic flux tubes with a shape of highly flattened rectangles with short sides identifiable as extremely short wormhole contacts (CP_2 size) and long sides with length of order Compton length. Magnetic monopole flux traverses along first space-time sheet between wormhole throats, goes through wormhole contact, and returns back along second space-time sheet. Many-fermion states are assigned with the throats and are located at the ends of strings traversing along the flux tubes.

Could this structure be in the case of electron a 127-sheeted structure such that the two wormhole contacts carry a superposition of pairs formed by states containing $n \in \{1, \dots, 127\}$ fermions at second contact and n antifermions with opposite charges at second contact so that $2^{127} - 1$ dimensional eigen-space would be obtained for a fermion with given spin and isospin. For instance, $n = 0$ state with no fermion-pairs could be excluded.

2. Right-handed neutrinos and antineutrinos are candidates for the generators of $N = 2$ supersymmetry in TGD framework. It however seems that SUSY is not manifested at LHC energies, and one can wonder whether right-handed neutrinos might be realized in some other manner. Also the mathematics involved remains still somewhat unclear. For right-handed neutrinos, which are not covariantly constant transformation to left-handed neutrinos is possible and leads to the mixing and massivation of neutrinos. For covariantly constant right handed neutrino spinors this does not happen but they can included into the spectrum only if they have non-vanishing norm.

This might be the case with a proper definition of norm with $\bar{\Psi} p^k \gamma_k \Psi$ replaced by $\bar{\Psi} n^k \gamma_k \Psi$: here n^k defines normal of the light-like boundary of CD. Covariantly constant right-handed neutrinos have neither electro-weak, color, nor gravitational interactions so that their NE would be highly stable. Unfortunately, the situation is still unclear and this leaves open the idea that right-handed neutrinos might play fundamental role in cognition and negentropy

storage. Amusingly, I proposed the notion of cognitive neutrino long time ago but based on arguments which turned out to be wrong.

One could indeed consider the possibility that each sheet of the 127-sheeted structure contains at most one ν_R at the neutrino end of the flux tube accompanied by $\bar{\nu}_R$ at anti-neutrino end. One would have a superposition $p = 2^{127} - 1$ states formed by many-neutrino states and their CP conjugates at opposite “ends” of the flux tube. It is also possible that $\bar{\nu}_R - \nu_R$ pairs are spin singlets so that one has superposition over many-particle states formed from these analogous to coherent state.

This is not the only possibility. The proposal for how the finite range of weak interactions emerges suggests a possible realization for how the number of states in superposition reduces from 2^{127} to $2^{127} - 1$. The left weak isospin of fermion at wormhole throat is compensated by the opposite weak isospin of neutrino/antineutrino plus $\bar{\nu}_R/\nu_R$ or cancelling its fermion number: therefore weak charges vanish in scales longer than the flux tube length of order of the Compton length. The physical picture is that massless weak boson exchanges occur inside the flux tube which therefore defines the range of weak interactions. Same mechanism could be at work for both wormhole throat pairs and therefore also for fermion and anti-fermion at opposite wormhole throats defining building bricks of bosons. The state $\bar{\nu}_R - \nu_R$ would be excluded from the superposition of pairs of many-particle states and superposition would contain $p = 2^{127} - 1$ states.

3. Could this relate to $h_{eff} = n \times h$ hypothesis? It has been assumed that $h_{eff}/h = n$ corresponds to space-time surfaces representable as n -fold singular coverings, whose sheets co-incide at the 3-D ends of the space-time surface at opposite boundaries of CD. There is of course no need to assume that the covering considered above corresponds to singular covering and the vision that only particles with same value of n appear in same vertices suggests that $n = 1$ holds true for visible matter.

One can still ask whether the elementary particle characterized by $p \simeq 2^k$ could corresponds to k -fold singular covering and to $h_{eff}/h = k$? This would require that phase transitions changing the value of k take place at the lines of scattering diagrams to guarantee that all particles have the same value of k in given vertex. These phase transitions are a key element of TGD inspired quantum biology.

In the first order of perturbation theory this would not mean any deviations from standard quantum theory for given k and the general vision that loop corrections from the functional integration over WCW vanish suggests that there are no effects in perturbation theory for given k . p-Adic coupling constant evolution would be discrete and make itself visible by the phase transitions at the lines of scattering diagrams (not identifiable as Feynman diagrams). The different values of $h_{eff}/h = n$ be also seen through non-perturbative effects assignable to the bound states and also via the proportionality of p-adic mass scales to $p^{-1/2} \simeq 2^{-k/2}$ predicted by p-adic mass calculations.

3.4 The notion of self

Self is identified as a generalized Zeno effect and corresponds to a sequence of state function reductions to a fixed (passive) boundary of CD remaining unaffected in the sequence of reductions: also the members of state pairs defining zero energy states at it are unaffected. Active boundary drifts farther away state function reduction by state function reduction and the state at it also changes. The analogy of unitary time evolution is in question and the experienced time corresponds to the increase of the temporal distance between the tips of CD.

1. One possibility is that sensory input and mental images (“Maya”) generated by it can be assigned with the active boundary of CD. A more elegant assumption suggested by quantum measurement theory is that the passive boundaries for sub-CDs give rise to mental images as outcomes of repeated quantum measurements. The unchanging part of self (“Self”) is associated with the passive boundary. It corresponds to negentropically entangled subsystem having no entanglement with environment. In ordinary ontology it would not be possible keep self un-entangled from the environment.

2. State function reductions occur at either boundary of CD as long as they produce maximal negentropy gain. If the reduction at opposite boundary produces larger negentropy gain, it occurs. Self dies and re-incarnates as time reversed self. During repeated state function reductions at same boundary the part of state at that boundary and boundary itself remains unaffected (this corresponds to unchanging part of self) whereas the state at opposite boundary changes and the boundary also shifts outwards. The increase of the distance between the tips of CD corresponds to the flow of geometric time and gives precise meaning for the ageing of self. For instance, sensory-motor rhythm could correspond to the sequence of repeated state function reductions to opposite boundaries of CD. Motor action would correspond to reversed arrow of time: this conforms with the finding of Libet that conscious decision is preceded by neural activity used to argue that there is no free will.

Time reversed self evolves as reductions shifting the opposite boundary of CD to opposite time direction so that the size of CD continues to increase and defines a measure for the duration of the entire sequence of re-incarnations. This implies quantum physical realization for the idea about transmigration of souls!

3. Repeated state function reductions form a sequence for analogs of unitary time evolutions lasting time Δt , which corresponds to the increase of the temporal distance between tips of initial and final CD. Ordinary Hamiltonian clock time evolution does not make sense except as idealization. Is Δt constant or is it determined by the reduction statistically? The most general and the only non adhoc assumption is that a superposition of CDs with different values of $\Delta t > 0$ is formed and that each repeated state function reductions perform a position measurement - that is localization of the active boundary of CD - so that one Δt is selected and Δt is thus varying. One can speak about average Δ as a kind of chronon of clock-time.
4. Suppose that self dies and thus re-incarnates as time reversed self S_1 , and S_1 in turn dies and reincarnates as S_2 having the same arrow of time as S . Does S_2 re-incarnate at the time when S died? This does not make sense. Also the first reduction to opposite boundary of CD must involve non-vanishing Δt . This conforms with what is known about claimed re-incarnations and might allow to test re-incarnation hypothesis.
5. The totally unexpected prediction is therefore that life is not just a brief spark in cosmic darkness. This particular life is only one in a sequence of lives: the next life will be lived at the opposite boundary of personal CD to opposite direction of geometric time. The negentropy gained during his life will be usable as possibly unconscious knowledge during the next life. What our next life will be depends how much we gather negentropic resources for the next life.
6. Self can also make moral choices since NMP in its weak form leaves us freedom to make also bad choices or especially negentropic choices (for details see [K12]). Possible are also choices, which do not yield optimal negentropy gain. By allowing sin NMP also makes possible really big negentropy gains: NMP would be like venture capitalist in this sense. In statistical sense there is however an evolution as increase of the negentropic sources of the Universe. Crime is part of being alive: living creatures are fighting desperately for NE and a clever but immoral manner to gain it is to eat other living beings.
7. One big news is that selves form a hierarchy (CDs within CDs) and sub-selves are identified as mental images. In TGD framework it is also possible for sub-selves of two unentangled selves to entangle negentropically. This corresponds to sharing of mental images and means that our conscious experience is not completely private. The pool of shared mental images might in fact make possible communication and social structures. Sharing of mental images is possible only in many-sheeted space-time forcing to generalize the standard view about subsystem.

4 Some applications

The ontology behind the applications involves the notion of many-sheeted space-time, ZEO, hierarchy of Planck constants identified in terms of dark matter, and p-adic physics as physics of cognition. Also magnetic body (MB) carrying dark matter and energy having non-standard value of Planck constant $h_{eff} = n \times h$ identified as intentional agent represents new ontology. The additional assumption $h_{eff} = h_{gr}$ identifying h_{eff} with gravitational Planck constant is rather powerful. Also p-adic length scale hypothesis is also central in applications.

4.1 The notion of magnetic body (MB)

MB is assumed to be carrier of dark matter.

1. The flux tubes of MB can suffer h_{eff} changing phase transitions inducing the change of the length of flux tube. This leads to a view about living matter as a network of bio-molecules connected by magnetic flux tubes. The ability of biomolecules to find each other in the dense molecular soup would rely on the reduction of h_{eff} bringing molecules near each other. The reconnections of flux tubes possible if the field strengths are same and therefore also cyclotron frequencies are identical are also expected to central element in bio-communications since they change the topology of the network and make possible analogs of relays.

The receptors to which information molecules attach could be seen as plugs to which magnetic flux tubes having information molecule at its end attach and give rise to a fusion of two flux tubes to a longer flux tube connection. For instance, nerve pulse transmission would be more like building quantum connections than communication.

2. Flux tubes with large h_{eff} make possible high T_c superconductivity [K16, K17]. Superconducting structures would be pairs of flux tubes carrying magnetic fluxes which have same or opposite directions. Cooper pairs would have members at separate flux tubes.

4.1.1 MB as intentional agent

Magnetic field associated with a given system decomposes to flux tubes and sheets to that system has MB (MB). The physics of MBs could be a new chapter in physics and MB could define the basic space-time correlate for non-locality.

