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Conditioning of Space-Time: The Relationship between Experimental Entanglement, Space-Memory, and Consciousness

Appendix 1

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Contents

1 Introduction **2**

2 Some basic notions and ideas **2**
2.1 TGD based view about space-time 2
2.2 Zero energy ontology and consciousness 3
2.3 TGD based ideas about information 5
2.3.1 Potentially conscious information as negentropic entanglement 5
2.3.2 How to make information conscious? 6
2.3.3 Information transfer physically 7
2.4 Defining notions like memory, learning, and conditioning 8
2.5 Hierarchy of Planck constants and dark matter 10
2.6 Biophotons and remote mental interactions 11
2.7 Time and length scales of consciousness 11
2.8 Relation of magnetic body to morphic fields of Sheldrake 13

3 Space **14**
3.1 Questions related to information and entanglement 14
3.2 Excess correlations as entanglement? 15
3.3 Em fields and information 16
3.4 Does space learn and remember? 17

4 Time **19**
4.1 Questions related to morphic resonance 19
4.2 Does time-like entanglement make sense 19
4.3 Holding times for space-memories 21
4.4 ESP, precognition, and sleep 22

1 Introduction

Thanks for Joey for excellent questions which to my opinion relate just to the key problems. The notions of information, entanglement, conditioning, space-memory, etc... provide nice challenges for articulation using TGD based concepts.

Before answering the questions I will formulate the basic concepts needed in TGD framework to make it easier to understand what follows. This already provides partial answers to many questions.

2 Some basic notions and ideas

Before answering the questions it is reasonable to first define basic notions such as information, entanglement, transfer of information, etc.. in TGD framework.

2.1 TGD based view about space-time

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

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

2. Induction procedure allows to geometrize various fields. Space-time metric characterizing gravitational fields corresponds to the induced metric obtained by projecting the metric tensor of H to the space-time surface. Electroweak gauge potentials are identified as projections of the components of CP_2 spinor connection to the space-time surface, and color gauge potentials as projections of CP_2 Killing vector fields representing color symmetries. Also spinor structure can be induced: induced spinor gamma matrices are projections of gamma matrices of H and induced spinor fields just H spinor fields restricted to space-time surface.

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

   M^4 and CP_2 are unique choices for many other reasons. For instance, they are the unique 4-D space-times allowing twistor space with Kähler structure. M^4 light-cone boundary allows a huge extension of 2-D conformal symmetries. Imbedding space H has a number theoretic interpretation as 8-D space allowing octonionic tangent space structure. M^4 and CP_2 allow quaternionic structures. Therefore standard model symmetries have number theoretic meaning.

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

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

   One ends up with a generalization of space-time surface to many-sheeted space-time with space-time sheets having extremely small distance of about 10^4 Planck lengths (CP_2 size). As one adds

a particle to this kind of structure, it touches various space-time sheets and thus interacts with the associated classical fields. Their effects superpose linearly in good approximation and linear superposition of fields is replaced with that for their effects.

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

5. A further objection is that classical weak fields identified as induced gauge fields are long ranged and should cause large parity breaking effects due to weak interactions. These effects are indeed observed but only in living matter. The resolution of problem is implied by the condition that the modes of the induced spinor fields have well-defined electromagnetic charge. This forces their localization to 2-D string world sheets in the generic case having vanishing weak gauge fields so that parity breaking effects emerge just as they do in standard model. Also string model like picture emerges from TGD and one ends up with a rather concrete view about generalized Feynman diagrammatics.

2.2 Zero energy ontology and consciousness

Zero energy states of ZEO correspond in positive energy ontology to physical events and break time reversal invariance. This because either the positive or negative energy part of the state is reduced/equivalently prepared whereas the second end of CD corresponds to a superposition of (negative/positive energy) states with varying particle numbers and single particle quantum numbers just as in ordinary particle physics experiment.

The first state function reduction at given boundary of CD must change the roles of the ends of CDs. This reduction can be followed by a sequence of reductions to the same boundary of CD and not changing the boundary nor the parts of zero energy states associated with it but changing the states at the second end and also quantum distribution of the second boundary in the moduli space of CDs. In standard measurement theory the follow-up reductions would not affect the state at all.

The understanding of how the arrow of time and experience about its flow emerge have been the most difficult problem of TGD inspired theory of consciousness and I have considered several proposals during years having the geometry of future light-cone as the geometric core element.

