Contents

1 Appendix: TGD and TGD based view about quantum biology and consciousness

The main text contains several critical comments challenging the ability of GRT and standard quantum theory to describe living matter properly. Topological Geometrodynamics (TGD) is a proposal for a unification of fundamental interactions and leads also to a new view about space-time, quantum theory, consciousness, quantum biology, and perception. TGD suggests a possible solution of the challenges posed by biology. Therefore a short summary about TGD is in order.

TGD [L1] emerged as a solution to what I call energy problem of general relativity. TGD leads to a new view about space-time and electromagnetic fields implying the notions of many-sheeted space-time and field body/magnetic body (MB), which would play central role in biology [L20] . New space-time concept involves also number theoretical generalization involving p-adic number fields and leading to a proposal for the space-time correlates of cognition.

Number theoretic approach - adelic physics [L2] leads to a prediction of phases of ordinary matter labelled by effective value $h_{eff} = n \times h_0$ of Planck constant giving rise to macroscopic quantum phases identifiable as dark matter and inducing the coherence of living matter. MB would carry dark matter.

The measurement problem of quantum theories forces modification of standard ontology to what I call zero energy ontology (ZEO) [L30] leading to a new view about the relationship of experienced time and geometric time of physicist. ZEO predicts also the occurrence of time reversals reducing self-organization to a dissipative dynamics in non-standard time direction.

1.1 TGD as a unification of fundamental interactions

Topological Geometrodynamics (TGD) [K1, K2] is a 41 year old proposal for a unification of fundamental interactions based on new view about space-time inspired by the problem of General Relativity (GRT) with classical conservation laws ("energy problem"). Matter makes GRT space-time curved leading to the loss of the symmetries of Minkowski space M^4 of Special Relativity (SRT). Poincare invariance implies the conservation laws of energy, momentum, and angular momentum via Noether's theorem [B4] lost in GRT.

If space-time is a 4-surface in space of form $H = M^4 \times S$, S some compact space with very small size, space-time isometries are raised to those of H to regain Poincare symmetries. $S = S = CP_2$ codes for the symmetries of standard model.

1. Classical TGD at space-time level: $X^4 \subset H = X^4 \subset M^4 \times CP_2$. The new elements are many-sheeted space-time topologically non-trivial in all scales, and topological field quantization implying that physical systems have field identity, field body, in particular magnetic body (MB) [L9, L8].

One ends up to a geometrization of gravitational field and gauge fields of the standard model as induced fields. The QFT limit is obtained by replacing the sheets of many-sheeted space-time with slightly curved region of M^4 and identifying gauge potentials and gravitational field as superpositions of induced fields at various space-time sheets.

2. Number theoretical vision is also a part of TGD . p-Adic number fields serve as correlates of cognition and imagination. Space-time is replaced with a book like structure having both real and various p-adic space-time sheets as pages. The outcome is adelic physics as fusion of various p-adic physics [L2]. The extensions of rationals (EQ) induce extensions of p-adic numbers fields and of adeles giving rise to a hierarchy of physics having interpretation in terms of evolution induced by the increase of the complexity of the EQ. Adelic physics leads also the hierarchy of Planck constants $h_{eff}/h_0 = n$ with n identified as dimension of EQ making possible quantum coherence in arbitrarily long time scales essential for understanding living matter.

   Second aspect of number theoretical vision are classical number fields: reals, complex numbers, quaternions and octonions. $M^8 - H$ correspondence [L16, L17] allowing to interpret complexified M^8 as complexified octonions allows to map surfaces of M^8 identified as roots of octonionic polynomials to PEs in $H = M^4 \times CP_2$.

3. Twistor lift of TGD generalizes ordinary twistor approach [L22, L23] so that 4-D masslessness implying problems in twistor approach is replaced with 8-D masslessness so that masses can be non-vanishing in 4-D sense. 4-D space-time surfaces are replaced with the analogs of their twistor bundles for which twistor structure is induced from 6+6-D twistor space of H - a product of twistor spaces of M^4 and CP_2. Twistor space has Kähler structure only for M^4 and CP_2 [A2]. Since Kähler structure is necessary for the twistor lift of TGD, TGD is unique. One outcome is length scale dependent cosmological constant taking a central role in the theory.