1. Flux tubes of MB would serve as correlates for quantum entanglement, which in TGD framework can be negentropic and for this reason rather stable under state function reductions. In GRT context the idea about wormholes as correlates of entanglement between blackholes is highly analogous. The problem with wormholes is that they are highly unstable. Magnetic flux tubes carrying monopole flux are stable since flux conservation prevents their pinching. The pairs of flux tubes with opposite fluxes can however split to two U-shaped flux tubes by reconnection. It is important to notice that magnetic flux tubes are necessarily closed and can be regarded as flux running along different space-time sheets in opposite direction and from sheet to another through the wormhole contacts at ends.

One can of course ask whether the braiding of flux tubes could be the correlate for entanglement. To my opinion entanglement without braiding is possible.

2. MB and dark matter at it would serve as intentional agent in biological systems [K40]. The organism-environment duality would be replaced by the trinity MB-organism-environment. For instance, EEG and its strong correlation with brain state and consciousness could be understood in terms of communication of sensory data from cell membranes to MB and control and coordination signals from MB to biological body [K4]. Signals would consist of dark photons with energies $E = h_{eff}f = n \times hf$ in bio-photon energy range and thus above thermal energies. For instance, the recently observed synchrony between hemispheres in absence of corpus callosum [J6] could be understood in terms of MB serving as “boss”.
3. The formation of flux tube reconnections would serve as a correlate for directed attention - attention could be directed to objects of external world or to their representations in brain.

The reconnection would take place for U-shaped flux tubes serving as kind of magnetic tentacles and lead to a formation of pairs of flux tubes connecting the two systems. If flux tubes carry monopole flux as one has reasons to expect, the flux tubes would be actually closed two-sheeted structures (also elementary particles would be this kind of structures) and flux tube pair would be pair of these. The flux tubes of MBs would serve as analogs of wave guides along with precisely targeted communications of dark photon signals (“massless extremals” (MEs)) would be possible. Also supra currents would be possible and the TGD based model of high T_c superconductivity relies on the same mechanism [K16]. These communications would be essential in living matter.

4. The formation of reconnections and phases transitions $n \rightarrow m$ changing $h_{eff} = n \times h$ would be a basic mechanism behind biocochemistry. U-shaped flux tubes would act like tentacles emerging from the system and reconnection of the tentacles would build a connection between two systems. The reduction of Planck constant would shorten the connecting flux tubes and could force the systems in the vicinity of each other after which bio-catalysis could take place. Braiding and its 2-braid variant for string world sheets and partonic 2-surfaces in 4-D space-time instead of strings in 3-D space would make possible realization of quantum computer program like structures.

4.1.2 MB is 4-dimensional

MB as preferred extremal represents in terms of space-time topology and geometry 4-D self-organization patterns, behaviors, functions, and skills. What is new that self-organization occurs for 4-D patterns rather than 3-D ones. The entire process is replaced with a new one. Sequence of state function reductions leads from a 4-D self-organization pattern to an asymptotic 4-D self-organization pattern [K32].

Morphogenesis provides examples of this kind of phenomena [I7, I8, I15]. The first key idea is that DNA and cell replication is induced by the replication of MBs serving as information carriers (see <http://tinyurl.com/ydg6okkk>) [K32]. The second key idea is that in zero energy ontology (ZEO) MB is 4-dimensional and represents behavioral patterns rather than only 3-dimensional patterns.

According to Michael Levin, concerning morphogenesis and morphostasis the basic challenge is to understand how the shape of the organism is generated and how it is preserved. The standard local approach based on belief on genetic determinism does not allow one to answer these questions satisfactorily.

1. The first approach to this problem relies on a self-organization paradigm in which the local dynamics of cells leads to large scale structures as self-organization patterns. In TGD framework 3-D self-organization is replaced with 4-D self-organization (the failure of strict determinism of the classical dynamics is essential motivating zero energy ontology (ZEO)). One can speak about 4-D healing: expressing it in somewhat sloppy manner, the space-time surface serving as a classical correlate for the patient is as a whole replaced with the healed one: after the 4-D healing process the organism was never ill in geometrical sense! Note that in quantal formulation one must speak of quantum superposition of space-time surfaces.
2. Second approach could be seen as computational. The basic idea is that the process is guided by a template of the target state and morphogenesis and healing are computational processes. What Levin calls morphogenetic fields would define this template. It is known that organisms display a kind of coordinate grid providing positional information that allows cells to “decide” about the profile of genetic expression (for references see [I8]). In TGD framework MB forming coordinate grid formed from flux tubes is a natural candidate for this structure. They would also realize topological quantum computation (TQC) with basic computational operations realized at the nodes of flux tubes to which it is natural to associate some biological sub-structures.

The assumption about final goal defining a template can be argued to be too strong: much weaker principle defining a local direction of dynamics and leading automatically to the final state as something analogous to free energy minimum in thermodynamics might be enough. Unfortunately,

second law is the only principle that standard physics can offer. Negentropy Maximization Principle (NMP) provides the desired principle in TGD framework. Also the approach of WCW spinor field to the maximum of vacuum functional (or equivalently that of Kähler function) gives a goal for the dynamics after the perturbation of the organism causing "trauma". If Kähler function is classical space-time correlate for entanglement negentropy, these two views are equivalent.

TGD thus suggests an approach, which could be seen as a hybrid of approaches based on self-organization and computationalism. The MB becomes the key notion and codes also for learned behaviors as TQC programs coded by the braiding of flux tubes. The replication of the MB means also the replication of the programs behind behavioral patterns (often somewhat misleadingly regarded as synonymous with long term memories): both structure and function are replicated. This hypothesis survives the killer tests provided by the strange findings about planaria cut into two and developing new head or tail while retaining its learned behaviors: the findings indicate that behavioral programs are preserved although planaria develops a new brain.

4.1.3 $h_{gr} = h_{eff}$ hypothesis

Nottale [E1] introduced originally the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$, where M is large mass such as that of Earth or Sun and m the mass of quantum coherent object and v_0 is a parameter with dimensions of velocity [E1]. Nottale did not propose macroscopic quantum coherence in astrophysical scales but in TGD framework this is a natural option [K21, K15].

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = n \times h$ 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 a gigantic value. The hypothesis $h_{eff} = \hbar_{gr}$ leads to much stronger predictions [K41, K40] than either hypothesis alone. One can also introduce analogs of h_{gr} for other interactions: the idea is that when the coupling strength between two charges becomes so large that perturbation theory does not exist, a phase transition increasing the Planck constant happens and guarantees the convergence.

The essential point is that h_{eff} and h_{gr} would characterized body parts of MB: this allows to understand the dependent on masses of two particles. The flux tubes with a given value of h_{eff} would carry only particles of particular mass m so that the random soup of biomolecules would become a highly ordered structure analogous to library in which each book type is its own shelf. Furthermore, the cyclotron energies $E_c \propto h_{eff}/m$ would be same irrespective of particle mass m although cyclotron frequencies are different.

The proposed identification of the energy range of dark photon cyclotron energies in living matter is as visible and UV range assigned to bio-photons which would therefore result in the transformation of dark photons to ordinary photons. Further important point, is that the energy spectrum would be in the range of molecular excitation energies (visible and UV range) so that dark photons transformed to ordinary ones would allow MBs to control biochemistry.

By Equivalence Principle one can 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 [E2, E3] discussed in [K38] 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. 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 blob with volume of size scale of 10^{-4} m (big neuron) is the limit.

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.

4.2 MB and biology

MB could play a key role in biology as intentional agent using biological body as motor instrument. MB could even serve as a template for biomolecules and even that fundamental bio-chemical processes are induced by those for MB. Dark cyclotron photons transformed to ordinary photons would be the fundamental control tool of MB. Also reconnection of flux tubes, change of length of flux tubes induced by the change of the value of $h_{eff} = h_{gr}$, superconductivity associated with a pair of flux tubes could be fundamental control mechanisms.

4.2.1 MB, biophotons, and biochemistry

The model for quantum biology relying on the notions of MB and dark matter as hierarchy of phases with $h_{eff} = nh$, and biophotons [K36, K35] identified as decay products of dark photons. The assumption $h_{gr} \propto m$ becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

1. 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 [K4] 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.
2. 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 MB. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.
3. 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.

It must be made clear that TGD has had an interpretational problem related to the identification of biophotons as decay product of dark protons [K40, K41]. The resolution of this problem leads to conclusion that both Earth's and galactic MBs control living matter with EEG related by scaling. This would be rather dramatic realization of non-locality.

The problem is following. If one wants bio-photon spectrum to be in visible-UV range assuming that bio-photons correspond to cyclotron photons, one must reduce the value of $r = h_{gr} B_{end} / mv_0$ for Earth particle system by a factor of order $k = 2 \times 10^{-4}$. r does not depend on the mass of the charged particle. One can replace B_{end} with some other magnetic field having value which is considerably smaller. One can also increase the value of v_0 .

1. For h_{gr} determined by Earth's mass and $v_0 = v_{rot}$, where $v_{rot} \simeq 1.55 \times 10^{-6}c$ is the rotation velocity of Earth around its axis and for $B_{end} \rightarrow B_{gal} = 1$ nT, where B_{gal} is typical strength of galactic magnetic field, the energy of dark cyclotron energy is 45 eV (UV extends to 124 eV). This is roughly by a factor 50 higher than the lower bound for the range of bio-photon energies. One possibility is that B_{gal} defines the upper limit of the dark photon energies and has variation range of at least 7 octaves with lower limit roughly 1/50 nT.

One can also consider the possibility B_{gal} defines lower bound for the magnetic field strengths involved and one has $v_0 > v_{rot}$. For sun the rotation velocity at Equator is $v_{rot} = 2 \times 10^{-5}$ m/s and v_0 is $v_0 \simeq 5.8 \times 10^{-4}c$. One has $v_0/v_{rot} \simeq 29.0$. If same is true in case of Earth, the value of the energy comes down from 25 eV to 1.6 eV which corresponds to visible wave length.

The assignment of B_{gal} to gravitational flux tubes is very natural. Now however the frequencies of dark variants of bio-photons would not be in EEG range: 10 Hz frequency would correspond to 5×10^{-4} Hz with period of 42 min. The time scale of 42 min is however very natural concerning consciousness and could be involved with longer bio-rhythms. Scaled EEG spectrum with alpha band around 46 min naturally assignable to diurnal sub-rhythms could be a testable prediction. Natural time would be sidereal (galactic) time with slightly different length of day and this allows a clear test. Recall the mysterious looking finding of Spottiswoode that precognition seems to be enhanced at certain time of sidereal day [J7]. Cyclotron frequency 1 Hz would correspond to 7 hours. One can ask whether 12 hours (25) is the natural counterpart for the cyclotron frequency 1 Hz assignable to DNA. This would correspond to lower bound $B_{gal} \rightarrow 7B_{gal}/12 \simeq .58$ nT or to $v_0 \rightarrow 1.7v_0$.

