Some comments related to Zero Energy Ontology (ZEO)

M. Pitkänen

Email: matpitka6@gmail.com.
http://tgdtheory.com/.

May 29, 2026

Abstract

Zero energy ontology (ZEO) lies behind TGD based quantum measurement theory in turn giving rise to a theory of consciousness by making observed part of system as a conscious entity - self. ZEO solves the basic paradox of quantum measurement theory forcing to give up ontology altogether in the Copenhagen interpretation. ZEO has become a key aspect of the entire TGD based physics. In this article I will consider more precise mathematical formulation and physical interpretation of ZEO. ZEO forms also the cornerstone of TGD inspired theory of consciousness and quantum biology and I will consider also some related aspects of ZEO such as the notions of free will and intentionality, the notions of memory and precognition as its time reversal, intuitive in contrast to formal reasoning, and remote metabolism as a universal thermodynamical mechanism of metabolism in ZEO based thermodynamics.

Contents

1 Introduction **2**

2 General view about ZEO **2**
2.1 Rough view about ZEO 2
2.2 ZEO and conservation laws 3
2.3 SSFRs in ZEO 4
2.4 BSFRs in ZEO 6
2.5 Quantum Cheshire cats do not exist in TGD Universe 8

3 ZEO, life, and consciousness **10**
3.1 Act of free will, intentionality, and ZEO 10
3.2 Precognition and ZEO 10
3.3 Intuitive and formal logical reasoning in ZEO 11
3.4 Metabolism in ZEO 12
3.5 Under what conditions does BSFR take place and what happens in it? 12
3.5.1 Two kinds of state function reductions 12
3.5.2 What happens in biological death from TGD perspective? 13
3.5.3 Death as a re-incarnation with opposite arrow of time 14
3.5.4 Could the re-incarnations with opposite arrow of time be seen in bio-chemistry? 15
3.5.5 What about ordinary re-incarnation? 15
3.5.6 Tukdam and TGD 17
3.6 Conditions on the periods with reversed arrow of time 18

4 Could brain be represented as a hyperbolic geometry? **20**
4.1 A concrete representation of hyperbolic geometry cannot be in question 20
4.2 Hyperbolic geometry and its tessellations 21
4.3 Could magnetic body provide a concrete geometric representation for the tessellation of hyperbolic space? 21

4.4 Could regions of brain be mapped to tessellations of 3-D hyperbolic space defined by magnetic body? 22
4.4.1 Some basic facts 22
4.4.2 About the precise correspondence between 3-D surfaces and H^3 23
4.4.3 The interpretation of the hyperbolic tessellations of neurons in terms of ZEO, $M^8 - H$ duality, and cognitive representations 25
4.5 Empirical support for MB as a carrier of information about state of BB 26
4.5.1 Salamander recovers after shuffling of its brain 26
4.5.2 A chordate able to regrow all of its organs if dissected into three pieces . . 26

1 Introduction

Zero energy ontology (ZEO) lies behind TGD based quantum measurement theory in turn giving rise to a theory of consciousness by making observed part of system as a conscious entity - self [L8]. ZEO solves the basic paradox of quantum measurement theory forcing to give up ontology altogether in the Copenhagen interpretation. ZEO has become a key aspect of the entire TGD based physics.

The basic prediction of ZEO is that ordinary ("big") state function reductions (BSFRs) involve change of the arrow of time. There is a lot of support for this prediction. The recent highly counterintuitive findings of Minev et all provided support for the time reversal in atomic systems [L16] [L16]. Fantappie [J3] proposed decades ago time reversal in living systems and introduced syntropy as time reversed entropy. In living matter the generation of more complex molecules from their building bricks can be seen as decay in time reversed direction. Phase conjugate laser beams are known to obey time reversed second law.

Also Libet's findings [J1] related to the active aspects of conscious experience find a nice explanation in terms of the time reversal. The latest application is to the understanding of the mysterious looking findings about earthquakes and volcanic eruptions suggesting that macroscopic quantum jumps involving time reversal are in question [L19]. This suggest that experimental verification of the time reversal and occurrence of macroscopic quantum jumps is possible by studying causal anomalies. For these reasons is important to try to develop the details of the view about ZEO as precise as possible.

In the sequel I will consider more precise mathematical formulation and physical interpretation of ZEO. ZEO forms also the cornerstone of TGD inspired theory of consciousness and quantum biology and I will consider also some related aspects of ZEO such as the notions of free will and intentionality, the notions of memory and precognition as its time reversal, intuitive in contrast to formal reasoning, and remote metabolism as a universal thermodynamical mechanism of metabolism in ZEO based thermodynamics.

2 General view about ZEO

The details of ZEO - in particular the technical details related to the conservation laws BSFR and SSFR - are from well-understood and the following is an attempt to fix these details by using analogy with cosmology.

2.1 Rough view about ZEO

Consider first what ZEO roughly means.

1. The realization of ZEO [L26, L8, L11, L24] involves besides the notions of "small" (SSFR) and "big" state function reduction (BSFR) also the notion of causal diamond (CD). CD defines perceptive field of conscious entity as a 8-D region $cd \times CP_2$, where cd is the 4-D causal diamond of M^4 defined as the intersection of future and past directed light-cones.

2. At the classical level the basic entity is space-time surface connecting 3-surfaces at the opposite boundaries of CD. The space-time surfaces inside sub-CD continue outside and there is

a hierarchy of CDs with largest CD beyond which space-time surfaces do not continue. This defines a space-time correlate for the hierarchy of selves.

Space-time surfaces are preferred extremals of the basic action principle defined by the twistor lift of TGD [L13]. Minimal surfaces with 2-D string world sheets as singularities would be in question. They connect 3-surfaces at the boundaries of CD and are analogous to Bohr orbits so that not any pair is possible and the conditions characterizing preferred extremal property might even imply 1-1 correspondence between these 3-surfaces.

3. Zero energy states are superpositions of preferred extremals. One can also understand zero energy states as superpositions of deterministic programs - quantum programs, functions in the sense of quantum biology, or quantum behaviors. ZEO allows to solve the basic paradox of quantum measurement theory since the non-determinism of quantum jump between zero energy states corresponds to the causality of free will and is not in conflict with the classical determinism realizing the causality of field equations. Experienced time and geometric time are not same but there is a strong correlation between them.

4. In SSFRs the active boundary of CD shifts to future - at least in statistical sense. This is preceded by a unitary time evolution generating superposition of CDs with different sizes but having fixed passive boundary and same superposition of 3-surfaces at it. SSFR involves time-localization to single CD with fixed temporal distance between its tips. Essentially time measurement is in question.

5. In BSFR the arrow of time changes and one can say that state function reduction measuring set of observables takes place at the active boundary of CD, which becomes a passive boundary at which state does not change during subsequent SSFRs in which CD increases in opposite direction with the former passive boundary becoming an active boundary. The change of the arrow of time in BSFR creates the illusion that instantaneous quantum jump corresponds to a smooth and deterministic time evolution leading to the final state [L16] [L16].

The mathematical and physical details of the picture are not completely nailed down, and the best manner to proceed is to return to basic questions again and again and to challenge the details of the existing picture. In the following I will do my best to invent nasty arguments against ZEO.

2.2 ZEO and conservation laws

The geometry of CD breaks Poincare invariance. Lorentz invariance with respect to the either tip of CD is exact symmetry and is extremely attractive in the construction of members of state pairs in ZEO. Classically Poincare invariance is exact and one can deduce expressions for conserved quantities for both bosonic and fermionic sector: the latter have interpretation as operators, whose eigenvalues in Cartan algebra are by quantum classical correspondence (QCC) identified as classical values of conserved quantities.

ZEO involves the somewhat questionable assumption that one can assign well-defined Poincare quantum numbers to both boundaries and that these quantum numbers are opposite: this motivates the term ZEO.

1. M^8-H duality [L21] allows to assign to CDs with either boundary fixed a moduli space, which corresponds to Poincare group. The proposal is that Poincare invariance is realized at this level and that the values of conserved charges in Cartan algebra correspond to the Poincare quantum numbers labelling these wave functions. The wave functions at the boundaries of CD could be arranged in representations of Lorentz group acting as exact symmetry of the boundary.

2. There is further little nuisance involved. Only time translations, which correspond to a non-negative time value as distance from the fixed boundary of CD are possible. One would obtain momentum eigenstates restricted to a future or past light-cone. This is of course what happens in TGD based cosmology. Maybe one must just accept this as a physical fact forcing to give up mathematical idealization.

   Formally one would replace the plane wave basis with a basis multiplied by characteristic function for future or past light-cone equal to 1 inside the light-cone and vanishing elsewhere.

This basis is closed with respect to summation. This would mean that the states are not anymore exact eigenstates of momentum globally but superposition of Lorentz boosts of the basic momentum obtained by Fourier expanding the characteristic function of future/past light-cone.

But what about CD which is intersection of future and past directed light-cones? Can one really assign to both boundaries wave functions defined in entire future (or past) directed light-cone? It seems that this is the case. Zero energy state would be entangled state as a superposition of products of boosted momentum eigenstates with opposite momenta representing the characteristic function of CD.

The usual idea about unitary time evolution for Schrödinger amplitude would be given up inside CD, and replaced by a sequence of unitary time evolutions producing de-localization of the active boundary of CD and followed by a localization.

3. There is still a problem. A complete de-localization for the boundaries of CD is not consistent with the intuitive idea that CD has definite size scale. In wave mechanics the plane waves are only idealizations and in the real world one replaces plane waves with wave packets. Gaussian wave packets have the nice feature that they remain Gaussian in Fourier transformation.

   If one has Gaussian wave packet for the temporal distance between the tips of CD concentrated on certain value of time, the Fourier transform for this is Gaussian wave packet concentrated around certain relative energy, which is two times the energy assignable to say passive boundary of CD. Instead of sharp value of time as distance between the tips of CD one would have Gaussian distribution for its value. This is consistent with Lorentz invariance since zero energy states allow superposition over states with varying momenta assignable to say active boundary. The wave function would be essentially Gaussian in energy in the rest system and one can consider also wave functions in Lorentz group leaving the passive boundary of CD invariant.

2.3 SSFRs in ZEO

In the proposed picture the sequence of SSFRs could mean gradual widening of the Gaussian wave packet for the value of measured time as the temporal distance between the tips of CD by discrete steps.

The basic condition is that the states at passive boundary of CD identified as superpositions of 3-surfaces remain unaffected during the sequences of SSFRs increasing the size of CD. This corresponds to generalized Zeno effect and in consciousness theory the unchanging part of zero energy state corresponds to unchanging part of self, one might call it soul. One can imagine two options.

Option I: CD increases statistically in SSFRs but classical energy is conserved for space-time surfaces connecting its boundaries. Energy density would decreases as CD increases. This does not seem too bad actually: it would be analogous to matter dominated cosmology.

Not only superpositions of 3-surfaces at passive boundary of CD would be conserved but also their 4-D tangent spaces would be unaffected: this is unnecessarily strong a condition for generalized Zeno effect.