1.2 TGD based quantum biology

One can approach TGD inspired quantum biology by making questions.

Problem #1: How to understand coherence of living systems? If only bio-chemistry is involved, we would be sacks of water and sacks of water do not climb in trees or write poems. Could quantum coherence induce the coherence? What entity serve as intentional agent and how it could realize its intentions?

1. Topological field quantization applies to electric and magnetic fields [L8]. For instance, magnetic field decomposes to flux tubes having finite thickness. Radiation fields are topologically quantized to topological light rays. Each system has its fields at separate space-time sheets touching each other only via wormhole contacts: system has field body, in particular magnetic body (MB) having hierarchical onion-like structure corresponding to the hierarchy of space-time sheets. Magnetic flux tubes would take a role analogous to wormholes in the ER-EPR correspondence proposed by Maldacena and Susskind [B3] in GRT context serving as topological correlates and prerequisites for entanglement.

2. MB serves as the intentional agent using biological body (BB) as motor instrument and sensory receptor. MB controls BB via dark photon dark photon beams with large h_{eff}. The double BB + environment is replaced with the triple MB + BB+ environment. The vision about life as nothing but biochemistry is given up.

3. Experiments of Blackman [J1] and others demonstrated the quantal effects of ELF radiation on vertebrate brain. For the ordinary value of Planck constant these effects are however impossible since the energy $E = hf$ of EEG photons is extremely small. This motivated what eventually became $h_{eff}/h_0 = n$ hypothesis derivable now from adelic physics [L2].

4. Dark matter at the flux tubes of MB corresponds to $h_{eff}/h_0 = n$ phases and induces coherence of visible living matter. The generalization and re-interpretation of Nottale's hypothesis [E1], which reads as $h_{eff} = h_{gr} = GMm/v_0$, where $v_0 < c$ has dimensions of velocity and M and m are masses at the ends of the magnetic flux tube along which gravitons travel is

essential element. The hypothesis implies that the cyclotron energy scale for charged particle is independent on m. The spectrum of Josephson frequencies for cell membrane is universal but now the energies are inversely proportional to h_{eff}. The flux tubes containing dark matter would make possible essentially dissipation-free communications based on supra currents and on dark photons.

Problem #2: How MB uses BB as sensory receptor and motor instrument?

1. Dark photons with large h_{eff} serve as as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to bio-photons [J3] with energies covering visible and UV associated with the transitions of bio-molecules [L15, L14]. The control by MB which layers having size even larger than that of Earth means that remote mental interactions are routine in living matter.

2. In ZEO field body and MB correspond to 4-D rather than 3-D field patterns. Quantum states are replaced by quantum counterparts of behaviors and biological functions. The basic mechanism used by MB would be generation of conscious holograms by using dark photon reference beams from MB and their reading. In ZEO also the time reversals of these processes are possible and make possible to understand memory as communications with geometric past. Sensory perception and memory recall would be time reversals of each other and correspond to sequences of SSFRs. Motor action would correspond to BSFRs.

Problem #3: Why metabolism? Particles with nonstandard h_{eff}/h_0 have higher energy as a rule. For instance, atomic binding energies are proportional to $1/h_{eff}^2$ and thus smaller. Cyclotron energies are proportional to h_{eff}. Metabolic energy is needed to excite particles to dark states and thus to increase their "IQ" .

This picture suggests a generalization of the view about self-organization based on non-equilibrium thermodynamics with a quantum view based on number theory, in particular the hierarchy of Planck constants [L3]. In non-equilibrium thermodynamics energy feed is a prerequisite of self-organization leading to a generation of coherent structures in long length scales and master-slave hierarchy is central. TGD can be at least formally seen as complex square root of thermodynamics, which leads to the question whether also ordinary self-organization could reduce to the hierarchy of Planck constants so that quite generally the coherent structures in long length scales could be seen as analogs of life forms with coherence induced by quantum coherence at the level of MBs. Hierarchy of MBs defining master slave hierarchy with ordinary matter at the bottom of the hierarchy would replace ordinary master slave hierarchy and quantum theory would make itself visible in all scales.