2. The idea has been that it is dark EEG photons, which correspond to bio-photons. Could one assign bio-photons also to dark EEG so that magnetic fields of Earth and galaxy would correspond to two different control levels? If $B_{end} = .2$ Gauss is assumed to determine the scale of the magnetic field associated with the flux tubes carrying gravitational flux tubes, one must reduce h_{gr} . The reduction could be due to $M \rightarrow M_D = kM$ and due to the change of v_0 . k could characterize the dark matter portion of Earth but this assumption is not necessary.

This would require $k = M_{dark,E}/M_E \simeq 5 \times 10^{-5}$ if one does not change the value of v_0 . This value of k equals to the ratio of B_{gal}/B_{end} and would be 1/4:th of $k = 2 \times 10^{-4}$. One might argue that it is indeed dark matter to which the gravitational flux tubes with large value of Planck constant connect biomatter.

3. Suppose that one does not give up the idea that also Earth mass gives rise to h_{gr} and scaled analog of EEG. Then M_D must correspond to some mass distinguishable from and thus outside Earth. The simplest hypothesis is that a spherical layer around Earth is in question. TGD based model for spherical objects indeed predict layered structures [K27]. There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth equal to 60.3 Earth radii [K21]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

One can imagine that dark particles reside at the flux tubes connecting diametrically opposite points of the spherical layer. Particles would experience the sum of gravitational forces summing up to zero in the center of Earth. Although the layer would be almost invisible (or completely invisible by argument utilizing the analogy with conducting shell) gravitationally in its interior, $h_{gr} = M_D m / v_0$ would make itself visible in the dynamics of dark particles! This layer could represent magnetic Mother Gaia and EEG would take care of communications to this layer.

The rotation velocity $v_{rot,M} \simeq 2.1 \times v_{rot,E}$ of Moon around its axis is the first guess for the parameter v_0 identifiable perhaps as rotation velocity of the spherical layer. A better guess is that the ratio $r = v_0 / v_{rot,M}$ is the same as for Sun and as assumed above for Earth. This would give for the ratio of cyclotron frequency scales $r = (B_{end} / B_{gal}) \times 2.1$. 66.7 min, which corresponds to $B_{gal} = .63$ nT, would correspond to .1 s. For this choice 1 Hz DNA cyclotron frequency would correspond 11.7 h rather near to 12 h. This encourages the hypothesis that 72 min is the counterpart of .1 s cyclotron time. The cyclotron time of DNA (very weakly dependent on the length of DNA double strand) in B_{gal} (or its minimum value) would be 12 h.

Magnetic body of Earth controlling bio-dynamics would be a dramatic manifestation of non-locality to say nothing about the control performed by galactic magnetic body. M_D would be associated with the magnetic Mother Gaia making life possible at Earth together with magnetic Mother Galactica. Both MBs would be in continual contact with biomolecules like ATP and the molecules for which ATP attaches or provides the phosphate. Metabolic energy would be used to this process. These MBs would be Goddesses directing its attention to tiny bio-molecules. If this picture is correct, the ideas about consciousness independent on material substrate and assignable to a running computer program can be safely forgotten.

4.2.2 Model for the flux tube connections between biomolecules

A more concrete TGD based model for the flux tubes connections between molecules relies on the general ideas of TGD inspired quantum biology [K45].

1. Biomolecules containing aromatic rings are known to play a fundamental role. For instance, most neurotransmitters and psychoactive drugs involve aromatic rings). 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 [K45] 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 yet be the signals. This distinguishes TGD view from standard neuroscience.

3. All quantum critical phenomena involve generation of large h_{eff} phases and changes of h_{eff} in the sense that their values are different at different ends of space-time surface at boundaries of CD. Folding emerges or disappears at 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 $h \rightarrow h_{eff}$ 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 would be structurally identical with the hydrogen bonding between members of DNA base pairs and they would fix the final folding pattern to high degree.

4.2.3 Pollack's mechanism

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water [L4, I16, I11] (see <http://tinyurl.com/oyhstc2>). The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the MB assignable to the exclusion zone and outside it [L4] [K45].

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclear strings whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner [K13, K7]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs.

Pollack's exclusion zones (EZs) might for instance explain why DNA is negatively charged. EZs or their generalization could play fundamental role in metabolism with protons running through mitochondrial membrane being dark as also other biologically important ions involved. EZs could be important even in electrolysis and allow to explain what happens in cold fusion. These hypothesis could be tested.

4.2.4 Remote DNA replication

The works of Luc Montagnier [I5] and Peter Gariaev [I9] suggests that remote replication of DNA is possible. The developments in the model of dark DNA allow to imagine a detailed mechanism for how water can represent DNA and how DNA could be transcribed to dark DNA - essentially the analog of DNA-RNA transcription would be in question. The transcription/association represents a rule and rules are represented in terms of negentropic entanglement (NE) in TGD framework with pairs of states in superposition representing the instances of the rule. Transition energy serves as a characterizer of a molecule - say DNA codon - and the entangled state is a superposition of pairs in which either molecule is excited or dark DNA codon is excited to higher cyclotron state with same energy: this requires tuning of the magnetic field and sufficiently large value of h_{eff} at the flux tube. NE would due to the exchange of dark photons: this corresponds to wave DNA aspect. Dark cyclotron photons also generate negatively charged exclusion zones (EZs) discovered by Pollack and in this process transform part of protons to dark ones residing at the magnetic flux tubes associated with EZs and forming dark proton sequences. This allows to identify a mechanism of remote replication.

The results of Montagnier and Gariaev strongly suggest that genetic code is representation by dark photons, presumably by frequencies. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L3] [K18] (see <http://tinyurl.com/zg3aaaj7>) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given

Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

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

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

4.3 Metabolism

The TGD inspired view about metabolism is as a mechanism making possible transfer of NE from phosphates to ATP and further to receiver molecules. TGD leads to new ideas about photosynthesis and suggests that also animal cells can perform process analogous to photosynthesis. Also remote metabolism is possible and there is evidence that it indeed occurs.

4.3.1 Metabolic energy is needed to transfer NE

At deep level metabolic energy might correspond to NE and thus information. Conscious information would be thus the basic currency and the transfer of metabolic energy and metabolites would make possible transfer of NE. It could be transfer of systems consisting of negentropically entangled parts or it could be transfer of NE with larger system, even Earth. NMP would force the systems to fight for NE and this would lead to the fight for metabolic resources. The transfer of entanglement (NE) is basic mechanism in quantum computation and would mean in biology stealing of NE, the fundamental crime! Metabolism in TGD framework is discussed in detail in [K9].

I have considered three possible three possible identifications of NE.

1. NE could be small scale entanglement - say between parts of molecules. This option is not favored by the needed large values of h_{gr} and thus of mass M .
2. NE could be between nutrient and larger structure - say Earth, Sun, or some other large enough structure to give a value of $\hbar_{gr} = GMm/v_0$ guaranteeing that dark cyclotron energies (no dependence on mass m) in the range of bio-photon energies (visible and UV) and guarantee that EEG frequencies correspond to these energies. This option discussed in [K41]. Nutrients would be carriers of both metabolic energy and NE. This option does not conform with the fact that even electrons can provide metabolic energy and in TGD framework therefore also NE for some bacteria (see <http://tinyurl.com/o8xqh6g>). This suggests that nutrients carry only the energy needed to transfer NE.
3. NE could be also between a larger structure and phosphate molecule added to ADP using metabolic energy. This option is the simplest one and would predict that phosphates are in unique role as standard entanglers to mass M . Any source of metabolic energy is in principle possible since metabolic energy is only needed to transfer the flux tube connecting phosphate to mass M to ADP so that ATP is obtained. The flux tube would represent the "high energy phosphate bond". ATP in turn attaches the flux tube to biomolecule, which becomes negentropically entangled. Metabolism would be make the transfer of NE possible. Metabolites would not contain information but it would be assignable to the flux tube between phosphate and mass M . Magnetic Mother Gaia would have very concrete meaning.

A good candidate for the larger structure could be a spherical layer at the distance of Moon from Earth would give correct value for $h_{eff} = h_{gr}$ [K41].

4.3.2 Pollack's mechanism and photosynthesis

An obvious idea is that Pollack's mechanism or its generalization is the predecessor of photosynthesis. The question is therefore whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of Pollack's mechanism [L4, I16, I11] (see <http://tinyurl.com/oyhstc2> leading to charge separation taking place also in photosynthesis. Pollack's mechanism creates in presence of radiation and water bounded by a gel at the boundary of water and gel an EZ, which is a layer negatively charged water with effective stoichiometry $H_{1.5}O$ consisting of layers with hexagonal structure. The TGD inspired proposal is that hydrogen bonded pairs of H_2O molecules are formed and that each of them loses one proton as dark proton at magnetic flux tubes outside EZ. The notion of many-sheeted space-time and topological field quantization are essential elements of the proposal. Same phenomenon could be caused also by irradiation by sun light.

The light dependent step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ of photosynthesis pumps protons through thylakoid membranes (for an illustration see <http://tinyurl.com/ycecu6uf>). The electrons excited by photons of sunlight are transferred along electron transport chain and lose energy used to pump protons through the thylakoid membrane and being thus transferred from stroma to grana against electric gradient. ADP transforms to ATP as these protons return to back through ATP synthase. This step is repeated again and again.

Could dark protons created by the analog of Pollack's mechanism be involved with photosynthesis? In what step the protons are transformed to dark protons by this mechanism?

1. The model of cell membrane leads to a proposal that pumps and channels quite generally are dark magnetic flux tubes and protons (and also other ions) are transferred through them as dark protons (dark ions). This would imply almost dissipation-free transfer.
2. The protons are pumped as dark protons through the thylakoid membrane along dark magnetic flux tubes serving as pumps using the energy provided by electrons flowing down in the electron chain. The dark protons return from grana through ATP synthase as dark protons as ATP is generated and transform with some rate back to ordinary protons in stroma. Otherwise the fraction of dark protons would steadily increase.
3. This leaves two options under consideration. Already the step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ creates dark protons by a generalization of Pollack's mechanism or this step creates ordinary protons transformed by Pollack's mechanism to dark protons as they are transferred to dark magnetic flux tubes serving as pumps. The first option looks more plausible.