Option II: CD increases but classical energies decrease. This looks more plausible - if not the only - option and is strongly favoured by the analogy of CD with expanding cosmology. It also conforms with uncertainty principle. The process would be essentially quantum analog of cooling or analog for what happens for particle in a box expanding adiabatially. The classical energies of the space-time surfaces in zero energy state would thus decrease as CD increases.

Also this option allows the states as superpositions of 3-surfaces to at passive boundary of CD to remain unaffected in the expansion of CD. The classical energies can however decrease because the space-time surfaces - tangent spaces of space-time surfaces at passive boundary - can change so that also energies can change.

This option is completely analogous to quantum adiabatic change in which the coefficients in the superposition of energy eigenstates are unaffected but energies change.

Option II looks more natural and will be considered in more detail.

1. The constraint that SSFRs as quantum measurements are for observables, which commute with observables, whose eigenstate the state at the passive boundary is, poses very strong constraints on what happens SSFR. Furthermore, preferred extremal is analog of Bohr orbit and cannot cannot be arbitrary pair of 3-surfaces. Therefore, when the CD changes, the preferred extremal also changes as a whole meaning also that also energy changes. These conditions could force adiabatic picture and the analog of Uncertainty Principle for classical energies as function of CD size.

2. The sequence of SSFRs could be also analogous analogous to what happens for a particle in box as the size of the box increases adiabatically: adiabaticity would actually be a hypothesis about what happens in the steps consisting of unitary evolution and SSFR. In adiabatic approximation the coefficients in the superposition of the energy eigenstates do not change at all: only the energies would change.

3. In thermodynamics this kind of process would correspond to a cooling, which could serve as a natural quantum correlate for the cooling in cosmology. In accordance with the idea that quantum TGD in ZEO corresponds to a complex square root of thermodynamics, one could interpret zero energy state as complex square root of thermal partition function for cosmology assignable to CD. The hierarchy of CDs would define Russian doll cosmology.

4. A further manner to understand this is in terms of Uncertainty Principle. As the size scale of CD given by temporal distance between its dips increases, the classical energy decreases. Intuitively the reduction of the classical energy is easy to understand. Increasing CD and keeping the 3-surface as such at passive boundary reduces time gradients at the passive boundary and space-time surface becomes more flat. Energy density is proportional to time gradients of coordinates and its therefore reduced. This argument is also used in inflation theories.

5. Change is the prerequisite of conscious experience and there would be indeed change also at the passive boundary of CD contributing to conscious experience. But in some sense this contribution - the "soul" - should *not* be changing! "Adiabaticity" would translate this idea to the language of physics.

What happens to CD in long run? There are two options.

1. The original assumption was that the location of formerly passive boundary is not changed. This would mean that the size of CD would increase steadily and the outcome would be eventually cosmology: this sounds counter-intuitive. Classically energy and other Poincare charges are conserved for single preferred extremal could fail in BSFRs due to the fact that zero energy states cannot be energy eigenstates.

2. The alternative view suggested strongly $M^8 - H$ duality [L5] is that the size of CD is reduced in BSFR so that the new active boundary can be rather near to the new passive boundary. One could say that the reincarnated self experiences childhood. In this case the size of CD can remain finite and its location in M^8 more or less fixed. One can say that the self associated with the CD is in a kind of Karma's cycle living its life again and again. Since the extension of rationals can change in BSFR and since the number of extensions larger than given extension is infinitely larger than those smaller than it, the dimension of extension identifiable in terms of effective Planck constant increases. Since $n = h_{eff}/h_0$ serves as a kind of IQ, one can say that the system becomes more intelligent.

   Also the temperature assignable to CD remains finite. In cosmological scales it could correspond to the analog of the temperature assignable to CMB. TGD based view about stars as blackhole like entities [L17] leads to the identification of the Hagedorn temperature assignable to the volume filling flux tube giving rise to star with the Hawking temperature of dark radiation at gravitational flux tubes. Even CMB temperature could be assigned with dark photons at gravitational flux tubes. The asymptotic temperature for CD before BSFR could correspond to this temperature.

   One expects that the center of mass coordinates of cm do not appreciably change during the quantum evolution. The hierarchy of CDs would imply that the Universe decomposes

effectively to sub-Universes behaving to some degree independently. The view about Karma's cycles provides a more precise formulation of the pre-ZEO idea that systems are artists building themselves as 4-D sculptures. In particular, this applies to mental images in TGD based view about brain. The assumption that stars correspond to repeatedly re-incarnating conscious entities allows to solve several time anomalies in cosmology [L17] so that there would be a direct connection between cosmology and theory of consciousness.

There could be a relationship between quantal flow of geometric time by SSFRs and p-adic variant of time coordinates giving a reason why for p-adicity.

1. TGD predicts geometric time as a real variant and p-adic variants in extensions of various p-adics induced by given extension of rationals (adelic space-time and adelic geometric time). Real and p-adic times share discrete points in the extension of rationals considered: roots of octonionic polynomials defining space-time surfaces as roots for their "real" and "imaginary" parts in quaternionic sense [L20]. The roots of the real polynomial with rational coefficients giving octonionic polynomial as its continuation define space moments of M^4 linear time assignable to special SSFRs. p-Adic time associated with the p-adic balls assignable the points are not well-ordered. One cannot tell about two moments of time which is earlier and which later.

2. This could relate to the corresponding lack of well ordering related to "clock time" associated with self at given level of evolutionary hierarchy defined by the extension of rationals. The increase of "clock time" as a distance between tips of CD for a sequence of small state function reductions (weak measurements) occurs only in statistical sense and "clock time" can also decrease. The moments of time correspond to roots of the real polynomial define "special moments in the life of self", one might say.

   At the limit of infinite-D extension the roots of the polynomial define algebraic numbers forming a dense set in the set of reals. Cognitive representation becomes dense set. These "special moments" need not however become dense.

3. One can raise an interesting question inspired by self inspection. As one types text, it often happen that the letters of the word become in wrong order, change places, and even jump from a word to another one. The experienced order of letters assignable to a sequence of SSFRs is not the same as the order of letters representing the order for the moments of geometric time. When one is tired, the phenomenon is enhanced.

   Neuroscientists can certainly propose an explanation for this. But could this be at deeper level quantum effect based on the above mechanism and have a description in terms of p-adicity assignable to prime p defining a ramified prime for the extension of rationals involved? When one is tired the metabolic resources have petered out and the IQs $n = h_{eff}/h_0$ defined by dimensions of extensions of rationals for the distribution of extensions tend to reduce, cognitive resolution for time becomes lower and mistakes of this kind become worse.

There is a further technical detail involved. For SSFRs the temporal distance between active boundary and passive boundary increases at least in statistical sense. It seems that one must define the inner product in S-matrix elements for the unitary step preceding SSFR using the previous state basis as sub-basis of the new state basis in the case that CD increases. In adiabatic approximation the S-matrix elements would be overlaps for the states with different size of CD and analogous to matrix elements between states of particle in boxes with the same fixed end but different moving end.

2.4 BSFRs in ZEO

Details of BSFR are not completely fixed. One can consider two options. Both options must satisfy the condition that the states at passive boundary of CD identified as superpositions of 3-surfaces remain invariant during the sequence of SSFRs. The tangent space-to the space-time surfaces need not however remain invariant. Therefore the classical energies of space-time surfaces can change since the energy densities are proportional to time derivatives of embedding space coordinates.

1. The size of CD increases steadily as was the original proposal and is thus not reduce in BSFRs. The problem with the steady increase seems to be that the size of CD becomes infinite eventually and the state evolves to what looks like cosmology. If the energy assignable with zero energy state is conserved, the energy density of matter inside CD increasing without limit becomes arbitrarily small. Is this a catastrophe?

   For TGD inspired cosmology this is the case at the limit of big bang in the sense that the energy density goes like $1/a^2$ (cosmic string dominance) and energy in a co-moving volume vanishes like a, where a is light-cone proper time. One can think that CD defines only perceptive field and that space-time surfaces continue also outside CD up to the maximal size of CD in the hierarchy of selves involved. The zero energy state would have finite energy energy but density of energy would go to zero at the boundary of CD. The perceptive field of conscious entity would increase steadily in size.

   As found, energy need not be conserved in the subsequence SSFRs because Gaussian wave packets of CDs around given size are required so that eigenstates of energy are not in question and the reduction of the width of Gaussian in the sequence of SSFRs implies reduction of average energy. Only the superpositions of 3-surfaces at the passive boundary of CD would be conserved.

   Even the conservation of energy combined with the increase of CD need not be a catastrophe. In matter dominated cosmology the conservation of mass takes place with respect to cosmological time which corresponds to the proper time measured as temporal distance from the passive tip of CD. This cosmological mass is not energy but closely relates to it. What looks of course counter-intuitive is that every self would evolve to a cosmology.

2. The size of CD could be also reduced in BFSR [L20]. $M^8 - H$ duality and existence of "braney" solutions encourages to take this option serious. The 6-D brane like entities correspond to $t = constant$ sections for linear M^4 time t. They would represent special moments in the life of self. The exceptional 6-D roots of octonionic polynomials as branes would emerge to the perceptive field conscious entity at these moment. Discontinuity of classical space-time evolution as SSFR. Every time-reversed re-incarnation of self would have have "childhood" and experience increase of CD from some minimal size to maximal size.

   Since the size of CD can be reduced, it could happen that the CD remains stuck below certain maximal size for ever. The associated mental images would continue living in the geometric past of bigger CD associated with self. The sub-CDs in past would represent memories of self. Cosmos in 4-D sense would be full of life. The interpretation of CD as perceptive field allows this. CD could also increase and become even a cosmology! This picture looks attractive from the view point of consciousness.

3. One can however invent an objection.

   (a) Suppose that in biological death I indeed re-incarnate with opposite arrow of time and continue to live towards geometric past. Suppose also that I re-incarnate as more advanced human being - at least in statistical sense. Human beings have parents. But how can I have parents in the former geometric future, if my parents how have already died live in the former geometric past?

   (b) The only solution of the paradox seems to be that the magnetic body (MB) - the boss - does not disappear in the death of biological body (BB). The MBs of my parents continue their existence and in my biological death means their separation in stanard time direction and meeting in the new time direction. They meet, fall in love, and give rise to my birth but all this in opposite time direction.

   This would provide an answer to a long-standing question about whether MBs are preserved in biological death or not. My view has been that biological death is more or less that MB loses interest in my BB and directs attention to something more interesting. One could however argue that also MB is generated in birth and genes code also for it so that it would die. If directing attention corresponds to BSFR MB would continue to exist after biological death. This particular reincarnation - CD - would be like vortex in the flow of time.

(c) Can one find any support for this crazy looking proposal? TGD Universe is fractal and lower levels in the length scale hierarchies are slaves. In particular, bio-chemical level serves as the slave of MB expected to obey kind of shadow dynamics. If the proposed topological dynamics of MBs solving the above paradox has a miniature representation at the level of DNA, one could take the proposal with some seriousness.