Problem #4: What is evolution? Evolution as increase of $h_{eff}/h_0 = n$ means increase of the dimension of extension of rationals in statistical sense at least since the number of extensions with dimension larger than given integer n is infinite and those with dimension smaller n is finite: algebraic complexity increases.

There are many other questions to be answered [L20]. How does genetic code emerge [L24], how to understand morphogenesis [L21], etc..

1.3 How to end up with TGD inpired theory of consciousness?

Materialism/physicalism is kind of meta problem eliminating altogether any serious consideration of the problem. Consciousness is assumed to be property of physical system completely fixed by its physical state. Free will would be illusion. The term conscious-"ness" already reflects the materialistic view. In finnish language the word "tajunta" avoids the interpretation as a property. To proceed, one must give up physicalism. One can proceed further to TGD inspired theory of consciousness by making questions.

Problem #1: How free will could be consistent with the determinism of field equations? What free will could be? It sees that behaviour is built from deterministic time evolutions connecting initial and final states: functions, behaviors, computer programs. Could free be in the selection between them. This suggests a new ontology in which deterministic time evolution becomes basic entity instead of time=constant snapshot of history. y instead of time=constant snapshot of history.

Problem #2: Similar problem plagues quantum measurement theory whose basic empirical rules are formulated in a rather convicing manner by von Neumann using projection postulate [B5]. State function reduction (SFR) is non-deterministic and Schrödinger equation deterministic. This has led to myriads of "interpretations".

The key idea is to replace the usual approach to physics equations as initial value problem with single time =constant snapshot with positions and initial velocities fixed with boundary value problem. One has two time=constant snapshots t_1 and t_2 and fixes now only the initial positions (but not velocities) at them. This can be generalized to fields and their initial values and even to space-time surfaces by replacing boundary values with 2 3-surfaces at time=constant snapshots. This picture is not quite correct but is concrete. A more precise picture will be described below.

Problem disappears if SFR selecs between quantum history defined as a superposition of classical deterministic histories - preferred exremals (PEs) of classical action. Classical physics would become exact part of quantum theory rather than mere approximation. One could speak of zero energy ontology (ZEO): zero energy states (ZESs) would be superpositions of pairs of ordinary quantum states (time=constant snapshot) at different values t_1 and t_2 of time coordinates and only those pairs connected by deterministic time evolution would be allowed.

This would imply classical and quantum conservation laws and total quantum numbers for initial and final states would be same - for book keeping purposes one can say that total conserved quantum numbers are opposite at the two ends - this is the practice in quantum field theories. Hence the term ZES.

The classical time evolutions in the superposition defining ZES are analogous to events in classical sense. They are however not events in the sense of non-terministic SFRs and cannot involve free will.

Problem #3: Experienced time and geometric time of physicist are very different. Subjective time however correlates with the geometric time: contents of sensory experience correspond to moment of geometric time with accuracy of .1 second.

Are there two times and two causalities? Could subjective time correspond to a sequence of SFRs occurring between ZESs. The correlation between the two times requires that in SFR the temporal distance $t_1 - t_2$ increases. Two arrows of time are possible- either t_1 or t_2 changes.

Problem #4: Observer is still an outsider in quantum theory. Observations affect the measured system but there is not attempt to understand the observer as a part of quantum system. Quantum theory of consciousness should be a generalization of quantum measurement theory. The central notion is that of self replacing that of observer.

1. Self is a system having quantum identity and thus able to remain unentangled during time evolution. Schrödinger evolution with non-trivial interactions however entangles the system immediately.

   On the other hand, Zeno effect is known to occur and means that system remains un-entangled when observables are measured repeatedly. Isn't ordinary ontology enough? In some sense conscious entity - self - should have part remaining un-entangled during subsequent measurements.