4.3.3 The analog of photosynthesis in animal cells

Visible and UV light can provide metabolic energy for animal cells. There are various light therapies (see <http://tinyurl.com/hescd3x>) using red or IR light, and they could basically provide metabolic energy. In [I6] (see <http://tinyurl.com/hgtaqr6>) it is reported that IR laser light depolarizes cell membranes implying stimulation. This could be understood if IR light corresponds to a Josephson frequency eV/m_e assignable to the cell membrane. Also visible light has similar effects and one can ask whether animal cells could perform the analog of photosynthesis using essentially same basic mechanism as used by plant cells.

What is interesting is the electron transport chain is involved also with the cellular respiration. Cells would act like plant cells and the analog of photosynthesis could be in question. This would explain the claims that the members of some religious cults can practically live utilizing only sunlight. I have actually proposed that analog of photosynthesis storing the energy by $ADP + P_i \rightarrow ATP$ type process using standard machinery could be actually involved and transfer the energy of IR light to metabolic energy further distributed by ATP.

The metabolic machinery for cellular respiration contains so called oxidative phosphorylation (OP) as a basic step: OP adds to ADP a phosphate giving metabolic currency ATP. ATP in turn distributes the metabolic energy further. OP uses electron transport chain to transfer metabolic energy from NADH by $NADH \rightarrow NAD^+ + H^+ + 2e^-$. The electrons go through the electron transport chain as in photosynthesis and transfer protons outside the mitochondrial membrane

very much like through thylakoid membrane in photosynthesis. The protons return through ATP-synthase and induce $ADP + P_i \rightarrow ATP$.

The metabolic energy must come from somewhere and OP indeed follows Krebs cycle (see <http://tinyurl.com/p6599hq>) in which the energy is extracted from nutrients and given to the NADP molecule. The photon energy could be fed directly to OP electron transport chain just as photon energy is transferred to this chain in photosynthesis. The presence of electron transport chain is necessary and one must feed the electrons and protons to this chain somehow.

1. Could the analog of photosynthetic reaction $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ with visible photons replaced with IR photons produce dark protons? Whether this is energetically possible and whether the electrons have high enough energies to drive the dark protons through the membrane is far from clear. One can of course imagine, that the number of pumped protons per electron is lower than usually.
2. A mechanism that I have called quantum credit card or remote metabolism [K9] looks more plausible. The splitting $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ could occur - not by absorption of positive energy photon but by emission of negative dark IR photon with the energy of visible photon. Cell would actively suck metabolic energy from IR light source. The emitted dark negative energy IR photon would decay to ordinary IR photons in reverse time direction, which would look like fusion in standard time direction and is thermodynamically non-favoured. ZEO predicting kind of syntropic processes to occur in living matter would be an essential prerequisite.

4.3.4 Remote metabolism

ZEO makes possible both arrows of geometric time in living matter so that negative energy signals in reversed time direction become possible and one must generalized thermodynamics by introducing the notion of syntropy introduced already by Fantappie [J8]. Active metabolism that I have referred to as quantum credit card mechanism or a remote metabolism [K9, K10] becomes possible: system gets positive energy as a recoil effect by sending negative energy dark photons to a source able to receive them. In ZEO based formulation of quantum measurement theory the generation of negative energy photons corresponds to a state function reduction creating self with reversed arrow of geometric time.

There are several examples where remote metabolism might be involved.

1. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy.
2. Sled dogs [I4] (see <http://tinyurl.com/zg9j3p9>) can run for several days without eating and no signatures of ordinary metabolism have been found. This phenomenon cannot of course be specific to sleigh dogs. Remote metabolism could explain the phenomenon as an extraction of metabolic energy from non-standard sources in absence of standard sources - say from the magnetic body associated with the collective formed by the dogs.
3. Yan Xin Qigong practitioners report that in so called Bigu state there is no need to eat solid food at all for days, weeks, months or even years. Western science is beginning to take Bigu state (<http://tinyurl.com/y7unnww4>) seriously [I1] and the first national conference on Bigu state was held at the Pennsylvania State University in 2000, with presenters such as as Rustum Roy, founding director of Penn State's Materials Research Laboratory and Hans Peter Duerr, former director of the Max Planck Institute.
4. Callahan [I2] has reported that plants suffering under-nutrition can attract insects responsible for their pollination. Callahan has also reported that plants and insects communicate using infrared light which according to his findings serves as a sensor input in insect olfaction: also in this case quantum credit card mechanism building magnetic flux tube bridges guiding the insects to the plant might be at work. In the case of IR metabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism.

5. Gut cells without mitochondria can survive (see <http://tinyurl.com/hqq79th>)! $ADP \rightarrow ATP$ transformation should occur since ATP is the universal energy currency. Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle (see <http://tinyurl.com/p6599hq>) extracting the energy from nutrients: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. This is again one quantum objection against vulgar darwinism.

4.3.5 Homeopathy, water memory, and immune systems

In [K7] a TGD based model of water memory and homeopathy is discussed. An important step in progress was due to Pollack's findings about exclusion zones of water explained in terms of fourth phase of water [L4]. Second step or progress was inspired by an anomaly claimed by Tajmar et al [E3, E2] and known as strong gravimagnetism. The attempt to understand the claim led to $h_{eff} = h_{gr} = h_{em}$ hypothesis unifying two TGD views about the notion of hierarchy of Planck constants proposed to characterize the phases of dark matter.

If dark proton (nucleon) sequences realized genetic code [L9] (see <http://tinyurl.com/jgflbe>), water would already realize genetic code at the level of dark matter and chemical realization would have evolved from this more fundamental realization.

In this framework [K7] the attempt to understand homeopathy leads to additional insights about about water as living system and about prebiotic life as being based on the dark realization of genetic code realized in terms of dark proton strings which are nothing than dark variants of nuclei. Formation of exclusion zones would be formation of primitive lifeforms and primitive form of metabolism. Homeopathy could be seen as a manifestation of a fundamental form of immune system based on the recognition of invader molecules using reconnection mechanism for magnetic flux tubes and on mimicking the braiding of the MBs of invader molecules using dark variants of proteins (later proteins) and eventually representing them symbolically in terms of dark DNA (later ordinary DNA) coding for the dark proteins. Genetic code might have geometric interpretation as coding for the 2-braiding of 3-D coordinate grids represented by magnetic flux tubes serving as the 4-D template coding not only for the structure of the organism but also its functions as spatio-temporal patterns. Protein folding would represent a behavior of protein and DNA would code also for it.

4.4 Proposals for the Physical Realizations of Genetic Code

The view about evolution as a random process suggests that genetic code is pure accident. My own view is that something so fundamental as life cannot be based on pure randomness. TGD has led to several proposals for genetic code, its emergence, and various realizations based on purely mathematical considerations or inspired by physical ideas [K28]. One can argue that genetic code is realized in several manners just like bits can be represented in very many manners. Two especially interesting proposals have emerged. The first one is based on geometric model of music harmony involving icosahedral and tetrahedral geometries. Second model having two variants is based on dark nuclear strings. Both models predict correctly the numbers of DNA codons coding for a given amino-acid.

For the successful options entire codons rather than letters are represented. The difference between letter-wise representation and codon-wise representations is analogous to that between spoken and written languages. In spoken languages words are not analyzed further to letters.

1. The geometric theory of harmony [L3] represents codons as 3-chords without assigning fixed notes to A,T,C,G and explains also DNA-amino-acid correspondence.
2. For the first variant of dark nuclear string serves as analog of DNA strand. The map of codons to the dark nucleon states of dark nucleon consisting of dark u and d type quarks does the same and also predicts the degeneracies successfully.

This model can be modified by replacing u and d by dark nucleon states p and n without any change in predictions related to genetic code. The evidence that DNA codons indeed couple to dark nucleon states [L13] supports this option.

4.4.1 Geometric Theory of Harmony and Genetic Code

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

In the article [L5] I introduced the notion of Hamiltonian cycle as a mathematical model for musical harmony and also proposed a connection with biology: motivations came from two observations. The number of icosahedral vertices is 12 and corresponds to the number of notes in 12-note system and the number of triangular faces of icosahedron is 20, the number of amino-acids. This led to a group theoretical model of genetic code and replacement of icosahedron with tetra-icosahedron to explain also the 21st and 22nd amino-acid and solve the problem of simplest model due to the fact that the required Hamilton's cycle does not exist. The outcome was the notion of bioharmony.

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

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

4.4.2 Mapping DNA and Amino-Acids to Dark Nucleon States

Could dark nuclear strings provide a representation of the genetic code. The answer was totally unexpected: the states of dark nucleons formed from three quarks can be grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, and 20 amino-acids and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

The dark model emerged from the attempts to understand water memory [K7]. The outcome was a totally unexpected finding [K13, K7]: the states of dark nucleons formed from three quarks connected by color bonds can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, 20 amino-acids, and tRNA and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

The basic idea is simple. The basic difference from the model of free nucleon is that the nucleons in question - maybe also nuclear nucleons - consist of 3 linearly ordered quarks - just as DNA codons consist of three nucleotides. One might therefore ask whether codons could correspond to dark nucleons obtained as open strings with 3 quarks connected by two color flux tubes or as closed triangles connected by 3 color flux tubes. Only the first option works without additional

assumptions. The codons in turn would be connected by color flux tubes having quantum numbers of pion or η .

This representation of the genetic would be based on entanglement rather than letter sequences. Could dark nucleons constructed as string of 3 quarks using color flux tubes realize 64 DNA codons? Could 20 amino-acids be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner? The codons would be not be anymore separable to letters but entangled states of 3 quarks.

If this picture is correct, genetic code would be realized already at the level of dark nuclear physics and maybe even in ordinary nuclear physics if the nucleons of ordinary nuclear physics are linear nucleons. Chemical realization of genetic code would be induced from the fundamental realization in terms of dark nucleon sequences and vertebrate code would be the most perfect one. Chemistry would be kind of shadow of the dynamics of positively charged dark nucleon strings accompanying the DNA strands and this could explain the stability of DNA strand having 2 units of negative charge per nucleotide. Biochemistry might be controlled by the dark matter at flux tubes.