In meiosis (`http://tinyurl.com/n5eqkdn`) germ cells, whose chromosomes are coctails of paternal and maternal chromoses (PCs and MCs), are formed. In fertilization (`http://tinyurl.com/ngzwhcq`) - in some sense a (time?) reversal of meiosis - pairs of PCs and MCs are formed. The fusion of paternal and maternal germ cells could be indeed seen in topological sense as a time reversal of replication. The replication of soma cells involves mitosis (`http://tinyurl.com/p35lkwr`) forming pairs of chromosomes of PCs and MCs.

Could the chromosomal dynamics be a miniature version of the proposed dynamics at the level of MB even at the level of organisms? If so, mitosis at the level of MB would correspond to a loose pairing of paternal and maternal MBs - formation of a relationship. Our personal MBs as analogs of germ cells would be coctails of MBs of PCs and MCs formed by reconnection process.

What about replication? In the case of asexual reproduction (`http://tinyurl.com/y8odomtf`) one could speak about replication at the level of MB of the entire organism. Also cell - and DNA replication would represent examples of asexual reproduction and in meiosis sexual reproduction of also DNA would take place.

When does BSFR occur? I have imagined several options, which need not exclude each other.

1. Could BSFR occur, when there are no observables at the active boundary commuting with those diagonalized at passive boundary. Measurement of observable at means generation of eigenstate in the extension of rationals and it typically occurs that the resulting state is outside the extension. Could BSFR occur when there are no observables in the extension of rationals in question.

2. $M^8 - H$ duality predicts universal special solutions besides 4-D space-time surfaces. These 6-D analogs of branes correspond to n moments of linear M^4 time, where n is the polynomial whose octonionic continuation defines space-time surfaces in M^4 as roots of its real or imaginary part in quaternionic sense. At these branes 4-D space-time surfaces are glued together along their ends- space-time looks is analogous to piecewise continuous curve in time direction - and they would correspond to "special moments in the life of self" [L20]. When all these moments as special roots of the octonionic polynomial are experienced, BSFR would be the only possibility. The polynomial with rationals coefficients defining the octonionic polynomial defines the extension of rationals used so that this option could be consistent with the first option.

3. Is BSFR is forced to occur because there are no preferred extremals connecting the pairs of 3-surfaces exists anymore. Could it happen that the state becomes increasingly classical during the sequence of SSFRs and thus becoming more and more local in WCW (the "world of classical worlds", which is essentially the space of 3-surfaces at either boundary of CD). The unchanging part of the zero energy state associated with the time-reversed state as outcome of BSFR at the new passive boundary would be maximally classical. This might relate to the fact that the world looks so classical. Also the fact BSFRs themselves look classical smooth time evolution ending to the outcome of BSFR, creates the illusion of classicality [L16].

2.5 Quantum Cheshire cats do not exist in TGD Universe

The article Quantum Cheshire Cats of Aharonov, Popescu, Rohrlich, and Skrzypczyk published in New Journal of Physics (see this) claims that the particle can be separated from its properties relies on the notion of weak measurement (see this). The mathematical model of weak measurements is not taken seriously by the mainstream and there are good reasons for the skepticism. However, the consideration of this notion from the TGD point of view provides considerable insights to the TGD view of quantum measurement theory.

The claimed apparent separation of the particle from its properties (the grin of Cheshire cat from the Cheshire cat) could be an illusion and have a more mundane interpretation. This strange separation actually occurs in the sensory perception: the object and its properties, say the state of motion, are represented separately and one can ask whether something like this could occur at quantum level. The hypothesis raises many questions.

1. For instance, what does one mean with the particle? Usually the particle is identified as a collection of its properties like spin, energy and momentum. Now one adds the notion of particle path and this is in conflict with the standard QM. Only if one accepts path as observable then one can speak of states $|A\rangle$ and $|B\rangle$.

2. The detection of the particle is taken to mean its absorption: not a measurement of any usual property. The measurement would mean a localization to path $|A\rangle$ or $|B\rangle$ in the space of paths but in standard QM only the localization to a point of 3-space makes sense.

3. The conclusion is that the particle and its spin, parallel to the plane defined by the paths A and B, travel through different paths. This claim follows from the observation that the addition of a very weak magnetic field, orthogonal to the quantization axis of spin, has effect only at the second path, call it B, whereas the addition of a very thin absorbing screen has effect on the different path, call it A. Therefore one concludes that the spin moves along B and the particle along A.

   In reality, the experimental arrangement guarantees that the spin directions are opposite on path A and B so that the claim about Chesire cat property is misinterpretation if taken literally.

4. How the spin directions at paths A and B are fixed.i.e. what determines the quantization axis of the spin. Could there be a magnetic field B_q, parallel to the plane defined by paths A and B, determining the quantization axis. When one adds a weak magnetic field ΔB orthogonal to the plane of A and B and therefore to B_q, it produces a torque trying to change the spin direction.

   If the direction of the spin at path B is opposite to that of B_q, it corresponds to the maximum of the dipole energy $E = -mu\cdot B_q$ which is unstable against the torque caused by the addition of ΔB. Think of a particle at the top of a hill. At path A the dipole energy is negative and minimum: this gives rise to stability and the addition of B. The torque has a negligible effect. One has quantum criticality at path and stability at path A.

5. Is the addition of a very thin screen ΔS analogous to the addition of the weak magnetic field ΔB. Is path B stable and not affected by ΔS and is path A critical and affected by ΔS This would explain the experimental findings.

6. There is however still a question to be answered. Why are the criticalities with respect to ΔB and ΔS orrelated? Why the criticality with respect to addition of ΔB implies stability with respect to the addition of ΔS and vice versa.

Could one understand the findings in the TGD framework.

1. There are the notions of preselection and postselection. Preselection is defined as a formation of a state $(|A\rangle + |B\rangle)|0\rangle$ and post selection as use of filter at path B to create state $|A\rangle|0\rangle + |B\rangle|1\rangle$. As noticed, there is no notion of particle path in wave mechanics. The notion of spin state makes sense.

2. In TGD, point-like particles are replaced by 3-surfaces. Holography = holomorphy principle [L32, L33] implies that 3-surfaces are replaced by 4-surfaces as analogs of Bohr orbits of 3-surfaces. This eliminates path integral and the associated infinities. This also forces zero energy ontology [L25] [K6] as new quantum ontology solving the basic paradox of quantum measurement theory.

   In TGD the introduction of states $|A\rangle$ and $|B\rangle$ makes sense in TGD. Fermions are located at Bohr orbits and define the spin states $|0\rangle$ and $|1\rangle$.

3. In TGD the classical description in terms of paths as Bohr orbits of 3-surfaces is an exact part of quantum description. At this level one can speak of classical energy and the notions of stability and criticality as unstability make sense.

4. Suppose that Bohr orbit A is obtained from stable Bohr orbit B by a deformation which increases its classical energy. This would make A unstable against the addition of ΔS. The state in which the Bohr orbit A ends by absorption at the screen is the stable state. Bohr orbit $|B\rangle$ is unstable against the addition of ΔS because it is not a minimum of classical energy.

   If the preselected spin state $|0\rangle$ is minimum of the magnetic energy then the $|1\rangle$ associated with $|B\rangle$ has a higher energy and is unstable against the addition of ΔB.

   These assumptions imply the correlation between the two kinds of criticalities and would explain the claimed findings without the Cheshire cat hypothesis.

3 ZEO, life, and consciousness

The most important implications of ZEO relate to consciousness and quantum biology. One can understand act of free will and motor action in terms of BSFR. BSFR corresponds to motor action and its time-reversal. SSFRs correspond to sensory perception in either direction of time [L12]. Model for memory is one prediction and predicts precognition as time reversal of memory [K5] [L27]. Also the relationship between generation of insight and mechanical logic deductions can be understood. In biology ZEO leads to remote metabolism as a universal purely thermodynamical mechanism of metabolism. One can also understand zero energy states as superpositions of deterministic programs - quantum programs, functions in the sense of quantum biology, or quantum behaviors.

3.1 Act of free will, intentionality, and ZEO

Act of free will would correspond to BSFR that is quantum jump leading to final state with opposite arrow of time. Final state is a superposition of deterministic time evolution connecting the 3-surfaces in the superpositions defining initial and the final states. In this picture state function reduction leads to final state inducing time reversed time evolution so that classically the causal order is changed. What in standard picture - say neural activities - causes the outcome, is caused by the outcome. Could it be that that mere volitional act with sharp enough intention is needed? The correct deterministic time evolution is dictated by intention as consequence rather than cause!

Here I cannot avoid the temptation to tell about my own strange experiences. At this age one must remember to take the pills every morning. I have the habit of filling my pill dispenser every Monday morning. I do not bother to count the pills one by one. I just take randomly a bunch of them hoping that their number is correct. And it is! Quite too often! Similar thing happens in market when I pay with coins: I do not count the coins but just take a handful of them. The sum of the coins is correct quite too often! Could a mere sharp intention dictate the outcome. Could one learn gradually this kind of sharp intentions.

Could this be crucial for various skills like playing tennis or computer game, where one simply cannot react rapidly by computing the outcome since time does not allow it? Could this explain also mathematical/physical/.. intuition as skill to solve problems by making quantum jump directly to the solution of the problem.

3.2 Precognition and ZEO

It seems that neuroscientists are beginning to take remote mental interactions such as precognition, telepathy, and psychokinesis seriously. The popular article entitled "*Scientists Discover That The Heart & Brain Respond To Future Events – Before They Happen*" (see `http://preview.tinyurl.com/y494hw5u`) describes changing views of neuroscientists towards precognition.

In ZEO precognitions are naturally time-reversed memories. Classical signals giving rise to sensory experience arrive from geometry future in the standard frame. During sleep state precognition should be possible if sleep corresponds to time-reversed state for the self.

In the associative and computational models of brain our ability to predict the future is taken to be an extrapolation based on memories and experience of earlier life. This looks very reasonable but when one asks how these memories are represented, problems begin to appear. In TGD framework ZEO predicts that memories correspond to mental images in geometric past, in the simplest case, when the original event took place. This solves a huge problem of standard since memory storage becomes brain in 4-D sense rather than in 3-D sense [K5].

ZEO however implies that also time reversed memories are possible. If sleep state correspond to time reversed self about which we do not have direct memories, memories with reversed arrow of time would be possible in this state. Precognition becomes possible if these memories can be communicated to the wake-up state with the ordinary arrow of time. In dreams some parts of brain are awake and they could make possible this communication. The communicated information could be also conscious to some selves above or below us in the hierarchy. Dreams can indeed predict what happens during the next day. The classical book "*An Experiment with Time* " (see `http://tinyurl.com/jtqysty`) of J. W. Dunne tells about precognitive dreams that he experienced.