2. Here zero energy ontology (ZEO) [L30] comes in rescue.

   The first option (not correct) to come in mind is following. Zero energy states (ZESs) are superpositions of pairs of ordinary states at times t_1 and $t_2 > t_1$. Could the state assignable to self at say t_1 be un-entangled and remain unaffected during subsequent SFRs affecting only the states at t_2? Self could be identified as the development of ZES by a sequence of unitary evolutions of the active part of the state at t_2 followed by SFR each. Self would have passive part P corresponding to t_1 - the unchanging part of self and the active part A assignable to t_2 corresponding to sensory input and everything related to it.

   Self would be a generalized Zeno effect. t_2 would increase - at least in statistical sense in each unitary evolution between two SFRs. The increase of t_2 would correspond to the increase of clock time. There would be the desired correspondence between experienced time as a sequence of these SFRs and geometric/clock time as $t = t_2 - t_1$. The sensory input and all induced by it would come from these SFRs and allow to assign clock time to experienced time flow.

The SFR in question cannot correspond to ordinary SFR since in standard quantum theory nothing would happen in it (Zeno effect). This "small" SFR (SSFR) is however analogous to so called weak measurement (`http://tinyurl.com/zt36hpb`) which is much like classical measurement.

3. What about standard SFR - the "big" SFR (BSFR)? Above it was assumed that t_1 corresponds to P. Why also why $t_2 > t_1$ could not correspond to P? The arrow of time a property of ZES would be reversed. Could BSFRs change the roles of A and P. The identification would be as "death" of self and reincarnation as self with opposite arrow of time. These reduction would take place routinely in elementary particle scales, where the lifetimes of selves would be shorter. In the next BSFR self would reincarnate in the original arrow of time.

As already noticed, this realization of ZEO in terms of snapshots is not realistic. How to realize ZEO physically?

1. Quite generally, one can solve the basic problem of quantum measurement theory by replacing initial value problem of classical physics with boundary value problem. A pair of time=constant snapshots at times $t = t_1$ and $t_2 > t_1$ is the first guess but is however not the correct choice.

   Rather, causal diamond (cd) formed as an intersection of future and past directed light-cones of M^4 is a more natural notion. cd is formed as spherical light front expands for time $T/2$ and contracts for time $T/2$ after that. The temporal distance between the tips of cd is T. The boundary of cd has two pieces opposite to each other. They are parts of light-cone boundary meeting at the sphere $r = T/2$. At the level of H cd is replaced with CD $=cd \times CP_2 \subset M^4 \times CP_2$.

   CD is identified as a imbedding space correlate for self determining the perceptive field of self. One has actually entire hierarchy of CDs within CDs with varying quantized size assignable to self hierarchy.

   (a) CD is more natural than pair of time=constant snapshots of H since the infinite size of the space-bounded by time=constant snapshots of H is mathematically problematic. The boundary of CD is also connected.

   (b) CD is natural in WCW geometry since its boundary has symplectic transformations of light-cone boundary as infinite-D symmetries analogous to Kac-Moody symmetries with light-like radial coordinate in the same role as the complex coordinate in conformal field theories. The metric 2-D of light-cone boundary of M^4 also implies huge extension of ordinary conformal symmetries.

   (c) CD has a natural interpretation as a correlate for the perceptive field of self. The past-direct light-cone defines the region about which sensory input comes as classical signals. The intersection of future directed light-cone with past-directed light-cone boundary defines the region from which the sensory input from self as a conscious entity emerges.

2. Zero energy ontology (ZEO) involves the hierarchy of causal diamonds (CDs) as correlates for perceptive fields of selves. The idea about ZES as pair of states at time t_1 and t_2 is not natural in TGD framework and is replaced with a notion consistent with the infinite-dimensional symmetries of TGD assignable to the light-cone boundary and to light-like 3-surfaces which play key role in TGD.

   ZESs are superpositions of deterministic classical time evolutions connecting passive "lower" boundary P and active "upper" boundary A of CD. The classical deterministic time evolution corresponds to a space-time surface - preferred extremal (PE) - connecting the 3-surfaces at P and A. There are also spinor fields obeying deterministic dynamics dictated by super-conformal symmetry.