1. The basic objection is that the arrow of geometric time alternates at imbedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappie [J1] to introduce the notion of syntropy. This suggests that the arrow of time depends on the size scale of CD and of space-time sheet.

   The solution of the problem is trivial in ZEO. In the ordinary quantum measurement theory one must assume that state function reduction can occur repeatedly: the assumption is that nothing happens to the state during repeated reductions. The outcome is Zeno effect: the watched pot does not boil.

   In TGD framework situation is different. Repeated state function reduction leaves the already reduce parts of zero energy state invariant but can change the part of states at the opposite boundary. One must allow a delocalization of the second boundary of CDs and one assumes that the second tip has quantized distance to the fixed one coming as multiple of CP_2 time. Also Lorentz boosts leaving the second CD boundary invariant must be allowed. One must therefore introduce a wave function in the moduli space of CDs with second boundary forming part of fixed light-cone boundary ($\delta M^4_{\pm} \times CP_2$).

2. The sequence of state function reductions on a fixed boundary of CD leads to the increase of the average temporal distance between the tips of CDs and this gives rise to the experience about flow of time as shifting of contents of perception towards future if the change is what contributes to conscious experience and gives rise to a fixed arrow of time.

3. Contrary to original working hypothesis, state function reduction in the usual sense does not solely determine the ordinary conscious experience. It can however contribute to conscious experience and the act of free will is a good candidate in this respect. TGD view about realization of intentional action assumes that intentional actions involve negative energy signals propagating backwards in geometric time. At some level of CD hierarchy the arrow of geometric time changes and the reduction start to occur at opposite boundary of CD at some level of length scale hierarchy.

The concept of self seems to be absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness and would be counterpart for observer in quantum measurement theory.

1. The original view was that self corresponds to a subsystem able to remain un-entangled under the sequential informational 'time evolutions' U. It is however unclear how it could be possible to avoid generation of entanglement.

2. In ZEO the situation changes. Self corresponds to a sequence of quantum jumps for which the parts of zero energy states at either boundary of CD remain unchanged. Therefore one can say that self defined in terms of parts of states assignable to this boundary remains unaffected as sub-system and does not generate entanglement. At the other boundary changes occur and give rise to the experience of time flow and arrow of time since the average temporal distance between the tips of CD tends to increase.

   When the reductions begin to occur at the opposite boundary of CD, self "falls asleep": symmetry suggests that new self living in opposite direction of geometric time is generated. Also in biological the change of time direction at some level of hierarchy might take place.

3. It looks natural to assume that the experiences of the self after the last 'wake-up' sum up to single average experience. Subjective memory is identifiable as conscious, immediate short term memory. Selves form an infinite hierarchy with the entire Universe at the top. Self can be also interpreted as mental images: our mental images are selves having mental images and also we represent mental images of a higher level self. A natural hypothesis is that self S experiences the experiences of its sub-selves as kind of abstracted experience: the experiences of sub-selves S_i are not experienced as such but represent kind of averages $\langle S_{ij} \rangle$ of sub-sub-selves S_{ij}. Entanglement between selves, most naturally realized by the formation of flux tube bonds between cognitive or material space-time sheets, provides a possible a mechanism for the fusion of selves to larger selves (for instance, the fusion of the mental images representing separate right and left visual fields to single visual field) and forms wholes from parts at the level of mental images.

4. Self corresponds in neuroscience to self model defining a model for organism and for the external world. Information or negentropy seems to be necessary for understanding self. Negentropically entangled states - Akashic records - are excellent candidates for selves and would thus correspond to dark matter in TGD sense since the number of states in superposition corresponds to the integer n defining h_{eff}. It is enough that self is potentially conscious: conscious experience about self is generated only in interaction free measurement. Repeated state function reductions to given boundary of CD is second possibility. This would assign irreversibility and definite arrow of time and experience of time flow with self.

5. CDs would serve as imbedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CDs). At space-time level space-time sheets in given p-adic length scale would be the natural correlates of selves. One ends also ends up with concrete ideas about how the localization of the contents of sensory experience and cognition to the "upper" (changing) boundary of CD could take place. One cannot exclude the possibility that state function reduction cascades could also take place in parallel branches of the quantum state.

2.3 TGD based ideas about information

2.3.1 Potentially conscious information as negentropic entanglement

I believe however that it is possible to talk about potentially conscious information.