3.3 Intuitive and formal logical reasoning in ZEO

The basic vision is that adelic space-time geometry provides correlates for sensory experience and cognition/imagination. Fermionic degrees of freedom would represent quantal Boolean mind. In ZEO given deterministic time evolution for 3-surface and induced spinor fields would give rise to sensory and cognitive time evolution and to Boolean evolution having interpretation as analog of logical deduction leading from premises to conclusions.

1. The basis of fermionic Fock states can be regarded as Boolean algebra. Superpositions and thus entanglement of fermionic qubits are however possible and one can speak about quantum Boolean logic. In standard view concepts are formally regarded as sets containing the instances of concept as elements. Quantum concepts could be superposition of quantum states representing the instances so that quantum abstraction would be much more complex notion than ordinary abstraction. Non-classical Boolean states would be superpositions of statements identifiable as abstractions. Schrödinger cat would be seen abstraction. "Dead" and "alive" would represent instances of this abstraction.

2. Zero energy states are superpositions of initial and final fermion states and there is also a superposition over 3-surfaces, and could be interpreted as representations for implications. The sum $\sum_n S_{mn}|n\rangle$, where S denotes unitary S-matrix, represents a superposition over all transitions $|m\rangle \to |n\rangle$ allowed by laws of physics. These transitions could be interpreted as logical implications.

   One could argue that by diagonalizing S-matrix one obtains only diagonal transitions and the situation is rather trivial: just logical identities. The point is however that in number theoretical physics the diagonalization of S would in general lead outside the extension of rationals determining the adele and is therefore not possible. Same number theoretical mechanism would also stabilize negentropic entanglement and could force BSFR. Only state big state function reduction extending the extension of rationals can reduce this kind of entanglement.

3. Probably every mathematician has pondered the mystery of mathematical insight. How for instance mathematical insight is generated? What eureka experience is basically? Insight would correspond naturally to a big state function reduction leading to a new state reversing the arrow of time.

   Truth can be deduced in given system of axioms also mechanically - at least in principle. How does insight relate to a logical deduction leading to a theorem? The final state of quantum jump is superposition of classical time evolutions leading from the final state to geometric past. With respect to standard arrow of time it is superposition of logical deductions leading from various initial states- initial assumptions - to the final state - to the outcome of the deduction. Superposition of states at boundary of CD could be seen as an abstraction. Deterministic time evolutions would represent the mechanical deductions.

   Note however that in the time reversed state arbitrary long time evolution in opposite time direction is in principle possible and would correspond to an arbitrary long ordinary deduction

or computation [L3]. After that a return to the original arrow of time would take place and provide the solution. The formal deduction leading to the outcome would be indeed forced by the outcome rather than vice versa?

3.4 Metabolism in ZEO

ZEO has also deep implications for biology. As already explained, ZEO allows to understand what behaviors, biological functions are at fundamental level.

Why metabolism is needed can be understood in TGD view about dark matter as phases of ordinary matter labelled by the value of effective Planck constant $h_{eff} = n \times h_0$, where n has also interpretation as dimension of extension of rationals giving rise to the extension of adeles [L6, L7]. n serves as a kind of IQ labelling different evolutionary levels and is bound to increase in statistical sense. Not only biology but also self-organization involving also energy feed could be understand in terms of the hierarchy of Planck constant.

In ZEO remote metabolism suggests itself as a completely universal purely thermodynamical mechanism of metabolism. Usually system loses its energy by dissipation. If the arrow of time is non-standard, systems seems to receive energy from environment. Note that the duration of time spent in time reversed state does not matter! What matters is the increment of time between states with same arrow of time! Sleep state could be seen also as a manner to collect metabolic energy. BSFR can be seen as an act of free will - motor action and sucking of metabolic energy from "environment" would be very natural.

The interpretation for the return to the original time direction by second BSFR would be as beginning of sensory perceptions in standard arrow of time as sequences of SSFRs. During this period subsystem would be dissipating energy to environment.

3.5 Under what conditions does BSFR take place and what happens in it?

In the following the question under what conditions "Big" state function reduction (BSFR) takes place and what happens in it.

3.5.1 Two kinds of state function reductions

The discussion however requires the basic ideas of ZEO as background.

1. "Small" state function reductions (SSFRs)

Small state function reductions (SSFRs) are counterparts of so called "weak measurements", which are rather near to classical measurements in the sense that nothing drastic happens.

1. The passive boundary of CD does not shift but changes in size because active boundary shifts and this induces change of size. For state pairs defining zero energy states the members at passive boundary do not change and the coefficients of possibly time-entangled state defined as their superposition do not change. The members of state pairs at active boundary change and this change is induced by unitary time evolution between too SSFRs. This time evolution could be regarded as a generalization of adiabatic time evolution.

2. In statistical sense the active boundary shifts towards future and the size of CD increases. The temporal distance between the tips defines clock time in one-one correspondence with SSFRs. Note that the unitary evolution forms a superposition of CDs with different sizes and SSFR means localization to single CD size.

3. The moment "Now" of self would naturally correspond to the M^4 hyper-plane dividing CD into two pieces of identical size. The radius of this 3-ball would be $r = T/2$, where T is the temporal distance between the tips of CD. At this hyperplane expansion of 3-ball with light-velocity would transform to contraction.

4. The mental images of self would correspond sub-CDs and also they would shifts towards geometric future in the sequence SSFRs. They would form a kind of log file about the life

history of self such that geometric time order would be opposite to subjective time order. Self could remember these experiences by sending signals to geometric future reflecting back in time direction - seeing in time direction would be in question.

What is in sharp conflict with natural expectation is that the memories would be stored in geometric future and part of them would become un-changing permanent part for the time reversed re-incarnation of self- kind of Karma.

Note however that self might have also mental images represented as sub-CDs in geometric past.

$M^8 - H$-duality suggests space-time picture about the "log files".

1. 4-D space-time surfaces in complexified M^8 having interpretation as complexified octonions are 4-D roots for octonion valued polynomial obtained as an algebraic continuation of a real polynomial with rational or even algebraic coefficients. $M^8 - H$ correspondence maps thee surfaces to minimal surfaces with 2-D singularities in H [L21, L20].

2. Besides this one obtains for any polynomial also special solutions as analogs of branes in M-theory. They have topology of 6-D ball and their projection to M^4 is $t = r_n$ hyperplane intersecting CD and with topology of 3-ball. r_n is a root of P and thus an algebraic number. I have called $t = r_n$ "very special moments in the life of self". Generalized vertices for particle reactions would correspond to partonic 2-surfaces localized at these 6-surfaces. At these surfaces incoming and outgoing partonic orbits would be glued together along their ends. The roots define positions of external particles at the boundaries of CD.

3. In SSFRs these balls at the active half of CD would shift towards future and new roots would emerge. These roots wold define a geometric representation of the memories of CD as "log file" increasing in size. If there are sub-CDs associate with them, one would have mental images shifting towards future.

2. "Big" state function reductions (BSFRs)

"Big" state function reductions (BSFRs) correspond to ordinary state function reductions (SFRs) in ZEO. In BSFR the roles of active and passive boundaries of CD are changed and the arrow of geometric time changes since the formerly passive boundary starts to shift to opposite time direction. State function reduction not commuting with the observables defining states at passive boundary as their eigenstates would takes place and the state at passive boundary would be changed. It would be however fixed by quantum dynamics. The findings of Minev *et al* provide support for the change of the arrow of time in ordinary SFR [L16].

The passive boundary can be shifted towards future so that the size of CD would decrease. One can say that the re-incarnate would be experience childhood. Note that also part of the "log file" about often personal experiences of self towards end of its life defining the permanent part of self-hood of the re-incarnate would disappear. The interpretation in terms of Karma is suggestive.

Remark: During a discussion with Marko Manninen, Marko noticed that people who have had near death experience often report that they experienced their entire life like a film during these moments. Could the "log file" representing stored mental images give rise to this experience at the moment of death?

3.5.2 What happens in biological death from TGD perspective?

What happens in biological death can be taken as a guideline in attempts to understand what happens in BSFR.

1. Death certainly occurs if there is no metabolic energy feed to the system. Metabolic energy feed is guaranteed by nutrition using basic molecules as metabolites. Since the increase of h_{eff} quite generally requires energy if other parameters are kept constant and since the reduction of h_{eff} can take spontaneously, the metabolic energy is needed to keep the distribution of values of h_{eff} stationary or even increase it - at least during the growth of organism and perhaps also during the mature age when it would go to increase of h_{eff} at MB.

If the size of CD for at least MB correlates with the maximum value of h_{eff} or its average, the size of CD cannot grow and can be even reduced if the metabolic energy feed is too low. The starving organism withers and its mental abilities are reduced. This could correspond to the reduction of maximum/average value of h_{eff} and also size of CD.

One can argue that if the organism loses metabolic energy feed or is not able to utilize the metabolic energy death and therefore also BSFR must take place.

2. In ZEO self-organization reduces to the second law in reversed direction of geometric time at the level of MB inducing effective change of arrow of time at the level of biological body [L22]. The necessary energy feed correspond to dissipation of energy in opposite time direction. In biological matter energy feed means its extraction from the metabolites fed to the system. One could say that system sends negative energy to the systems able to receive it. A more precise statement is that time reversed subs-system dissipates and metabolites receive the energy but in reversed time direction.

   In living matter sub-systems with non-standard arrow of time are necessary since their dissipation is needed to extract metabolic energy. The highest level dissipates in standard time direction and there must be a transfer of energy between different levels. This hierarchy of levels with opposite arrows of geometric time would be realized at the level of MB.

3.5.3 Death as a re-incarnation with opposite arrow of time

These observations suggest that one should consider the reincarnation with opposite arrow of time with wisdom coming from the death of biological systems.

1. We know what happens in death and birth in biological systems. What happens in biological death should have analogy at general level. In particular, in death the decay of the system to components should occur. Also the opposite of this process with reversed arrow of time should take place and lead at molecular level to the replication of DNA and RNA and build-up of basic biomolecules and at the cell level to cell replications and development of organs. How these processes could correspond to each other?

2. The perceived time corresponds to the hyperplane $t = T/2$ dividing CD to parts of same size. Here T is the distance between the tips of CD and therefore to maximal diameter of temporal slice of cd, which is 3-ball. The part of CD above it shifts towards future in SSFRs. In BSFR parts of the boundary of space-time surfaces at the active boundary of CD become unchanging permanent parts of the re-incarnate - kind of log file about the previous life. One can say that the law of Karma is realized.

   If CD decreases in size in BSFR the former active boundary keeps its position but its size as distance between its tips is scaled down: $T \to T_1 \leq T$. The re-incarnate would start from childhood at $T - T_1/2$ and would get partially rid of the permanent part of unchanging self-hood corresponding to interval $[T - T_1/2, T/2]$ so that the permanent part of reincarnate would correspond to $[T - T_1/2, T]$. Reincarnate would start almost from scratch, so to say. The part between $T - T_1/2$ and T would be preserved as analog of what was called BIOS in personal computers.