3. The active boundary A of CD moves farther away from the passive boundary P by unitary time evolutions inducing de-localization of A. SSFR induces localization of A and after it ZES corresponds to single CD. The expectation is that the temporal distance between the tips of CD increases in statistical sense.

In BSFR the roles of A and P change and the former P begins to shift to opposite direction of geometric time. CD however increases in statistical sense all the subjective time. This increase would correspond to cosmic expansion. Could selves evolve gradually evolve to entire cosmologies? Their energy content would increase. This is not prevented by ZEO: classical conservation laws hold true for all PEs but due to the localizations of CDs energy conservation in quantal sense can be broken slightly.

Problem #4: Are we the only conscious systems or is pan-psychism realized in some sense? For physicist it is very difficult to imagine anything but pan-panpsychism. There would be self hierarchy corresponding to length scale hierarchy. Self would have sub-selves, which it experiences as mental images. Sub-sub-selves would be experienced as kind of averages. Self in turn defines mental image of self above it. These 3 preferred levels in hierarchy for given self would correspond to super-ego-ego-Id triplet of Freud.

An attractive idea that CDs form a fractal analog for covering of manifold by open sets defining an atlas of charts. Now the charts would be conscious entities. CDs can have sub-CDs (mental images) and CDs can also intersect so that sharing of sub-CDs and corresponding mental image is possible.

Problem #5: What about the physical and possible space-time correlates for cognition and imagination?

1. p-Adic number fields, $p = 1, 2, 3, 5, 7...$ [A1] obtained as completions of rationals emerged to TGD via p-adic mass calculations [L7, L11, L12, L13] relying p-adic length scale hypothesis are for several reasons natural candidates for the correlates of cognition. p-Adic topology defined by ultrametric was proposed already by Parisi [B2] to be natural for description of cognition. Non-determinism of p-adic differential equations due to the p-adic pseudo-constants having vanishing derivative but depending on finite number of pinary digits serves as a natural space-time correlate for imagination. Only the regions in which pseudo-constant are genuine constants have real counterparts and are realizable imaginations.

2. p-Adic physics would be a natural correlate for cognition. Correlates of imagination would be space-time sheets obeying the same field equations as real ones. Cognitive representation are discrete and finite and would consist of a discrete sets of point of space-time surface for which imbedding space coordinates belong to the extension of rationals considered so that they are shared by real and various p-adic space-time sheets.

3. Ramified primes of n-D extension allow product composition as a product of primes of the extension such that the number of these primes is smaller than n with some primes of extension appearing as powers higher than 1. In the case of split primes this number has the maximal value n and for non-split primes the number is 1: the numbers of these two kinds of primes are infinite whereas the number of ramified primes is finite. Furthermore, the p-adic counterparts of polynomials defining space-time surface in M^8 and extension of rationals via their roots have in $O(p) = 0$ approximation multiple roots so that they correspond to critical dynamics for cognition and physics too.

   The quantum criticality of TGD therefore suggests that ramified primes are both cognitively and physically preferred (defining preferred p-adic length scales as kind of set of organisms able to live in symbiosis). Therefore the collection of ramified primes of extension defines a special set. For hierarchies of polynomials obtained by functional composition $P = P_{n_k} \circ P_{n_{k-1}} .... \circ P_{n_1}$ of irreducible polynomials with the property $P_r(0) = 0$ the ramified primes of all levels are ramified of P and analogous to conserved genes as also the extensions in the hierarchy. One obtains infinite number of evolutionary hierarchies with conserved "genes" having also interpretation as an abstraction hierarchy.

Problem #6: How to understand intelligence and evolution of intelligence?

1. p-Adic number fields allow an infinite number of extensions induced by finite-dimensional extensions of rationals: besides algebraic extensions one can have extensions defined by roots of e. These define a hierarchy in which algebraic complexity increases.