The ability of the model to explain genetic code in terms of spin pairing is an impressive achievement, which I still find difficult to take seriously.

1. The original model mapping codons to dark nucleon states assumed the overall charge neutrality of the dark proton strings: the idea was that the charges of color bonds cancel the total charge of dark nucleon so that all states uuu, uud, udd, ddd can be considered. The charge itself would not affect the representation of codons. Neutrality assumption is however not necessary. The interpretation as dark nucleus resulting from dark proton string could quite well lead to the formation the analog of ordinary nucleus via dark beta decays [L16] so that the dark nucleus could have charge. Isospin symmetry breaking is assumed so that neither quarks nor flux tubes are assigned to representations of strong $SU(2)$.

There is a possible objection. For ordinary baryon the mass of Δ is much larger than that of proton. The mass splitting could be however much smaller for linear baryons if the mass scale of excitations scales as $1/h_{eff}$ as indeed assumed in the model of dark nuclear strings [L7, L16].

2. The model assumes that the states of DNA can be described as tensor products of the four 3-quark states with spin content $2 \otimes 2 \otimes 2 = 4 \oplus 2_1 \oplus 2_2$ with the states formed with the 3 spin triplet states $3 \otimes 3 = 5 \oplus 3 \oplus 1$ with *singlet state dropped*. The means that flux tubes are spin 1 objects and only spin 2 and spin 1 objects are accepted in the tensor product. One could consider interpretation in terms of ρ meson type bonding or gluon type bonding. With these assumptions the tensor product $(2 \otimes 2 \otimes 2) \otimes (5 \oplus 3)$ contains $8 \times 8 = 64$ states identified as analogs of DNA codons.

The rejection of spin 0 pionic bonds looks strange. These would however occur as bonds connecting dark codons and could correspond to different p-adic length scale as suggested by the successful model of X boson [L19].

One can also ask why not identify dark nucleon as as closed triangle so that there would be 3 color bonds. In this case $3 \otimes 3 \otimes 3$ would give 27 states instead of 8 ($\oplus 1$). This option does not look promising.

3. The model assumes that amino-acids correspond to the states 4×5 with $4 \in \{4 \oplus 2 \oplus 2\}$ and $5 \in \{5 \oplus 3\}$. One could tensor product of spin 3/2 quark states and spin 2 flux tube states giving 20 states, the number of amino-acids!
4. Genetic code would be defined by projecting DNA codons with the same total quark and color bond spin projections to the amino-acid with the same (or opposite) spin projections. The attractive force between parallel vortices rotating in opposite directions serves as a metaphor for the idea. This hypothesis allow immediately the calculation of the degeneracies of various spin states. The code projects the states in $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$ to the states of 4×5 with same or opposite spin projection. This would give the degeneracies $D(k)$ as products of numbers $D_B \in \{1, 2, 3, 2\}$ and $D_b \in \{1, 2, 2, 2, 1\}$: $D = D_B \times D_b$. Only the observed degeneracies

$D = 1, 2, 3, 4, 6$ are predicted. The numbers $N(k)$ of amino-acids coded by D codons would be

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] .$$

The correct numbers for vertebrate nuclear code are $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$. Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result $(2, 9, 1, 5, 3)!$

It is difficult to exaggerate the importance of this simple observation suggesting that genetic code is realized already at the level of dark or even ordinary nuclear physics and bio-chemistry is only a kind of shadow of dark matter physics.

4.4.3 Mapping DNA and Amino-Acids to Dark 3-Nucleon States

The assumption that entire codon rather than letter corresponds to a state of dark proton does not conform with the model for the origin of purines as DNA nucleotides [L13] assuming that purines and in fact all nucleotides are combined with dark proton unless one assumes that 3 nucleotides combine with the same dark proton. This looks somewhat artificial but cannot be excluded.

Amazingly, the arguments of the model involve only the representations of rotation group and since p and n have same spin as u and d , the arguments generalize to 3- nucleon states (ppp, ppn, pnn, nnn) connected by two color bonds and organized to linear structures. Concerning genetic code, exactly the same predictions follow in the recent formulation of the model. In this case quark color is not present. One could however use the 1-dimensionality and the ordering of dark nucleons as already described.

This variant has several nice features. The model is consistent with the model for dark nucleon strings consisting of nucleons and color bonds between them. There is no need to introduce Δ type nucleon states and colored states are not needed in fermionic sector. Color bonds must be colored if one wants ordinary bosonic statistics for flux tubes but here braid statistics might help. Colored bonds could of course have some important function.

4.5 Applications to neuroscience

Models of EEG and nerve pulse are basic applications of the notion of MB in neuroscience. The basis idea is that EEG and its fractal counterparts are communications to the various layers of MB having onion-like structure with cyclotron frequency correlating with the size of the layer. Josephson junctions about which basic example is cell membrane would communicate sensory information to MB as dark photons.

4.5.1 Experimental evidence for MB

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum [J6] (see <http://tinyurl.com/3gjhtgb>)! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres [K31]. This would be like forcing soldiers to march in the same pace and brain hemispheres could cooperate without any neural communication between hemispheres. The communication between hemispheres would be needed for more refined collaboration involving “discussion” between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

4.5.2 EEG as communications between MB and BB

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity [K16, K17]. A fractal hierarchy of EEGs and its generalizations identified in terms of generalized Josephson radiation is predicted with levels labeled by p-adic length scales and the value of \hbar at various levels of dark matter hierarchy [K4]. At macrolevel one can approximate neuronal and axonal (and also cell-) membrane as Josephson junction formed by the two lipid layers of the membrane. At microscopic level ionic pumps and channels defined by Josephson junctions involving magnetic flux tubes connecting interior and exterior of the cell.

“Generalized” means that Josephson frequency as energy difference $E = ZeV/h_{eff}$ of Cooper pair for membrane potential is replaced with the sum of difference of cyclotron energies and E . This implies that the variations of membrane potential by oscillations and nerve pulses induced frequency modulation of the frequency of dark photons sent to the MB. This defines a coding of the information carried by nerve pulses do dark photons. Whale’s song represents a good analogy for the coding. Besides EEG one would have its counterparts for various organs, organelles and even cell.

4.5.3 Nerve pulse

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse [K19]. One can imagine several manners for how this could happen. Some years ago I learned that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large \hbar and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (TQC) leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors - microtubule space-time sheet and the space-time sheet in cell exterior - connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

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

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which \hbar should be correspondingly larger): synchrony is predicted also now.
3. Nerve pulse itself would correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the

membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

4. The view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as topological quantum computer (TQC) since also microtubule-cell membrane systems are good candidates for performers of TQC. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.
5. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The assumption of only bosonic ions leads to a highly predictive model. The new nuclear physics predicted by TGD predicts that ordinary fermionic ions (such as K^+ , Na^+ , Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary W^\pm bosons is a possible manner to achieve this if new nuclear physics is indeed present.

4.6 Remote mental interactions

MB would be central for understanding of remote mental interactions as special case of those occurring between MB and biological body. Now the biological body would not be own biological body and could be even non-living system containing quantum critical parts. Remote mental interactions would not be anything exotic or special. In this framework [K33, K34] also hypnosis [L2] and psychedelic experiences [K25] might be seen as remote mental interactions.

4.6.1 Precognition, psychokinesis, telepathy

I have considered various remote mental interactions in the book [K33]. Much of the material has evolved via the panel discussions associated with Journal of Non-locality and I am grateful for Lian Sidorov and people working in her group for a fruitful collaboration during these years.

1. Magnetic flux tube pairs involving also MEs (“massless extremals” [K44, K14] as analogs of laser beams) connecting the sender and receiver make possible a universal mechanism for the transfer of intent and action. The pair of flux tubes forms a kind of sensory-motor loop. In biology the fundamental realization could be by a pair of flux sheets going through the strands of DNA with passive strand sending sensory data to the MB and active strand receiving control commands leading to various forms of gene expression. MEs are ideal for the transfer of both classical information and momentum.

This is not the only possible realization. For instance, one could think that the passive strands of DNA send sensory data to the MB of DNA and active strands of DNA receive control commands: time scale would be rather slow. Also the lipid layers of cell membrane could have similar division of labor and now the time scale could be that for nerve pulse.

2. The transfer of intent gives rise to mechanism of remote interaction which can act both endo- and exogenously. Magnetic flux tubes characterized by their fundamental frequencies make possible bridges between sender and receiver (say healer and healee) and allow a resonant interaction in which healer can initiate various control commands acting as 4-dimensional templates represented as holograms. Also smaller MEs can be sent along the MEs serving as bridges (this is like throwing balls with light velocity!).

3. The MEs and magnetic flux tube pairs connecting sender and receiver can act as a reference wave which can initiate an arbitrarily complex hologram representing biological program. Sender has the ability to generate and amplify the frequencies which induce holograms representing the control commands. In particular, in living matter sender can initiate complex biological programs without knowing anything about their functioning.

One can distinguish between psychokinesis applied to living matter and inanimate matter.

1. When the target consists of living matter, the mechanisms would be same as in communications between magnetic and biological bodies making possible bio-control of biological body by MB and the receipt of sensory input from biological body by MB. Hypnosis would be one example of this kind of interaction.
2. Remote mental interactions in the case inanimate matter could use simpler variants of the fundamental mechanisms utilized in living matter. For instance, zero energy ontology assigns with the CD of electron and quarks time scales .1 s and 1 ms defining fundamental biorhythms. The CD assignable to elementary particles could be involved also with psychokinesis. NE could be essential for the transfer of metabolic energy (say in simple psychokinesis moving an object) and for control actions -say in intentional change of sequences of binary digits produced by random number generator. Target system would not be completely inanimate. Thermodynamical restrictions favor large values of Planck constant.

The basic problem in many remote mental interactions such as the intentional effect on random number generator is “Who knows how?”. How the mere intent can be transformed to action without any knowledge about the details of the action? The attempt to understand how neuro-feedback affect the behavior of single neuron leads to the same question.