3. At the moment of birth CD possibly would thus decrease in size and the former passive boundary now in the range $[T - T_1/2, T - T_1]$ and lower tip of new CD at $T - T_1$ would become active and the seat of sensory experience. Arrow of time would change. Where the analog of biological decay is located? The region of CD in the range $[T/2, T - T_1/2]$ disappearing from "log file" is the natural candidate. This region is also the place, where the events related to birth in opposite time direction should take place.

4. The decay of the organism should therefore correspond to the development and birth of re-incarnated organism at the level of MB (it must be also remembered that genuine time reversal takes place at the level of MB and induces only effective time reversal at the level of ordinary bio-matter). The decay of organism dissipates energy in standard time direction: this energy could used by the re-incarnate as metabolic energy. How long lasting biochemical processes have effective time reversals depends on the quantum coherence scale determined by the size scale of corresponding CD.

3.5.4 Could the re-incarnations with opposite arrow of time be seen in bio-chemistry?

The possible occurrence of effective time reversals at the level of bio-chemistry could be perhaps tested experimentally.

1. Could the replication of DNA and RNA and build-up of various bio-molecules be effective time-reversals for their decays. Could the same apply to the replication of cells and generation of organs. Replication of DNA is self-organization process in which second DNA strand serves as a template for a new one. The decay of DNA should therefore involve two DNA strands such that the second DNA strand serves as a template for the effectively time reversed replication. The double strand structure indeed makes possible for the other strand to decay first. Cell replication should use another cell as replicate and same would happen in the cell decay.

2. An interesting mental exercise is to imagine the time reversals of various basic processes like transcription and translation. In the time reversal of translation of mRNA to amino-acid sequence the amino-acid sequence and mRNA would return to ribosome machinery, and amino-acid and tRNA codon associated with tRNA would return to form tRNA. mRNA strand would shift one step backwards and the process would repeat itself and finally mRNA strand would return to open DNA strand. In the time reversal of transcription of DNA to mRNA, mRNA strand would return to open part of DNA strand, decay to RNA codons and eventually DNA strand would close. It should be easy to check whether these processes really occur in the decay process.

3. The formation of stem cells involves de-differentiation. Could it mean time reversal of the entire process leading to a differentiated cell? Also this idea could be tested.

In biology pairs of various structures often occur. Could they correspond in some sense to effective time reversals of each other whereas at the level of magnetic body one would have genuine time reversals

1. Could the opposite inherent chiralities of MBs of DNA strands correspond to opposite arrows of time at the level of MB of DNA realizing dark genetic code [L2]? Could this be seen as a kind of explanation for the double strand structure of DNA. Could the passivity of DNA strand with respect to transcription correspond to opposite arrow of time at the level of MB? Could the passive strand become active in time reversal?

2. Even brain has this kind of pairing. Right brain hemisphere is passive in the sense that it does not seem to contribute to wake-up intelligence (presumably identified as analytic intelligence). Could either hemisphere serve as a template in the development of brain or could this happen only at the level of MB of brain? Could different time arrows at the level of MB be used to understand the strange passive character of right brain and could one one understand the holism of right brain *viz.* analytic reductionism of left brain as reflection of the fact that dissipation as decay corresponds to time reversal for self-organization generating structures at the level of MB.

3.5.5 What about ordinary re-incarnation?

A couple of comments relating to the notion of re-incarnation in standard sense are in order.

1. Eastern philosophies talk about the possibility of liberation from Karma's cycle. Can one imagine something like this? The above picture would suggest that in this kind of process the reduction of the size of CD does not occur at all and therefore there would be no decay process equivalent to the growth of time reversed organism. This would serve as an empirical signature for the liberation - if possible at all. CD would continue to increase in size or perhaps keep its size. It would seem that a new kind of non-biological source of metabolic energy would be needed.

2. Reincarnation is a basic notion in Eastern philosophies. In ordinary reincarnation person has memories about life of a person, who lived earlier. There is evidence for this. This cannot be understood in terms of time reversed re-incarnation.

   Recall that there would be a hierarchy of selves and corresponding CDs within CDs. It has remained an open question whether CDs could also overlap? Could re-incarnation in ordinary sense be explained in terms of this kind of overlap?

   Suppose that one has two overlapping CDs: CD_1 and CD_2 and that CD_2 extends farther to the future of CD_1. The sub-CDs of CD_1 shift to future as the active part of CD_1 shifts to future and increases in size giving rise to a kind of log file defining the personal memories of CD_1. In this kind of situation the mental images of CD_1 can enter to CD_2 and become mental images of CD_2. This would be sharing of mental images but in different sense as compared to the fusion of mental images by entanglement, which could also require intersection of sub-CDs of mental images.

   Could one imagine that the cosmos is full of selves serving as counterparts of memes wandering around and finding for selves hosting them by providing metabolic energy? Note that ZEO means that CD center of mass degrees of freedom do not carry any conserved quantum numbers so that the motion of these lonely CDs would not be restricted by conservation laws!

3. This picture suggests that CD:s form a conscious fractal atlas consisting of charts with various resolutions analogous to the atlas defining a covering of manifold by open sets. The earlier proposal was that in biological death MB redirects its attention to a new system. This picture would be modified: the MB of of CD_1 would still attend the time-reversed system and experience time-reversed life. Some sub-CDs of CD_1 would however belong to a new CD in its geometric future - CD_2. This conforms with the intuitive expectation that space-time surfaces continue outside CD and only the perceptive field of conscious entity is restricted to CD.

4. Mental images should correspond to sub-selves and therefore sub-CDs of CD. Contrary to what I have proposed earlier, it seems that after images cannot correspond to BSFR type re-incarnations of mental images nor re-incarnations in standard sense.

   Mental images would shift towards the future together with active part of CD and form a kind of log file. Could after images be memories of previous mental images involving a signal time reflect from the the mental image in log file and creating the after image as a sensory memory of the earlier visual mental image? Or could one understand after images in terms of propagation of dark photon signals along closed magnetic loops giving rise to periodically occurring mental images.

In [L28] I discussed how the evolution of self by BSFRs could correspond to a transition to chaos as iteration of the polynomial defining the space-time surface. The proposed picture was that the evolution by SSFRs corresponds to iteration of a polynomial P assignable to the active boundary of CD. This would predict a continual increase of the degree of the polynomial involved. This is however only one possibility to interpret the evolution of self as iteration leading to chaos.

1. One could argue that the polynomial $P_{nk} = P_n \circ .... \circ P_n$ associated with the active boundary remains the same during SSFRs as long as possible. This because the increase of degree from nk to $n(k+1)$ in $P_{nk} \to P_{nk} \circ P_n$ increases h_{eff} by factor $(k+1)/k$ so that the metabolic feed needed to preserve the value of h_{eff} increases.

   Rather, when all roots of the polynomials P assignable to the active boundary of CD are revealed in the gradual increase of CD preserving P_{nk}, the transition $P_{nk} \to P_{nk} \circ P_n$ could occur provided the metabolic resources allow this. Otherwise BSFR occurs and self dies and re-incarnates. The idea that BSFR occurs when metabolic resources are not available is very natural for this option.

2. Could $P_{nk} \to P_{nk} \circ P_n$occur only in BSFRs so that the degree n of P would be preserved during single life cycle of self - that n can increase only in BSFRs was indeed the original guess.

While preparing this contribution I learned about a highly interesting claim (https://tinyurl.com/yap8ss4p) made by the research group led by Harold Katcher. The claim is that the epigenetic age (there are several measures for it such as methylation level of DNA) of rats has been reduced up to 50 percent. The theory goes that epigenetic age of molecules would be controllable by hormonal signalling globally.

BSFR would mean death of conscious entity and its reincarnation with opposite arrow of time. The system would rejuvenate in the transition starting a new life in opposite time direction from childhood so to say - rejuvenation would be in question. Doing this twice would lead to life with original arrow of time but starting in rejuvenated state. The claim of the group suggests that living matter could do this systematically using hormonal control.

3.5.6 Tukdam and TGD

This piece of text was inspired by a document (https://rb.gy/abt8za) about a strange phenomenon known as Tukdam. What happens is that in Tukdam the person is physically dead but is believe to be in a continued meditation. There is no EEG, the heart does not beat, and there is no normal metabolism. However, the decomposition processes do not start. The condition can last up to a couple of weeks. Similar longer-lasting ones have been reported: a yogi can be buried underground for months in an oxygen-free state and then wake up.

This challenges neuroscience's view of the brain as the seat of consciousness. According to reports there could be awareness and a sensory experience consisting of different light sensations. The Tibetan Book of the Dead describes these experiences. Near-death experiences have many similar features [L29].

In the body in Tukdam, the area of the heart is reported to feel warmer to the touch than the rest of the body, but the thermometer does not detect this difference. This would indicate that the body receives metabolic energy at the cellular level from some other source than in the normal metabolism, and that living matter can detect what measuring devices based on the recent knowledge provided by modern physics cannot detect. Where could this energy come from? If one wants to answer this, one must also ask what happens in death and what is consciousness and what is life.

1. Dark energy and matter are the two basic puzzles of recent day physics. In the TGD approach, I have identified dark matter as a phase of ordinary matter, for which the effective Planck constant h_{eff} is much larger than normally.

   In particular, the gravitational Planck constant $h_{eff} = h_{gr}$ assignable to gravitational flux tubes can be very large and makes quantum coherence possible even on astrophysical scales. Large Planck constants would be associated with the dark matter magnetic body, which would be the TGD counterpart to the magnetic field of Maxwell's theory, but would differ from it in many respects. As a quantum coherent unit, this magnetic body would control the ordinary biological body and induce its coherence. The classical energy of a magnetic body, consisting of volume energy and magnetic energy, would be dark energy.

2. In the TGD Universe dominated by zero energy ontology, consciousness is a universal phenomenon and present on all scales, from elementary particles to the level of the cosmos. Even galaxies, stars and planets would be conscious beings. Also life and death would be universal phenomena. Likewise, the biological decomposition process associated with death would correspond to the universal decomposition process, which would essentially correspond to the decomposition of magnetic monopole flux tubes (magnetic catabolism), which would induce the catabolism of the breakdown of biomolecules. Its time-reversed version would be magnetic anabolism and induce the building of bio-structures such as molecules.

3. The fundamental metabolic processes would be essentially magnetic anabolism and catabolism induced by "big" state function reductions (BSFRs) changing the arrow of time and inducing the biological anabolism and catabolism. Death would mean reincarnation with the opposite arrow of time.

In Tukdam, the biological body would be dead, but the magnetic body would still be alive and prevent the biological decay from starting. The disintegration of the magnetic body would start

in Tukdam much later than normally, and initiate the disintegration of the biological body. The content of the conscious experience in Tukdam, light sensations and deep peace, would come from the magnetic body. The dead biological body would not provide contribution from sensory input, motor activity, and cognition.

By a strange accident, just before seeing the document about Tukdam, I wrote an article [L30, L31] about a seemingly completely unrelated topic, solar flares related to the reversal of the direction of the sun's magnetic field in the solar cycle, which has a period of 11+11 years.