2. The natural interpretation for the increase of the dimension of algebraic extension of rationals is as increase of the complexity of cognition and evolution can be assigned to the increase of extension of rationals. This increase is unavoidable since the number of extensions with dimension larger than given integer n is infinite and those with dimension smaller than n is finite. The value of effective Planck constant $h_{eff}/h_0 = n$ introduced by observations about effects of ELF em fields on brain and proposed to label a hierarchy of dark matters as phases of ordinary matter could correspond to the dimension of extension. The larger the value of n, the large the scale of quantum coherence, and the more complex the living systems in question.

   Remark: Shannon formula with the logarithm of probability replaced with the logarithm of the p-adic norm of probability allows negative values of Shannon entropy having interpretation as information associated with the entanglement [L18]. Ordinary entanglement entropy measures the ignorance about the state of either entangled system.

3. All p-adic numbers fields are needed and this leads to a fusion of reals and the extensions of p-adic number fields induced by given extension of rationals to form an adele [L2]. The hierarchy of adeles defines an evolutionary hierarchy. The dimension $n = h_{eff}/h_0$ of extension serves as a universal "IQ".

4. A physical correlate for ethics is suggestive. Good deeds increase conscious information of the Universe. Bad deeds reduce the conscious information. Bad deeds indeed force secrecy and reduction of conscious information: evil doer does not usually boast with his deeds and unethical acts lead to secrecy. Quite concretely: good deeds increase quantum coherence and bad deeds reduce it.

These question represent only a small fraction of what must be understood. One can ask about the correlates for directed attention, intentionality, emotions, memory, anticipation, qualia, etc..??

1.4 ZEO and reduction of self-organization to dissipation with reversed arrow of time

ZEO based quantum measurement theory leads to a new view about self-organization.

1. There are two kinds of state function reductions: SSFRs and BSFRs [L29]. In SSFRs members of states at "passive" boundary of CD are not changed but active boundary and states at it change. Statistical sense active boundary recedes from passive one. The distance between tips identifiable as clock time (geometric time) and correlating with subjective time as sequence of SSFRs increases.

   BSFRs correspond to ordinary state function reductions and in these the arrow of geometric time changes. The self assignable to SSFRs dies and and reincarnates but with opposite arrow of time [L30, L28]. The experiments of Minev et al [B1] give direct support for ZEO based quantum measurement theory [L25].

2. ZEO leads also to a new view about self-organization [L27]. Self-organization involves generation of coherence in longer length and time scales and requires energy. In ZEO self-organization reduces to dissipation in opposite arrow of time (second law applies now in opposite arrow of time). Dissipation of energy corresponds in standard time direction extraction of energy from environment - feed of metabolic energy. Generation of structures/gradients (temperature, concentrations) correspond to their disappearance in opposite time direction. Biological systems would be basic example of this. Already Fantappie [J2] proposed the possibility of time reversal and suggested that syntropy as time reversed entropy plays key role in living matter.

3. Under what conditions BSFR does take place? I have proposal several ad hoc answers to this question. One can however adopt an empirical approach and look what happens in biological death and birth of a biological organism, which should now occur in time reversed sense. The metabolic energy feed to the system is needed to increase the average value of h_{eff} or at least to maintain the distribution of effective Planck constants $h_{eff} = n \times h_0$ with n identifiable

as a dimension for an extension of rationals and a measure for algebraic complexity an kind of "IQ". BSFR could occur when metabolic energy feed is not enough to guarantee increase of CD size correlating with the increase of average h_{eff}. Time reversal in BSFR would solve the problem. This approach suggests a rather detailed view about what might happen in BSFR [L6].

1.5 The view about perception inspired by ZEO

The philosophical ideas behind TGD inspired biology and neurosciece are described in [L20]. TGD based view about sensory perception is discussed in [L19].

1. Boundary of system, "skin" would correspond to that of space-time sheet. It would be boundary of the projection of 3-surface in $M^4 \times CP_2$ to M^4 rather than genuine boundary of 3-surface.

2. In neuroscience one assumes that sensory qualia are produced at the level of brain and this leads to problems. In TGD sensory organs are the seats of qualia. New view about time allows to circumvent the obvious objections such as phantom limb. This resolves the basic problem of neuroscience due to the fact that brain area associated with various sensory qualia do not seem to differ in any manner.