1. Magnetic mirrors make possible also feedback and this feedback could make possible learning. For instance, in psychokinesis (especially so in micro PK), this learning would be crucial and analogous to that what occurs when we learn to drive a car. In healing this kind of feedback might help to find the healing frequency by trial and error.
2. It is quite possible that also multibrained and -bodied higher level collective selves actively participate in the process as a third party such that the remote mental interactions would act as a relay states. I have suggested similar explanation for Sheldrake’s findings about learning at the level of species and Tiller’s findings about the “transfer of intent”. This could make possible coherent amplification effects (TEM, prayer groups) and could make available information resources of all brains involved with the group. This could for instance explain the ability of a remote viewer to see an object on basis of data which need not have any meaning for her.
3. A fast amplitude modulation of alpha waves introducing higher harmonics to the carrier wave is a good candidate for mediating communication between brains and higher level multibrained selves. Mesoscopic “features” in brain involve precisely this kind of amplitude modulation and might represent just this kind of messages. Interestingly, also speech is produced by a fast amplitude modulation of 10 Hz basic vibration frequency of speech organs (assignable to electron CD as a fundamental frequency) and kHz (quarks) frequency is a special frequency from the point of view of hearing.

The article of J. Spottiswoode [J7] discusses two strange findings about remote mental interactions.

1. There is a statistical tendency of the anomalous cognition (AC) performance to concentrate in a 2 hour period around 13.30 of the local sidereal time (ST), which is the time measured using as a reference distant stars and thus running at a slightly different rate than the solar time: the lag is $\Delta T = 24/365$ hours ~ 3.7 minutes during 24 hours.
2. The anticorrelation between the level of geomagnetic fluctuations and AC performance has also a maximum during 2-hour period around ~ 13.30 ST.

The fact that AC performance is associated with the same sidereal hour suggests the identification of the galactic magnetosphere as a conscious involved with remote cognition. For interstellar and galactic magnetic fields cyclotron time scales correspond to the time scales of human consciousness so that also these magnetic flux quanta could receive sensory input from biosphere and control it.

4.6.2 Hypnosis as remote mental interaction

In TGD framework one can argue that hypnosis represents an example about the fact that brain is not “private property”: hypnotist uses the biological body and brain of the subject as instrument [L2]. Therefore remote mental interaction would be in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species, - a higher level self and MB carrying dark matter, and these MBs can use lower level MBs as their instruments to realize their intentions. Biological bodies would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.

This view challenges the prevailing views about brain as a sole seat of consciousness and the assumption that conscious entities assigned with brains are completely isolated. Given MB can use several biological bodies although one can assign to it the one providing the sensory input - at least during wake-up state. Note however that it is easy to produce illusion that some foreign object is part of biological body.

For more than decade ago I proposed a model for so called bicamerality based on the notion of semitrance [K20]. In semitrance the brain of subject becomes partially entangled with a higher level self - in this case the self of family or more general social group uses the biological body of member for its purposes. Higher level self gives its commands and advice interpreted by the bicameral as “God’s voice”. The consciousness of schizophrenic might be basically bicameral. Also hypnotic state and dream consciousness are candidates for bicameral consciousness.

In [L2] I develop essentially this idea but using as input the recent understanding of about TGD inspired theory of consciousness and quantum biology and end up with a proposal for a detailed mechanism for how the MB hijacks some parts of the brain of the subject: prefrontal cortex and anterior cingulate cortex are argued to be the most plausible targets of hijacking. Also a mechanism explaining how the sensory hallucinations and motor actions are induced by hypnotist by inhibiting a halting mechanism preventing imagined motor actions to become real and sensory imagination to become “qualiafied”.

4.6.3 Psychedelic experiences and time non-locality

There is a book about psychedelic induced experiences titled as “Inner paths to outer space” (<http://tinyurl.com/gnb4bp9>) written by Rick Strassman, Slawek Wojtowicz, Luis Eduardo Luna and Ede Frecska [J5]. The TGD inspired hypothesis [K34] goes as follows.

1. Psychedelics bind to the same receptors as the neurotransmitters with similar aromatic rings (weaker assumption is that neurotransmitters in question possess aromatic rings). This is presumably consistent with the standard explanation of the effect of classical psychedelics as a modification of serotonin uptake. This binding replaces the flux tube connection via neurotransmitter to some part of the personal MB with a connection via psychedelic to some other system, which might be even in outer space. A communication line is created making among other things possible remote sensory experiences.

Magnetic fields extending to arbitrary large distances in Maxwell’s theory are replaced with flux tubes in TGD framework. The MBs of psychedelics would carry very weak magnetic fields and would have very large h_{eff} - maybe serving as a kind of intelligence quotient.

2. This would be like replacing the connection to the nearby computer server with a connection to a server at the other side of the globe. This would affect the usual function of transmitter and possibly induce negative side effects. Clearly, TGD inspired hypothesis gives for the psychedelics much more active role than standard hypothesis.

3. Psychedelics can be classified into two groups depending on whether they contain derivative of amino-acid trp with two aromatic rings or phe with one aromatic ring. Also DNA nucleotide resp. its conjugate have 2 resp. 1 similar aromatic rings. This suggests that the coupling between information molecule and receptor is universal and same as the coupling between the two bases in DNA double strand and consists of hydrogen bonds. This hypothesis is testable since it requires that the trp:s/phe:s of the information molecule can be brought to same positions as phe:s/trp:s in the receptor. If also protein folding relies on this coupling, one might be able to predict the folding to a high degree.
4. A highly suggestive idea is that molecules with aromatic rings are fundamental conscious entities at the level of molecular biology, and that more complex conscious entities are created from them by reconnection of flux tubes. DNA/RNA sequences and microtubules would be basic examples about this architecture of consciousness. If so, protein folding would be dictated by the formation trp-phe contacts giving rise to larger conscious entities.

This model meets of course strong objection: finite light velocity does not allow communications with outer space in standard physics framework. In TGD framework ZEO changes the situation. Second objection is that the communications require huge amount of energy unless they are precisely targeted. The third objection is that quantum coherence in very long, even astrophysical scales is required. In TGD framework these objections do not apply.

5 Morphogenesis in TGD Universe

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake [L1, I13] is one of those who have taken it seriously and has been labelled as a crackpot by mainstreamers (I have discussed Sheldrake's views from TGD point of view in [L1, L10]). One just assumes that the structures are there and performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

In standard physics the description of spatial structures would be in terms of enhanced densities of biomolecules or of their gradients in some space-time region. This is the only possibility because the space-time of standard physics is topologically and geometrically utterly trivial. Empty Minkowski space is an excellent approximation for it.

What philosopher has to say about this? If space-time topology were topologically non-trivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD (for which Wheeler suggested its name) all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. Again philosopher gets excited since this would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

5.1 The dynamics of space-time surfaces

This dynamics predicts two kinds of space-time regions [L8] (see <http://tinyurl.com/yboog5sr>).

1. The regions of first kind are locally minimal surfaces. These minimal surfaces are as 4-D analogs of geodesic lines analogs of asymptotic states of particle physics for which interactions are not on. They also satisfy non-linear geometrization of massless field equations so that both particle and wave aspects are present. What is especially important is that static minimal surfaces have vanishing mean curvature and look like saddles locally. They cannot be closed surface if stationary.
2. Second type of regions are not minimal surfaces: there is a non-trivial coupling of the minimal surface term to 4-force density analogous to the divergence of Maxwellian energy momentum

tensor. This is a generalization of the dynamics of a point-like charged particle in Maxwell field. These regions are identified as interaction regions: in particle physics these two regions correspond to external free particles and the interaction region. Magnetic flux tubes play fundamental role in TGD based quantum biology are deformations of string like objects, which represent simplest 4-D minimal surfaces.

Essential is the coupling between induced Kähler form (mathematically like Maxwell field) and the geometry of the surface: the divergence of energy momentum current assignable to the analog of cosmological term (4-volume) equals to the divergence of that assignable to Kähler action: this expresses local conservation of four-momentum. One could also speak about coupling between Kähler field and gravitational field: Penrose's intuition about the the role of gravitation in biology would be correct.

When the coupling is absent, minimal surface property implies the separate vanishing of both divergences and separate conservation of corresponding energy-momenta. All the known extremals of Kähler action are minimal surfaces: this is due to their very simple algebraic properties making easy to discover them. Physically this correspond to quantum criticality: dynamics is universal and does not depend on coupling parameters.

5.2 General view about morphogenesis

These observations lead to a rather general view about morphogenesis.

1. The presence of the Kähler field (em field is sum of Kähler field and second term) makes possible flow equilibria such as cell membrane, which are not minimal surfaces. These surfaces can be closed and stationary making possible isolation from environment crucial for living organisms.

Spherical soap bubble is a good analogy: it is not minimal surface as the soap films spanned by frames are. They look locally like saddle surfaces with opposite external curvatures in two orthogonal directions, this implies that they cannot be closed surfaces. Bubble is not possible without a pressure difference Δp between the interior and exterior of the bubble: the blowing of the soap bubble generates Δp , and means external energy feed analogous to metabolic energy feed.

Δp is analogous to a non-vanishing voltage V over cell membrane. The electric field of cell membrane and the energy feed providing the energy of electric field as metabolic energy are essential for the stability. More generally, V would generalize to non-vanishing of energy momentum tensor of Kähler field with non-vanishing divergence serving as a correlate for the energy transfer between Kähler and volume (gravitational) degrees of freedom.

This generalises to all morphologies, which correspond to closed surfaces. They necessarily involve both Kähler electric and magnetic fields coupling to the geometry to stabilize the morphology. This statement would give some content for the exaggerated claim that biology is nothing but electricity + Schrödinger equation that I heard during my first student year.

2. For instance, the presence of Kähler electric field can correspond to electric fields of cell membrane or along a part of body. If it is too weak, things go wrong in development. As was found decades ago, consciousness is lost if the electric field between frontal lobes and hindbrain gets too weak or has wrong direction [J2]. Cell dies if the membrane potential becomes zero and EEG disappears in death. Also microtubules have electric field along their axes essential for their existence.

Michael Levin and his collaborators [I7, I8, I15] have discovered further fascinating connections between electric fields and morphogenesis. One of the discoveries is that the electric fields of the embryo are controlled by neurons of the still developing brain (see <http://tinyurl.com/y77fcc7r>). This conforms with the view that neurons and their MBs correspond to a higher level in the hierarchy than ordinary cells and there take care of control in longer scales. The MB of the developing brain would be the controller.

3. A non-trivial coupling (four-momentum transfer) between the volume and Kähler degrees of freedom requires that the energy momentum currents have opposite and non-vanishing

divergences. For the energy momentum tensor of ordinary Maxwell field the divergence is proportional to the contraction of Maxwell current and Maxwell field so that the current must be non-non-vanishing.