The reversal of the Sun's magnetic field would correspond to magnetic catabolism as the breakdown of long monopole flux tubes into very short parts. It would be followed by magnetic anabolism as their re-fusion into long flux tubes. The solar cycle would correspond to the sleep-wake cycle, or more precisely: a series of lives in different directions of time. Death would only be a change of time's arrow, nothing final.

The model unexpectedly leads to a biological analogy and to understanding what might happen to the magnetic body in biological death.

3.6 Conditions on the periods with reversed arrow of time

In zero energy ontology (ZEO) falling asleep (death at"my" level of self the hierarchy) corresponds to ordinary - or "big" - state function reduction (BSFR) and also means a reincarnation with opposite arrow of time. We would be therefore conscious during sleep and wake-up would correspond to falling sleep of that other, time reversed self.

When I fall asleep, I wake-up later tomorrow morning for instance, not yesterday morning. It is interesting to see what kind of conditions this implies and whether it is possible to satisfy this easily and even more interesting is to see whether a time travel to the geometric past - maybe the Golden Youth - could be possible.

The following assumptions are made about what happens in BSFR.

1. Causal diamond (CD) is a correlate for self. CD is obtained by gluing together two identical half-cones along their bottoms. Moment "Now" corresponds to the largest hyperplane $T_{now} = T$ (origin of time coordinate is at either (call it "lower") tip of CD) .

2. During the sequence of SSFRs defining self, the 3-surfaces at the passive boundary of self are fixed although their 4-D tangent space changes and corresponds to the unchanging part of selfhood - soul one might say. The opposite active boundary of CD and 3-surfaces at it change and shift towards geometric future.This gives rise to wake-up consciousness involving sensory input and thoughts, emotions etc. induced by it. Each SSFR is preceded by the analog of unitary time evolution.

3. BSFR means a death of self (subself) and its reincarnation with an opposite arrow of time. One can equally well speak about the analog of falling in sleep and waking up after that for some level of hierarchy of selves. The self born in the death of the self with an opposite arrow of time self has no direct memories about the state. Self can however have memories about dreams in which part of say brain is awake. These memories store information about what self experienced during the sleep.

   In BSFR the active boundary of the CD becomes passive and is frozen. The size of CD is scaled down so that CD becomes small: this implies that the reincarnated self has a childhood and much of the memories - often not pleasant - stored near the active boundary as subselves living forth and back as conscious entities disappear. The surviving memories of self become "silent wisdom" of the reincarnated self.

4. If CD belongs to a larger CD, call it CD_{super} representing a larger unit of consciousness, the sub-CDs must shift to the same direction as the active boundary of CD_{super}. Otherwise the sub-CDs would drop from the flow of consciousness. This is analogous to co-movement of matter in cosmology.

   Note that the mental images of self correspond to sub-CDs around T_{now} and shift towards geometric future as CD increases and new mental images emerges at T_{now} plane: by $M^8 - H$ correspondence these special moments in the life of self correspond to roots of the polynomial defining space-time surface and reside are the upper half-cone of the CD. As CD increases,

new roots pop up inside the upper half-cone near the T_{now} hyper-plane for some particular SSFRs. Completely counterintuitively, the mental images about past experiences are therefore in the geometric future of T_{now} hyperplane!

The proposed picture must be consistent with everyday experience. Call the two periods of self sleep wake-up and sleep label the two different BSFRs by "sleep" and "wake-up".

1. In each SSFR CD size increases - at least in statistical sense this implies that T grows. Each SSFR corresponds to a scaling for the CD shifting its active boundary towards the geometric future. During its life cycle CD experiences scaling Λ:

$$T_{now} \to T_{now,sleep_1} = \Lambda(SSFR)T_{now} \quad , \quad \Lambda(SSFR) > 1 \quad .$$

2. When the system falls in sleep the size of CD is scaled down so that also the value of T_{now} is scaled down by $\Lambda_{BSFR} < 1$:

$$T_{now,sleep_2} = (1-\Lambda(BSFR))2T_{now,sleep_1} = (1-\Lambda(BSFR))\Lambda(SSFR)2T_{now} \quad , \quad \Lambda(BSFR) < 1 \quad .$$

After that the CD begins to increase in size by small scalings in SSFRs to opposite time direction and T_{now} begins to decrease from its value $T_{now,sleep}$ begins to decrease.

3. If CD belongs to a bigger CD - call it super-CD - representing a larger unit of consciousness with a longer life cycle, one can argue that the CD must shift to the same direction as the larger CD increases. Otherwise the CD would drop from the flow of consciousness defined by super-CD. This is analogous to co-movement of matter in cosmology. Therefore a given life cycle corresponds also a shift ΔT of sub-CDs towards the growth direction of super-CD takes place and one has for the time coordinate $T_{super,now}$ of the super-CD. Therefore one must perform shift$T \to T + \Delta T$ for $T_{now,sleep_1}$ and $T_{now,sleep_2}$ to take into account the drifting. This gives for the moments "Now" before ad after the shrinking of CD in BSFR (falling asleep):

$$T_{super,now,sleep_1} = T_0 + T_{now,sleep_1} + \Delta T \quad ,$$

$$T_{super,now,sleep_2} = T_0 + (1 - \Lambda(BSFR))2T_{now,sleep_1} + \Delta T \quad .$$

4. Similar formula holds true for the moment of wake-up. In the previous formula T_{now} is replaced with $T_{now,sleep_2}$ and one has

$$T_{super,now,wakeup_1} = T_0 + \Lambda^{1)}(SSFR)T_{now,sleep_2} + \Delta T^{1)} \quad ,$$

$$T_{super,now,wakeup_2} = T_0 + (1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2T_{now,sleep_2} + \Delta T^{1)} \quad .$$

The parameter T_0 depends on the choice of the origin of time for super-CD but is irrelevant.

One can deduce a consistency condition for the parameters of the model.

1. During the sleep period the time coordinate $T_{super,now}$ for moment "Now" in the coordinates of larger CD changes in the following manner:

$$T_{super,now,sleep} = T_0 + T_{now,sleep_1} \to T_{super,now,wakeup}$$

$$= T_0 + \Lambda^{1)}(BSFR)T_{super,now,sleep_2} + \Delta T^{1)} \quad .$$

T_0 is an irrelevant parameter associated with super-CD. Note that there is breaking of time reversal symmetry since self associated with CD_{super} has fixed arrow of time unlike CD. Hence ΔT has at least in a statistical sense the same sign irrespective of the arrow of time of self.

2. This picture should be consistent with what we observe. When the tired average self fall a sleep at the evening, it wakes wake-up at the morning and is full of energy. Quite generally, wake-up occurs after time $\Delta T(sleep)$ meaning that the value of time T_{super} has increased by

$$T_{super,now,wakeup} = T_{super,now}(sleep_1) + \Delta T(sleep) \ .$$

These two expressions for the value of $T_{super,now}(wakeup)$ must be consistent and this gives a conditions on the parameters involved:

$$(1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2T_{now,sleep_1} + \Delta T^{1)}$$

$$= T_{now,sleep_1} + \Delta T + \Delta T(sleep) \ .$$

$\Delta T(sleep)$ is given by

$$\Delta T(sleep) = [(1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2 - 1]T_{now,sleep_1} + \Delta T^{1)} - \Delta T \ .$$

Intuitively it seems clear that for a given arrow of time it is not possible to wake-up before one falls asleep, and the condition $\Delta T(sleep) > 0$ for the standard arrow of time gives a constraint on the parameters. One cannot however exclude the possibility of time travel without dying or falling asleep first of the duration of time travel is much longer than that of wave-up period: $\Delta T^{1)} - \Delta T$.

A special solution corresponds to $\Delta T(sleep) = \Delta T^{1)} - \Delta T$ and $(1-\Lambda^{1)}(BSFR))2\Lambda^{1)}(SSFR) = 1$ giving $T_{now,sleep_2} = T_{now}$.

4 Could brain be represented as a hyperbolic geometry?

There are proposals that neuronal systems in brain could have hyperbolic geometry [J2] (`http://tinyurl.com/ybghux6d`) in the sense that neurons could be mappable to a 2-D lattice like structure representable in terms of to 2-D hyperbolic geometry H^2. A concrete identification as a lattice-like structure in H^2 would not be in question.

4.1 A concrete representation of hyperbolic geometry cannot be in question

The tessellations of P^2 represented as Poincare disk have large density of points near the boundary. The concrete geometry of the cortex could very roughly correlate with the geometry of near the boundary of Poincare disk or even boundary sphere of 3-D Poincare ball representing 3-D hyperbolic space H^3. A rather abstract representation based on statistical properties of the network formed by the neurons would be in question. If a genuine geometric representation as a tessellation of hyperbolic space exist it must be realized somewhere else than brain.

To see what is involved, note that the line element of Poincare disk is given by

$$ds^2 = d\eta^2 + sinh^2(\eta)d\phi^2 \ .$$

to be compared with the line element of ordinary disk given by

$$ds^2 = d\rho^2 + \rho^2 d\phi^2 \ .$$

For given neuron the size of the radial coordinate η of Poincare disk would correspond roughly to the number of connections it has, kind of popularity. For large values of radial coordinate η the circles of Poincare disk have radius proportional to η and circumference proportional to $sinh(\eta)$ increasing exponentially for large values of η whereas for ordinary disk both radial distance circumference would be proportional to ρ.

For the neurons of cortex, in particular pyramidal neurons, the image points would have large distance from the origin of hyperbolic space. The image points for neurons resembling each other would have small distance with respect to the angular coordinate of the Poincare disk. Since

similar neurons can have large distances from each other at the level of brain, the representation must involve a map taking them close to each other.

4.2 Hyperbolic geometry and its tessellations

The standard representations for 2-D hyperbolic geometry are 2-D Poincare plane (`http://tinyurl.com/y8tnklz6`) and Poincare disk (`http://tinyurl.com/y8bcd6cv`). Poincare disk is claimed to be natural representation space for the lattice like structure of neutrons. These lattice structures of H^2 are known as tessellations.

Remark: There is a painting of Escher visualizing Poincare disk. From this painting one learns that the density of points of the tessellation increases without limit as one approaches the boundary of the Poincare disk.

The group $SL(X)$, $X = C, R$, consists of matrices $[a, b; c, d]$ with $a, b, c, d \in X$ satisfying $ad - bc = 1$. The modular group $SL(2, Z)$ acts subgroup of both $SL(2, C)$ and $SL(2, R)$. $SL(2, C)$ *resp.* $SL(2, R)$ forms a double covering of Lorentz group $SO(1, 3)$ *resp.* $SO(1, 2) = SL(2, R)$. $SL(2, C)/SU(2) = SO(1, 3)/SO(3)$ defines 3-D hyperbolic geometry H^3 realized as $a = \sqrt{t^2 - x^2 - y^2 - z^2} =$ *constant* hyperboloid of future light-cone M^4_+ having $SO(1, 3)$ as isometries. $SL(2, R) = SO(1, 2)$ acts as isometries of H^2 realizes as hyperboloid of M^3_+. $SL(2, C)$ *resp.* $SL(2, R)$ acts as complex *resp.* real Möbius (conformal) transformations $z \to (az + b)/(cz + d)$, $ad - bc = 1$, of complex plane *resp.* upper half plane.