3. If the sensory organs are seats of the qualia, sensory processing must involve feedback loop between sensory organ and brain and perhaps even magnetic body. Brain (perhaps MB) would provide feed back as virtual sensory input and the process would to a standardized sensory mental image. The communication by nerve pulses is quite too slow for this purpose. TGD proposal is that dark photons propagating parallel to magnetic flux tubes parallel to axons are the real communication too. Bio-photons in energy range of visual and UV photons would result as dark photons transform to ordinary photons (h_{eff} is reduced to h). Dark photon communications would explain why the effective nerve pulse conduction velocity can approach light-velocity.

   Sensory percept would be an artwork. There the assumption that identical genomes give rise to identical perceptions would not be realistic. Every organism would be an artist.

   The function of nerve pulses would be to connect the flux tubes associated with axons of pre- and post-synaptic neuron to single flux tube so that dark photon signals can propagate. This would be like opening communication channel in usual IT communications. Keeping it open all the time would cost too much energy. The increase of h_{eff} for ions associated with flux tubes might be also involved and indeed requires metabolic energy. Nerve pulses patterns would generate generalized Josephson radiation communicating sensory data represented by it to MB.

4. Attention would be part of recognition or perhaps the recognition. Attention has as correlate flux tube connection between the attending system and target of attention making possible flow of dark photons and supra currents. This would be true when the target is system of external world or sub-system of brain. The dynamic flux tube networks in which connecting flux tube means attention would be essential for brain functioning.

   At molecular level the attention in this sense makes possible for water to recognize invader molecules using U-shaped flux tubes acting as tentacles and reconnecting with similar flux tubes of target molecule. This would also allow to build a magnetic representations for the cyclotron frequency spectrum of these molecules. This would give rise to water memory and primitive immune system [L10].

1.6 Some comments about topics discussed in the main article

1.6.1 Quantum of time

In what sense time quantum could be understood.

1. Subjective time and geometric time. SSFRs correspond to time chronons ΔT identifiable as changes of the distance between tips of CD. T increases in statistical sense. Quantization of perceived clock time. No quantization at the level of geometry.

2. Cognitive representations give rise to a discretization of space-time. This represents finite measurement and cognitive resolution and does not correspond genuine quantization.

3. Very special moments in the life of self. Correspond to special values of M^4 time as roots of polynomials. Could be associated with phase transition like phenomena.

1.6.2 Maximal signal velocity and space-time metric

In classical GRT there is no reference with which to compare the metric. Maximal signal velocity corresponds to light-like geodesic. I TGD the situation changes.

- In TGD framework space-time is surface in $M^4 \times CP_2$ and the flat metric of Minkowski space M^4 serves as a universal reference metric with one can compare. Typically the maximal signal velocity along space-time surface is smaller than in M^4.

- CP_2 length scale in turn gives universal meter stick. M^4 also provides preferred coordinates: in general relativity general coordinate invariance allows all coordinates and in general case there are no preferred coordinates. Besides this H provides well-defined conserved quantities.

- In TGD M^4 metric serves as a reference metric. Light-velocity in Minkowskian regions of space-time surface smaller than in M^4. In regions with Euclidian signature - which are also possible - one cannot speak about light-velocity and signals. The interior of the space-time surface for elementary particle is basic example. The orbit of the 3-surface defining elementary particle however serves as a signal.

1.6.3 Enhanced cognition and sensory perception

In TGD framework a more plausible reason for enhanced cognition and sensory perception be due to the generation of phases with larger h_{eff}. Requires metabolic energy feed.

Larger h_{eff} implies quantum coherence in longer scale and improveds the precision of percetion since cognitive representations become more accurate - the number of space-tme points having imbedding space coordinates in extension of rationals increases with the dimension $n = h_{eff}/h_0$ of extension.

Sensory and cognitive enhancement would require generation of phases with larger value of h_{eff}. This requires quantum criticality - essentially generation of more sensitive sensory receptors - and feed of metabolic energy.