In TGD the energy momentum tensor is replaced with energy momentum current allowing to have well-defined notion of energy momentum and corresponding conservation laws. Now the divergence contains two terms. The first one is the contraction $Tr(T_K H^k)$ of energy momentum tensor T_K of Kähler action with the second fundamental form H^k : this term proportional to T_K is new. Second term is proportional to the contraction $j_K J \nabla h^k$ of the induced Kähler form J with Kähler current j_K and gradients ∇h^k of imbedding space coordinates analogous the divergence of energy-momentum tensor $j^\beta F^\alpha_\beta$ in the case of ordinary Maxwell action. One expects both terms to be non-vanishing.

For the mere Kähler action, which I believed for decades to determine the preferred extremals, j_K is either vanishing or light-like. In presence of coupling it can be both non-vanishing and time-like. The realization that cosmological term is present was forced by the twistor lift of TGD whose existence is possible only for $H = M^4 \times CP_2$ [K26, K49].

4. The predicted stabilizing Kähler (and em) currents would naturally correspond to the DC currents flowing along the body in various scales discovered already by Becker [J10, J2] and found to be essential for the survival of the organism. In particular, Becker's DC currents are essential for the healing of wounds and in the regeneration of organs. In the first first aid stage of the healing DC currents are generated locally and after than central nervous system (CNS) takes care of the generation of the current (for TGD based discussion of Becker currents see [K32] (see <http://tinyurl.com/ydg6okkk>) or [K17]). Also this is easy to understand from the proposed stability criterion.

5.3 Quantitative view

The emergence of life would require the coupling between Kähler and volume degrees of freedom. The following gives a quantitative discussion based on p-adic length scale hypothesis and twistor lift of TGD [K26, K46].

1. The coefficient $\Lambda/8\pi G \equiv 1/L^4$ of the volume term in the action is analogous to cosmological constant in general relativity. The predicted wrong sign of Λ is the stumbling block of superstring theories. In TGD framework the sign is correct.
2. p-Adic coupling constant evolution predicts that the cosmological constant depends on p-adic length scale $L(k)$ characterizing the size scale of the Universe, most naturally as that of horizon size. In zero energy ontology (ZEO) $L(k)$ is identifiable as the size scale of causal diamond (CD) [K46].

One important implication is a solution to the problem of cosmological constant. Although cosmological constant is huge at very early times (or more precisely, in very short p-adic length scales), it is small in the length scales of recent cosmology. The values of cosmological constant at smaller p-adic lengths scales are however visible also in the recent day physics in many-sheeted space-time and biology could make them visible as the following arguments show.

3. There are two paired p-adic length scales: short p-adic length scale $L(k_1)$ and long p-adic length scale $L(k)$. The vacuum energy density $\rho_{vac} = \Lambda/8\pi G$ is naturally proportional to $1/L^4(k_1)$. One has energy $E = 1/L(k_1)$ per 3-volume $L(k_1)^3$.

$\rho_{vac} = \Lambda/8\pi G$ is also naturally proportional to $1/GL^2(k)$ since $\Lambda = x/L(k)^2$ is natural by dimensional considerations. If $L(k)$ corresponds to the size scale of the horizon, Λ decreases during cosmic evolution and the problem of cosmological constant disappears. One has

$$\frac{1}{L^4(k_1)} = \frac{\Lambda}{8\pi G} \quad , \quad \frac{\Lambda}{8\pi} = \frac{x^2}{L^2(k)} \quad . \quad (5.1)$$

Here the p-adic length scale $L(k)$ could characterize the p-adic size scale of CD. $G = l_{Pl}^2$ is gravitational constant, l_{Pl} Planck length scale, and $L = L(k_1)$ is a smaller length scale. $L(k_1)$ expressible using the geometric mean

$$L(k_1) = \left(\frac{8\pi G}{\Lambda}\right)^{1/4} = x^{-1/2} \sqrt{L(k)l_{Pl}} \quad (5.2)$$

of $L(k)$ and Planck length l_{Pl} and allows an identification as a p-adic length scale for a suitable choices of the parameter x [K46]. One has $(8\pi)^{1/4} \simeq 2.4$.

What could this pairing of short and long p-adic length scales mean? The notion of magnetic body (MB) could provide an explanation. MB has onion-like layered structure with layers labelled by p-adic length scales up to some maximum size scale. This suggests that a biological structure with size scale $L(k_1)$ has MB for which the largest layer has the size scale $L(k)$. $L(k_1)$ would correspond to smallest length scale in the hierarchy. Both scales could correspond to size scales of CDs.

Remark: When $L(k_1)$ is scaled by 2^r ($k_1 \rightarrow k_1 + r$), $L(k)$ is scaled by 2^{2r} , ($k \rightarrow k + 2r$).

4. From the parameterization

$$\rho_{vac} = y \frac{H^2}{8\pi G} \quad (5.3)$$

of the dark energy density in terms of Hubble constant at given space-time sheets one obtains an estimate for the inverse of the Hubble constant H , which depends on space-time sheet in terms of $L(k)$, as

$$\frac{1}{H(k)} = \sqrt{\frac{y}{8\pi x}} L(k) \quad (5.4)$$

$H(k)$ refers now to Hubble constant in given p-adic length scale characterizing a level in the hierarchy of space-time sheets and is *not* the ordinary Hubble constant defined in very long scales at GRT limit of TGD. Naturality suggests the condition $\sqrt{\frac{y}{8\pi x}} = 1$.

One expects that the coupling between Kähler action and volume term can be non-vanishing only if the two contributions to the energy momentum tensor are of the same order of magnitude. Otherwise minimal surface property takes care that field equations are satisfied, and one does not obtain closed membrane like structures crucial for life.

1. To achieve this, Kähler action $\propto E^2 - B^2$ must be of the same order of magnitude as $(\Lambda/8\pi G) \equiv x/GL^2(k)$ giving in the case of cell membrane for the Kähler electric field strength the rough estimate

$$E \sim \frac{\sqrt{x}}{l_{Pl}L(k)} \quad (5.5)$$

Remark: The electric field of the cell membrane corresponds to $E \sim 5 \times 10^{-4} \text{ eV}^2$ in the units of particle physicist ($\hbar = 1$ and $c = 1$) in which unit of distance is $1/eV$ and one has $1 \text{ m} \leftrightarrow 1.24 \times 10^6 \text{ eV}^{-1}$.

2. If an estimate for the typical strength E of bio-electric field is given, one can get some idea about the length scale $L(k)$ as

$$L(k) = \frac{\sqrt{x}}{l_{Pl}E} \quad (5.6)$$

By feeding in Planck length $l_{Pl} \sim 1.6 \times 10^{-35}$ m and the electric field $E \sim 5 \times 10^6 V/m$ of the cell membrane, one obtains for the cell membrane the estimate

$$\begin{aligned} L(k) &\sim \sqrt{x} \times L_0 \ , \quad L_0 = 1.1 \times 10^6 \text{ ly} \ . \\ L(k_1) &= x^{-1/4} L_1 \ , \quad L_1 = \sqrt{l_{Pl} L_0} = 4.2 \times 10^{-7} \text{ m} \ . \end{aligned} \quad (5.7)$$

Note that $L(k)$ scales as $x^{1/2}$ and $L(k_1)$ as $x^{-1/4}$.

3. The value of electric field for cell membrane is essential for the argument. If one wants to generalize the argument from cell membrane to other systems, one must have an idea about how it scales. Membrane potential is near the value for which the potential energy ZeV_0 for a Cooper pair is slightly above the thermal energy at physiological temperature. Hence the possible magnetic flux tube assignable to membrane proteins acting as Josephson junctions through cell membrane carry weakest possible electric field: this conforms with metabolic economy. A natural generalization would be that for a flux tube of length L one has $E = V_0/L$. This gives the scalings

$$L(k) \propto \left(\frac{L}{L_c}\right) \ , \quad L(k_1) \propto \left(\frac{L}{L_c}\right)^{1/2} \ . \quad (5.8)$$

The value of the parameter x is open and one can make only guesses. Naturality would suggest that x is not too far from unity.

Option I: The size of the Milky Way is estimated to be about $L_{MW} = 10^5$ ly. $L(k) = L_{MW}$ would be obtained for $x = .01$. One should be however cautious with this estimate: also $x \sim 1$ might be acceptable.

1. For $L(k_1)$ the formula $L(k_1) = x^{-1/2} \sqrt{L(k) l_{Pl}}$ gives for $x = .01$

$$L(k_1) = 4 \text{ nm} \ .$$

This is near the p-adic length scale $L(149) = 5$ nm assignable to the ordinary cell membrane. There are indeed indications that galactic year defines a biorhythm [K40]. For $x = 1$ giving $L(k) = 10^6$ ly one would have $L(k_1) = 1.26$ nm, which does not correspond to cell membrane length scale.

2. For the inverse of the Hubble constant $H(149)$ one obtains for $x = .01$ the estimate

$$\frac{1}{H(k)} \simeq 2 \sqrt{\frac{y}{8\pi x}} L(k) \ . \quad (5.9)$$

$H(149)$ does not correspond to standard cosmological constant. One has $H(149) = L(k)$ for $y = 2\pi x = .0628$.

3. The scaling $L(k) \rightarrow 10^5 L(k)$ the size scale of the observed Universe about 15 Gly scales $L(k_1 = 149)$ to $L(k_1) = 1.3 \mu\text{m}$, which corresponds to $L(165) = 1.25 \mu\text{m}$ in a reasonable approximation ($L(167) = 2.5 \mu\text{m}$ is the p-adic length scale of nuclear membrane). This scale would correspond to a distance through which one has membrane potential V_0 . Could the size scales of galaxy and observed Universe indeed correspond to those of lipid layer of cell membrane and cell membrane?

Option II: One could argue that the long length scales correspond to the size scale of Earth. In TGD based view about EEG MB as onion-like structure has also layer with size scale of Earth radius R_E .

1. The condition that $L(k) = R_E = 6.3 \times 10^6$ m gives $x = 6.4 \times 10^{-16}$ and $L(k_1) = 6.7$ mm. $L(k_1)$ could characterize a brain structure involved in the generation of EEG. Note that the estimate assumes the electric field of cell membrane. One can argue that the value of $x = 6.4 \times 10^{-16}$ is highly un-natural.