The modular group $SL(2, Z)$ acting as the subgroup of $SL(2, R) \subset SL(2, C)$ consists of matrices $[a, b; c, d]$ having integer valued elements satisfying $ad - bc = 1$. Alternative definition identifies the elements differing by sign (`https://en.wikipedia.org/wiki/Modular_group`) is a basic example of infinite discrete sub-group.

Modular group is representable as a free product $Z_2 * Z_3$ with generators S *resp.* T subject to relations $S^2 = I$ and $(ST)^3 = I$. Modular group has braid group B_3 of 3 braids as a universal covering group. Modular group has an infinite number of congruence subgroups $\Gamma(N)$ as subgroups. The diagonal elements of $\Gamma(N)$ satisfy $a \mod N = d \mod N = \pm 1$ and $c \mod N = d \mod N = 0$ so that the matrices are equal to $\pm I$ modulo N. There is also a hierarchy of subgroups $\Gamma_0(N)$ for which matrices are upper triangular matrices modulo N.

In TGD one has also p-adic length scale hierarchy with preferred p-adic primes $p \simeq 2^k$. Therefore the groups $\Gamma(p^n)$ are of special interest in TGD framework.

If replaces N with an extension of rationals, one obtains huge hierarchy of subgroups expected to be relevant in TGD framework. One can define the notion of integer also for the extensions of rationals. Algebraic integer is defined as a root of a monic polynomial $P_n = x^n + ...$ with integer coefficients. Also the counterparts of the groups $\Gamma(N)$ can be defined, in particular those associated with $N = p^n$.

H^n, $n = 2, 3$ allows infinite number of tessellations as left coset spaces $G\backslash H^n$ of $H^n = SO(1, n)/SO(1, 1)$. G is here some infinite discrete subgroup $G \subset SO(1, n)$ of $SO(1, n)$ such as $\Gamma(N)$. For ordinary sphere S^2 the analogs of tessellations are finite lattices and correspond to Platonic solids - tetrahedron, octahedron and cube, and icosahedron and dodecahedron. tessellations would therefore define hyperbolic analogs of Platonic solids.

The groups $SL(2, Z)/Z_N$ are finite groups. For $N = 3$ one obtains tetrahedral group and $N = 5$ gives icosahedral group. Both groups play central role in TGD inspired model of genetic code [L1, L14] but their origin has remained unclear. $\Gamma(N)$ is a normal subgroup $SL(2, Z)$ so that the coset space is group too: $SL(2, Z)/\Gamma(N) = SL(2, Z_N)$. One can represent the elements of group algebra $G(SL(2, Z))$ of $SL(2, Z)$ as entangled elements in the tensor product of $G(SL(2, Z)/\Gamma(N))$ and $G(SL(2, Z_N))$. Number theoretic state function reduction as a "small" state function reduction (SSFR) for elements of $G(SL(2, Z)))$ would project them to unentangled products of elements of $G(SL(2, Z)/\Gamma(N))$ and $G(SL(2, Z_N))$. Maybe genetic code could relate with $\Gamma(N)$ with $N = 3$ and $N = 5$.

4.3 Could magnetic body provide a concrete geometric representation for the tessellation of hyperbolic space?

In TGD framework magnetic body (MB) having an onion-like structure and carrying dark matter as ordinary matter labelled by effective Planck constant $h_{eff} = nh_0$, where n corresponds to the

dimension of extension of rationals serving as a kind of IQ. Various quantum scales, in particular quantum coherence length are expected to be proportional to n so that algebraic extensions of rationals define an evolutionary hierarchy with levels labelled by the dimension of extension. Space-time surface for given value of n can be regarded as a covering spaces with n sheets related by the action of Galois group of Galois extension acting as symmetry.

The question is whether one could generalize the hypothesis [J2] (`http://tinyurl.com/ybghux6d`) in TGD framework. In the sequel such a generalization replacing 2-D hyperbolic space with its 3-D counterpart and assuming that the hyperbolic tessellation is associated with MB of brain or of its subsystem considered. This generalization reduces to P^2 if one restricts P^3 to subspace P^2 and restricts $SL(2,C)$ ($SO(1,3)$) as symmetry to cylindrical symmetry $SL(2,R)$ ($SO(1,2)$). Cylindrical symmetry is natural to magnetic flux tubes and cylindrical magnetic flux sheets so that P^2 option might be more natural.

The notion of MB is extremely general and makes sense in all scales, and one can consider the possibility that the hyperbolic tessellations could provide a kind of universal for the MB of system responsible for cognitive representations.

4.4 Could regions of brain be mapped to tessellations of 3-D hyperbolic space defined by magnetic body?

The question is whether some 3-D lattice-like structures formed by neurons of brain or its subsystem could correspond to tessellations of 2-D or 3-D hyperbolic space H^3 realization as cognitive representations at the MB of brain having hierarchical onion-like structure correlating with hierarchical structure of brain. The tessellation would be defined by an infinite discrete subgroup G of $SL(2,C)$ such that elements are algebraic integers in the extension of rationals. The unit cells of the tessellation would be labelled by elements of G and would therefore define cognitive representation.

One can consider two basic options. Brain or its substructure as 3-D structure is mapped

1. either to a tessellation of H^3 at which $SL(2,C)$ acts as isometries,

2. or to a cylindrically to a tessellation of H^2 at which $SL(2,R)$ acts as isometries represented as upper half-plane or as Poincare disk where the action is as conformal transformation. One can consider also mapping to a complex plane compactified to Riemann sphere at which $SL(2,C)$ acts: now the action is however not as isometries but conformal transformations.

   The interpretation could be in terms of symmetry breaking selecting time axis and spin quantization axis as direction of cylinder.

4.4.1 Some basic facts

Consider first some basic facts about the possible role of 3-D hyperbolic space and its tessellations in TGD.

1. 3-D hyperbolic space H^3 representable as hyperboloid $t^2 - x^2 - y^2 - z^2 \equiv t^2 - r_M^2 = a^2$. a has interpretation as light-cone proper time and in TGD inspired cosmology it corresponds to cosmic time. 2-D hyperbolic space could be seen as subspace of H^3. Now infinite discrete subgroups of $SO(1,3)$ would define tessellations as lattice-like structures. They would serve as 3-D analogs of Platonic solids. I have proposed [K2] that they could explain the astrophysical objects a located along lines with redshifts coming as multiples of a basic redshift in terms of lattice-like structures in cosmic scales.

2. Brain region itself cannot correspond in any manner to a region of H^3 represented as $a = constant = a_0$ hyperboloid. MB of brain region might however do so. The mapping of brain region to the hyperboloid $a = a_0$ could be mediated by gravitational magnetic flux tubes which can be radial since the Kähler flux vanishes in good approximation and there is no conserved monopole flux. Only the cognitive representation as discrete points in extension of rationals would correspond to points of the hyperboloid.

   If MB participates in cosmological expansion assignable to CD, its size would scale up like a as also the cognitive representation associated with the tessellation, whose points would

be labelled by discrete infinite subgroup G - say congruence group $\Gamma(N)$ for extension of rationals. In ZEO this means that the part of tessellation inside CD would approach to the boundary of CD (or cd). The finite size of CD would however prevent the expansion to values of $a > T$, T is the size of CD define as the maximal radius of the intersection light-cones involved. It would also prevent MB from reaching the boundary of CD. One cannot therefore exclude cosmic expansion of MB.

3. One can challenge the assumption about cosmic expansion of MB. Quite generally, all known astrophysical objects participate in cosmological expansion by receding from each other as the cosmic redshifts show but do not experience cosmological expansion themselves. TGD solves this paradox by the assumption that cosmic expansion takes place as quantum phase transitions in which expansion occurs in rapid jerks, which correspond to reductions of length scale dependent cosmological constant Λ by a power of 2 if p-adic length scale hypothesis is accepted [L18] .

   There is evidence that even Earth has experienced this kind of expansion during Cambrian Explosion, which would have increased the radius of Earth by factor 2 [L10]. This would have been also a giant step in biological evolution as the multicellular life developed in the Earth's interior would have bursted to the surface of Earth and oceans would have formed. An interesting question inspired by the fractality of TGD Universe is whether one could see also the biological growth and development of organs and organelles as sequences of this kind of phase transitions.

   This situation might hold true also for MB so that also it should evolve by rapid jerks as the value of Λ is reduced.

4. In TGD space-times are surfaces in $M^4 \times CP_2$. In zero energy ontology (ZEO) they are 4-surfaces in causal diamond (CD), where one has $= cd \times CP_2$, where cd is diamond-like intersection of future and past directed light-cones.

   For light-cone M^4_+ one has a natural slicing is by using the hyperboloids $a = constant$. This slicing would define a natural time coordinate as analog of cosmic time. The usual linear Minkowski coordinates define a second natural natural slicing by $t = constant$ sections, where t is the linear Minkowski time.

   One can define the standard hyperbolic coordinates of M^4_+ by the line element

$$ds^2 = da^2 - a^2(d\eta^2 + sinh^2(\eta)d\Omega^2) \ .$$

   $d\Omega^2 = d\theta^2 + sin^2(theta)d\phi^2$ is the line element of unit sphere S^2. η is the hyperbolic angle identifiable as analog of ordinary angle and having expression

$$tanh(\eta) = \frac{r_M}{t} \equiv \beta$$

   having an interpretation as velocity $\beta = v/c$ n radial direction satisfying $\beta \leq 1$: one has $t = acosh(\eta)$ and $r_M = asinh(\eta)$.

4.4.2 About the precise correspondence between 3-D surfaces and H^3

What could the precise correspondence between 3-D surface giving rise to a cognitive representation of MB and tessellation of H^3 be?

1. The space-time surface representing MB is not hyperbolic space itself but could in some sense have discrete subgroup of $G \subset H^3$ as its symmetries: a possible interpretation would be as cognitive representations [L23, L15] consisting of points of H with coordinates in extension of rationals defining the adele [L6, L7]. The lattice-like structure associated with 3-surfaces could be mappable to this kind of hyperboloid for some value of a.

   Could the part of MB representing sub-system of brain in question be seen as an intersection of the with $t = T$ section of M^4_+ with the slicing of M^4_+ by $a = constant$ hyperboloids such that magnetic images of neurons as points of the tessellation of H^3 defining cognitive

representation would belong to the intersection? For $t > T$ the 3-D structure would be preserved in good approximation.

2. The usual time=constant snapshot in M^4_+ satisfying $t = T$ intersects the hyperboloids with $0 \leq a \leq T$. The condition $t = acosh(\eta) = T$ gives $a = T/cosh(\eta)$ so that a indeed varies in this range. This gives for the radial M^4 coordinate $r_M = asinh(\eta) = Ttanh(\eta)$ giving $r_M \leq T$.