The possible role of hyperbolic geometry is mentioned. In TGD framework hyperbolic geometry would provide a natural framework for cognitive representation at magnetic body [L5]. Highly unique cognitive representations would be in question. Cognitive representation would form a hierarchy and layers of MB with larger values of h_{eff} would correspond to more abstract cognitive representations.

1.6.4 Time localization of events and the notion of causal reference frame

The notion of causal reference frame as assignment of local light-cone to each point of space-time was criticized in the main text.

1. In TGD framework the problem can be seen as being caused by wrong view about time. In TGD framework one must distinguish between subjective and geometric time. Subjective time corresponds to sequence of SSFRs and each conscious observer has its own subjective time. This applies to all systems, not only HOs. Subjective time ordering is directly experienced. The experienced order of SSFRs corresponds to that of geometric time values only statistically so that identification of the two times is not possible: the two times are however strongly correlated in ZEO. Time ordering anomalies are predicted.

   For instance the chronon of sensory experience about .1 seconds. Below this time scale the time order of events does not make sense. Even longer uncertainties are possible and this

might be testable. For instance, the ordering of letters typed at computer can vary. This might have a mundane explanation but could also reflect different orders of geometric and subjective time.

2. p-Adic physics could serve as a model for the time ordering anomalies resulting when geometric time is identified as subjective time. p-adic numbers are not well ordered and the p-adic analog of time coordinate could serve as a statistical model for subjective time for a system characterize by p-adic prime p. Its mapping via canonical identification $\sum z_n p^n \to x_n p^{-n}$ to real time coordinate would not preserve time ordering in strict sense.

1.6.5 Scavanger hunter task and precognition

The strange findings about scavenger hunter task suggest that precognition is involved. Also state function reduction in the sense of ZEO might be involved and somehow explain why the knowledge about the future participation to scavenger hunter task improved the estimates about success in it.

1. In TGD framework precognition would be made involve macroscopic quantum coherence and quantum entanglement and require also ZEO allowing the propagation of signals in both time directions. The arrow of time would change in BSFR. In neuro science motor actions would correspond to BSFRs changing the arrow of time and sensory perceptions to SSFRs.

2. One could see to geometric future/past by sending a future-/past- signal which is time reflected. Memory and precognition could be seen as seeing in time direction. The time reflection would involve BSFR for a sub-CD.

3. This allows to overcome light-velocity barrier and communications with arbitrary distance space-time regions in both time directions in principle become possble.

1.6.6 Perception of earth quakes as perception of signals propagating backwards in time?

There seems to be no consumption of metabolic energy but actually its increase in the perception of earthquakes, suggests that ELF radiation represents time reversed signals and time reversed metabolism. In TGD framework earthquakes could be macroscopic BSFRs changing arrow of time at some layers of MB [L26]. The em radiation generated by earthquake would propagate to geometric past. Time reversal at the level of MB would induce effective time reversal at the level of ordinary matter. Are the perceived signals time reversed signals generated by BSFR? This kind of sensory perception could be also regarded as precognition.

How the ELF signals preceding earthquake could be detected?

1. Magnetic flux tubes are ideal antennas and could make possible electromagnetic perceptions. Magnetic flux tube connections would serve also as correlates of attention. In the model for water memory U-shaped flux tubes serving as tentacles would reconnect with those of invader molecule and form bridges formed by two flux tubes between the water's MB and target molecule. Resonance for dark cyclotron photons would serve as a mechanism of attention and recognition: tuning to the same wavelength would be the mechanism.

2. Dark photons with large h_{eff} transforming to ordinary photons identifiable as bio-photons [J3] in visible and UV (at least) could make possible em perception in the entire wave legth range. Also magneto-reception becomes possible since flux tube antennas can serve also a compass: this leads to a model for the ability of birds to navigate in Earths' magnetic field [L4].

   The magnetic flux tubes of water serving as antennas give rise to water memory. Also now the MB of biological water could be involved and develop flux tubes having cyclotron frequencies at the frequencies associated with earthquakes. Natives living in regions where earthquarks occur would develop this kind of flux tube system allowing to perceive the em radiation associated with the earthquake.

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