2. There are indications for the existence of life in Mars, whose radius is 1/2 of that for Earth. $L(k)$ would scale down by 1/2 as also the cell membrane thickness. Could this be assumed also for the **Option I**? By the proposed criterion the strength of electric field E for cell membrane should be 2 times stronger than for Earthly cell (for same physiological temperature). For instance, membrane potential could be same but membrane thickness could be 1/2 of that for Earthly membrane.

Interestingly, the TGD based version of Expanding Earth model [L26, L25] predicts that Earth experienced a rapid expansion doubling its radius. Even more, neuronal cell membranes are 2 times thicker than ordinary cell membranes. Animals utilizing aerobic respiration emerged in Cambrian explosion and eventually also neurons and TGD suggests an explanation in terms of oxygenation as the life in underground oceans entered to the surface through the cracks generated by the expansion [L27].

5.4 Morphogenesis in astrophysical scales?

The proposed general picture has interesting implications for the TGD view about stars and planets. Minimal surfaces have vanishing mean curvature vector H^k defined by the trace of the second fundamental form. The external curvatures sum up to zero and the surface looks like saddle surface locally. This strongly suggests that one cannot have (spherically symmetric) closed 3-surfaces obtained by taking two almost copies of 3-surface having a boundary and gluing them together along boundaries as the assumption that there are not boundaries requires. Could stars and planets be flow equilibria analogous to soap bubbles for which pressure difference is necessary and is provided by an external energy feed (blowing the bubble). When the energy feed ceases, the bubble collapses? The analogy with the stellar dynamics leading eventually to a collapse to a blackhole is obvious.

5.4.1 Morphogenesis and metabolic energy feed in astrophysical scales as explanation for some puzzling findings?

The analogy with morphogenesis could allow to build a more coherent picture from several puzzling observations related to TGD made during years.

1. One cannot obtain an imbedding of Schwarzschild exterior metric without the presence of long range induced gauge field behaving like $1/r^2$ [K27]. Any object with long range gravitational field must have also electroweak gauge charge. The charge can be made arbitrarily small but must be non-vanishing. The natural guess was that em charge - closely related to Kähler charge - is in question. If flow equilibrium analogous to soap bubble is in question, the charge must be Kähler charge with the energy momentum currents of Kähler field feeding energy to prevent gravitational collapse.
2. During 1990s I did considerable amount of work [K27] in attempts to construct spherically symmetric solutions of field equations using only Kähler action but failed. In this case, the field equations state the vanishing of the divergences of energy-momentum and color currents. All known extremals of both Kähler action and its twistor lift involving also volume term analogous to cosmological term are minimal surfaces and extremals of both Kähler action and volume term.

The failure to discover extremals which are not minimal surface might be simply due to the fact that they are not simple. One can however ask whether there are actually no radially symmetric stationary extremals of Kähler action? Could volume term be needed to stabilize them?

3. 4-surfaces with vanishing induced Kähler field are necessarily minimal surfaces. The vanishing of induced Kähler field is however not necessary. In fact all non-vacuum extremals of Kähler action are minimal surfaces. The known repertoire of minimal surfaces includes cosmic strings, massless extremals representing radiation, and CP_2 type extremals with Euclidian signature of induced metric representing elementary particles. For these Kähler action is present but minimal surface field equations give extremal property separately in volume and Kähler degrees of freedom.

Cosmic strings would dominate in the very early cosmology before space-time as a 4-surface with 4-D M^4 projection had emerged. The vision is that the thickening of their M^4 projection during cosmic expansion generated Kähler magnetic flux tubes carrying magnetic monopole fluxes. The thickening of cosmic strings need not leave them minimal surfaces but one expects that this is true approximately.

The feed of energy and particles from flux tubes (suggesting that they are not minimal surfaces) would have generated visible matter and led to the formation of stars. The flux tubes would take the role of inflaton field in standard approach. Flux tubes would have also second role: they would carry the quanta of gravitational and gauge fields and thus would be mediators of various interactions.

Dark matter identified as phases with non-standard value of Planck constant $h_{eff}/h_0 = n$ having purely number theoretical origin in adelic physics [L21, L22] would reside at magnetic flux tubes and the general vision about TGD inspired biology is that it controls the ordinary biomatter, which would involve metabolic energy feed as a stabilizer of the flow equilibrium. This picture suggests a generalization.

4. The vision about dark nucleosynthesis [L20], which emerged from the model of “cold fusion” has led to the proposal that dark nucleosynthesis preceded ordinary nucleosynthesis. Dark proton sequences were generated first by the analog of Pollack effect [L4], [L4] at magnetic flux tubes suffering also weak decays to produce states involving dark neutrons. These states decayed to dark nuclei with smaller value of $h_{eff}/h = n$ and eventually this process led to the formation of ordinary nuclei. This process liberated practically all nuclear energy and heated the system and led eventually to the ordinary nuclear fusion occurring in the cores of stars.

In living systems dark nuclei realized as dark proton sequences realize dark analogs of DNA, RNA, amino-acids, and tRNA and would provide the fundamental realization of the genetic code [L24, L23]. This picture predicts a hierarchy of dark nuclear physics and dark realizations of the genetic code and analogs of the basic biomolecules. Could biology be replaced by a hierarchy of “biologies” in a more general sense.

5. In the generalized biology stellar cores would provide metabolic energy realized basically as energy flow associated with Kähler field in stellar core making possible to realize star as an analog of cell membrane as flow equilibrium. Also the flow of Kähler charge, presumably in radial direction, would be involved if the energy momentum current of the induced Kähler field is non-vanishing and could relate to the mass loss of stars.

Even in the case of planets dark nucleosynthesis could provide a radial energy flow to guarantee stability. Nucleosynthesis could have occurred inside planets and have produced heavier nuclei. The standard picture about stars as providers of heavier elements and supernova explosions giving rise to fusion generating elements heavier than Fe could be wrong.

6. This picture conforms with what we know about dark matter. Dark matter would consist of $h_{eff}/h_0 = n$ phases of ordinary matter at magnetic flux tubes. If also magnetic flux tubes are minimal surfaces in good approximation, gravitational degrees of freedom assignable to the volume action as analog of Einstein-Hilbert action and stringy action would not interact with Kähler degrees of freedom appreciably except in the events in which dark energy and matter are transformed to ordinary matter. These events could be induced by collisions of magnetic flux tubes. The energy exchange would be present only in systems not representable as minimal surfaces. Dark matter in TGD sense has key role in TGD inspired quantum biology.

5.4.2 Blackhole collapse as an analog of biological death?

Before one can say something interesting about blackholes in this framework and must look more precisely what cosmic strings are. There are two kinds of cosmic strings identifiable as preferred extremals of form $X^2 \times Y^2 \subset M^4 \times CP_2$. X^2 is minimal surface.

1. Y^2 can be homologically non-trivial complex sub-manifold of CP_2 for which second fundamental form vanishes identically. Induced Kähler form is non-vanishing and defines monopole

flux. Both Kähler and volume term (cosmological constant term formally at least) contribute to energy density but the energy momentum currents and also tensors have vanishing divergence so that there is no energy flux between gravitational and Kähler degrees of freedom.

2. Y^2 can be also homologically trivial geodesic sphere for which Kähler form and therefore Kähler energy density vanishes identically. In this case only cosmological constant Λ represents a non-vanishing contribution to the energy so that energy transfer between gravitational and Kähler degrees of freedom is trivially impossible.

What could happen in blackhole collapse?

1. Blackhole is not able to produce “metabolic energy” anymore and preserve the spherically symmetric configuration anymore. The outcome of blackhole collapse could be a highly folded flux tube very near to minimal surface or perhaps, or even a cosmic string. The latter option is not however necessary.
2. Is this string homologically non-trivial having large string tension or homologically trivial and almost vacuum for small values of Λ ? The huge mass density of blackhole does not favour the latter option. This leaves under consideration only the homologically non-trivial cosmic strings or their deformations to flux tubes.

The string tension for cosmic string is estimated to be a fraction of order 10^{-7} about the effective string tension of order $1/G$ determined by blackhole mass which is proportional to the Schwarzschild radius. Therefore the cosmic string should be spaghetti like structure inside the horizon having length about 10^7 time the radius of blackhole. Note that TGD predicts also second horizon below Schwarzschild horizon: the signature of the induced metric becomes Euclidian at this horizon and this could explain the echoes claimed to be associated with the observed blackhole formation [L12, L28].

3. One could say that Big bang starting from homologically non-trivial cosmic strings would end with Big crunch ending with similar objects.

Living systems are conscious and there is indeed a strong analogy to TGD inspired theory of consciousness. One could say that the particular sub-cosmology corresponds to a conscious entity (many-sheeted space-time predicts a Russian doll hierarchy of them) which repeatedly lives and dies and re-incarnates with opposite arrow of time.

1. In zero energy ontology (ZEO) key role is played by causal diamonds (CDs) carrying analogs of initial and final states at their boundaries are in key role. The M^4 projection of CD is intersection of future and past directed light-cones. The shape of CD strongly suggests Big Bang followed by Big Crunch.
2. TGD inspired theory of consciousness predicts that conscious entities - selves - correspond to a generalized Zeno effect. Self is identified as a sequence of “small” state function reductions (weak measurements) increasing gradually the size of CD by shifting the active boundary of CD farther away from that passive boundary which is not changed (Zeno effect).

The states at the active boundary are affected unlike those at the passive boundary. Self dies when the first “big” state function reduction to the active boundary occurs and the roles of the active and passive boundary are changed. The arrow of geometric time identified as the distance between the tips of CD changes and the CD starts to grow in opposite time direction. The evolution of self is a sequence of births and deaths followed by a re-incarnation.

3. In astrophysical context this evolution would be a sequence of lifes beginning with a Big Bang and ending with a Big Crunch with two subsequent evolutions taking in opposite time directions. Somewhat like breathing. This breathing would take place in all scales and gradually lead to a development of sub-Universes as the size of CD increases.
4. In ZEO the first big state function reduction to active boundary of CD occurs when all weak measurements have been done and there are no observables commuting with the observables, whose eigenstates the states at the passive boundary are. Self dies and reincarnates.

One can also try to build a classical view about what happens. Measurement involves always a measurement interaction generating entanglement. Could the transfer of quantum numbers and conserved quantities (also color charges besides Poincare charges) between Kähler and volume degrees of freedom define the measurement interactions in practice. When this transfer vanishes, there is no measurement interaction and no further measurements are possible. Also metabolism ceases and self dies in biological sense.

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