   It seems that this projection is 3-D analog of Poincare disk as a "Poincare ball" of radius $r_M \leq T$ with at least analog of hyperbolic geometry. At least the density of intersections with hyperboloids increases as one approaches light-cone boundary since the density of hyperboloids increases.

3. A tessellation of H^3 corresponds to the points $\{(asinh(\eta_n), \Omega_n)\}$. The lattice-like structure in $E^3$for $t = T$ would correspond to points (r_M, Ω) in $\{Ttanh(\eta_n), \Omega_n\}$. The difference from the representation hyperbolic geometry as H^3 is that instead of $r_M = asinh(\theta_n)$ for H^3 one has $r_M = Ttanh(\eta_n)$ for the analog of Poincare disk. For small values of η one has $sinh(\eta) \simeq \tanh(\eta)$ but not for large values so that E^3 is compressed to Poincare ball B^3.

   Neurons with large number of connections would correspond to points of tessellation with large values of η_n and similar neurons even if far away from each other would be mapped near to each other at spheres η_n = constant surfaces (spheres for H^3 or circles for H^2).

   The discrete geometries for the magnetic image of neural sub-system as tessellations would naturally correspond to discrete subgroups of $G \subset SO(1,3)$ as analogs $G\backslash H^3$ of Platonic solids. As found, there is infinite number of them and concordance groups $\Gamma(N)$ ore of special interest. One obtains also their 2-D variants as 2-D planar slices consistent with the symmetries just like one can have 2-D lattices as sub-lattices of 3-D lattices in E^3.

   Remark: The elements of subgroup $G \subset SL(2, C)$ for given extension of rationals provide natural coordinates for the unit cells of tessellation, and can be used instead of $\{\eta_n, \Omega_n\}$.

4. The system could have a finite size due to finite light-velocity if it has resulted in an event analogous to Big Bang like event (TGD predicts a hierarchy of cosmologies within cosmologies and cd is geometrically analogous to Big Bang followed by Big Crunch). This option does not however look plausible at the level of visible bio-matter. At the level of MB this could be make sense and correspond to the emergence of a new onion-like layers to MB bringing in new scale of quantum coherence as CD.

   In the case of MB one can estimate the T from the assumption that EEG corresponds to communications between brain and particular layer of its MB. Schumann frequency 7.8 Hz corresponds to wavelength of $\lambda = 2\pi R_E$, R_E Earth radius. EEG alpha band is around 10 Hz and corresponds to a slightly shorter wave length lengths. If this frequency is realized as cyclotron frequency the corresponding part of MB should be of the order of Earth size. This would give $R \sim R_E$ and $T \leq R/c \leq .1$ s. The part of neuronal system considered could be the above described intersection corresponding to time $t = T$. After this no expansion would take place and the 3-D analog of Poincare ball would be preserved.

   Note that if MB would participate in cosmic expansion, one would expect that the frequency scale of EEG scales down like $1/a$, which is not observed. Different bands of EEG could however correspond to different values of $a = a_0$ defining different layers of MB.

The neuronal network has been assumed to be accompanied by flux tube network with flux tubes parallel to axons defining the "small" part of MB with size of order body size [L4, L9]. How the topology of this network correlates with the topology of the "large" part of MB with layers having size scales even larger than Earth size? Could the "small" networks at the level of biological body be representations of the "large" networks at the level of MB - or vice versa.

The higher level representations would re-organize the nodes of "small" flux tube networks by various criteria such as the number of connections to other nodes. Similar nodes - even distant ones - would correspond to points near to each other. Therefore similar neurons could be treated as coherent units with coherence induced from that at higher level. Synchronous firing would be the

signature for nearness at the higher level. The hierarchy of layers of MB would perform basically classification of the objects of the system at the lowest level.

There is a huge number of possibilities for the cognitive representations corresponding to various values of N (in particular powers preferred prime p) labeling $\Gamma(N)$, to hierarchy of extensions of rationals and the values of T possibly identifiable as roots of polynomials defining representation of layer of MB in M^8. Therefore one can hope that this vision could provide universal view about the anatomy of MB in relation to that of biological body (in very general sense).

4.4.3 The interpretation of the hyperbolic tessellations of neurons in terms of ZEO, $M^8 - H$ duality, and cognitive representations

This picture suggests an interesting connection to TGD based view about quantum measurement theory [L25], which actually extends physics to a theory of consciousness. Causal diamonds (CDs) have a key role in ZEO and hyperbolic geometry is very naturally associated with them. The notions $M^8 - H$ duality [L21, L20] could provide an explanation for the special value $t = T$, and tessellations could correspond to a particular cognitive representation [L23].

1. In zero energy ontology (ZEO) replacing ordinary ontology of quantum theory the notion of causal diamond (CD) plays a central role. CDs for a length scale hierarchy and CDs have sub-CDs. Space-time surfaces for given CD have ends at the upper and lower boundary of CD. In this picture the appearance of hyperbolic geometry at the level of MB would be very natural.

2. $M^8 - H$ duality [L21] states that space-time surfaces could be regarded either as algebraic surfaces in M^8 or as preferred extremals of action in $H = M^4 \times CP_2$ reducing to minimal surface satisfying infinite number of additional conditions. Otherwise the consistency of dynamics in H dictated by partial differential equations with algebraic dynamics in M^8 dictated by algebraic equations would not be possible.

   One can say that space-time surfaces are roots of an octonionic polynomial obtained as an algebraic continuation of a real polynomial with rational coefficients to octonionic polynomial. This in the sense that either imaginary or real part of P in quaternionic sense vanishes and gives rise to 4-D surface in the generic case.

3. A special prediction of M^8 picture is that besides 4-D surfaces as roots of algebraic equations also 6-D special brane-like solutions with topology of 6-sphere S^6 are possible. For these solutions both real and imaginary parts vanish. These solutions have counterparts in H, and their intersection with cd is $t = r_n$ ball, where r_n is the root of P.

4. I have called the moments $t = r_n$ "very special moments in the life of self" identified as evolution of zero energy state of self by "small" state function reductions (SSFRs) as analogs of weak measurements. Also the size of CD increases in this process in statistical sense and corresponds to the increase of clock time as a natural correlate of subjective time defined by the sequence of SSFRs.

5. Could the state of neuron system at $t = T$ correspond to $T = r_n$ as a root of polynomial P? Could these special moments correspond to rapid jerks in the cosmological expansion so that also the development of living organism would involve a sequence of them increasing the value of Λ. Presumably these jerks would occur at the level of MB and possibly induce those at the level of biological body. At the level o MB they could also correspond to a phase transition like events in the evolution of consciousness involving scaling up the size of MB.

To summarize, the tessellations of H^3 or $E^1 \times H^2$ suggest a universal cognitive representations realized at the MB of the system. One would have hierarchy of p-adic length scales and extensions of rationals giving rise to hierarchies of tessellations defining cognitive representations at corresponding layers of MB. Living matter would be only a special case. In living matter EEG would define important hierarchies of tessellations but also other frequency ranges would do so.

4.5 Empirical support for MB as a carrier of information about state of BB

If the view about hyperbolic brain and body is true, an abstract plan of brain and BB would be realized at MB. There are several findings supporting this view and in the following two examples are described.

4.5.1 Salamander recovers after shuffling of its brain

In the lab, the neurons of the brain of a salamander were shuffled like a pack of cards. The salamander however recovered and preserved its memories (identified as learned behaviors) [J4]. In [K3, K4] this finding was considered as a support for the view that the brain is analogous to a hologram (TGD Universe can be seen as a conscious hologram [K1]). It seems, however, clear that a single neuron cannot represent the information content of the entire brain. However, if memories are represented by the images of neurons at the level of the MB, the shuffling of neurons has no effect on memories as the experiment indeed demonstrated. Neurons would be analogous to RAM in computer science.

4.5.2 A chordate able to regrow all of its organs if dissected into three pieces

The popular article "Polycarpa mytiligera can regrow all of its organs if dissected into three pieces" `https://cutt.ly/SndWg8l` tells about an extraordinary biological discovery.

The creature known as Polycarpa mytiligera is a marine animal commonly found in Gulf of Eilat that is capable of regenerating its organs. The surprising discovery was that the animal can regenerate all of its organs even when dissected into three fragments.

Such a high regenerative capacity has not been detected earlier in a chordate animal that reproduces only by sexual reproduction. In the experiment, the researchers dissected specimens in a method that left part of the body without a nerve center, heart, and part of the digestive system. Not only did each part of the creature survive the dissection on its own, all of the organs regenerated in each of the three sections.

This is highly interesting challenge for TGD. The information about the full animal body was needed for a full generation. How it was preserved in dissection? Was genetic information, as it is understood in standard biology, really enough to achieve this?

1. In TGD inspired quantum biology magnetic body (MB) carrying dark matter as $h_{eff}/h_0 = n$ phases is the key notion. h_{eff} is an effective Planck constant defining the scale of quantum coherence. n is dimension of extension of rationals defined by a polynomial defining space-time region, and serves as a measure for algebraic complexity and serves as a kind of IQ. MB with high IQ defined by n serves as the master of BB controlling it and receiving information from it. The layers of MB also define abstracted representations of BB.

2. If BB suffers damage, the information about BB is not lost at MB and MB, which carries abstracted representations about BB and able to control BB, could restore BB partially. Healing of wounds would be the basic example. A more dramatic example about healing was discovered by Peoch: the neurons of the salamander brain can be shuffled like cards in a package but the animal recovers.

   Indeed, since nothing happens to the MB of salamander or Polycarpa Mytilera, recovery is in principle possible. The new finding gives additional support for MB as a carrier of the biological information.

One can also make questions about the recovery process itself. Could recovery be seen as a self-organization process of some kind?

1. In the TGD framework, quantum measurement theory relies onzero energy ontology (ZEO) and solves its basic problem. The basic prediction is that in the TGD counterparts of ordinary state function reductions ("big" SFRs or BSFRs) time reversal takes place. In small SFRs (SSFRs) identifiable as analogs of "weak" measurements, the arrow of time is preserved. ZEO makes it also possible to understand why the Universe looks classical in all scales although

BSFRs occur in all scales at the dark onion-like layers of MB controlling the lower layers with ordinary biomatter at the bottom of the hierarchy.

2. Time reversed dissipation after BSFR looks like self-organization from the perspective of the outsider with a standard arrow of time, called it briefly O, and would bea basic self-organization process in living systems. In dissipation gradients disappear but in time-reversed dissipation they appear from the perspective of O.

3. This makes possible also self-organized quantum criticality (SOQC), which is impossible in standard thermodynamics because criticality by definition means instability. The change of the arrow of time changes the situation from the perspective of O since the time reversed system tends to approach the criticality. Homeostasis would rely SOQC rather than on extremely complex deterministic control programs as in the computerism based picture. Change the arrow of time for a subsystem and let it happen. Very Buddhist approach to healing!

4. The change of the arrow of time would be also central in the healing processes and also regeneration.

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