1. Many-particle property of information suggests that in quantum context entanglement is a reasonable physical correlate for this kind of information. Entanglement entropy as a measure and this is interpreted as single particle property and a measure for the lack of information about the state of the entangled particle. One can however interpret this entropy also as a characterizer of the relationship between the two systems.

   Could one assign to this relationship a potentially conscious information and find a measure for it. This information measure should satisfy same axioms as Shannon's entropy but should be non-negative. A number theoretical modification of Shannon entropy satisfying the same axioms indeed exists. The probabilities appearing in the arguments of logarithms are replaced with their p-adic norms with some p-adic prime p. It is certainly defined for rational entanglement probabilities but can be defined also for probabilities in algebraic extensions of rationals. For some p-adic prime this information measure is maximized. Should this p-adic prime characterize the cognitive relationship between the two systems?

2. One can look the situation also from the point of view of generalized quantum measurement theory. The fundamental observable for a pair formed by sub-system and complement is assumed to be the density matrix describing the entanglement between them. Consider first ordinary entanglement entropy defining negative information. In quantum jump for a given system a reduction of the system to unentangled pair of subsystem and complement would occur provided this generates negentropy. Negentropy Maximization Principle (NMP) states that the reduction occurs for a subsystem-complement pair for which the reduction of entanglement entropy is maximal. The outcome would be zero negentropy for this subsystem-complement pair. The process would continue until no divisions to this kind of pair are possible.

3. Suppose now that the entanglement is negentropic. In this case the state function reduction to un-entangled state does not reduce entropy and is thus not allowed. Therefore NMP would favor the preservation and even generation of negentropic entanglement.

There is however a problem. One can always say that rational/algebraic entanglement is only a special case of real entanglement and that there is no experimental manner to distinguish rational entanglement from transcendental entanglement without infinite measurement resolution. How can one distinguish between negentropic and ordinary entanglement? What makes entanglement negentropic?

1. One should have consistency with standard quantum measurement theory. In standard measurement theory entanglement for which density matrix is proportional to unit matrix is exceptional since all entanglement probabilities are exactly equal. In the real situation one can never require this but in some critical situation this condition might be natural.

2. Consider the formulation of quantum measurement theory in TGD framework. The first condition is certainly that state function reduction occurs to an eigenspace of density matrix. In the generic case a ray of Hilbert space is the outcome since entanglement probabilities are in general different. If there are several degenerate entanglement probabilities, this principle does not tell all.

3. Negentropy Maximization Principle in the real context would force to select a ray. But in this kind of situation one can also define entanglement entropy using number theoretic Shannon entropy. If this is done, the entanglement would be negentropic and stable! State function reduction does not occur.

4. Density matrix proportional identity matrix corresponds in the case of 2-body entanglement to unitary entanglement coefficients typical for quantum computing systems, and can be negentropic. In this case one can definitely say that entanglement is rational with probabilities $p_i = 1/N$, and one can use the number theoretic Shannon entropy which is negative and identifiable as information

measure. This notion generalizes to n-body systems. If the entanglement is negentropic for all sub-system-complement pairs, the system can be stable with respect to NMP.

5. What kind of systems could possess unitary entanglement or its generalization n-body systems. Hierarchy of Planck constants interpreted in terms of non-determinism of Kähler action defining the basic variational principle of TGD defines a hierarchy of phases interpreted as dark matter and serving as excellent candidates for macroscopic quantum phases for large values of $h_{eff} = n \times h$. The non-determinism implies that two space-like 3-surfaces at the ends of causal diamond (CD) have large number of space-time surfaces connecting them. In fact, there is continuous degeneracy. Conformal transformations act as gauge symmetries giving rise to new space-time surface of this kind and one can assume that the number n conformal equivalence classes is finite. Since all classical and quantal observables have same values for the different sheets one can assume that the entanglement associated with a pair of systems characterized by same value of n is unitary and thus completely democratic with respect to sheets. Dark matter would make potentially conscious information possible as negentropic entanglement and would imply evolution and would make living matter living.

The variational principle guaranteeing this would be maximization of negentropy gain (NMP) in quantum measurement implying that negentropy (nothing to do with negative of thermodynamical entropy) is maximized as negentropy entanglement is generated.

1. How negentropic entanglement (NE) could represent information? It might have interpretation as formation of quantum rules: the state pairs in the superposition would be different instances of the rule. The large the number of superposed states, the larger the information and the higher the abstraction level of the rule. Universe would be forming this kind of rules and at the same time building more and more NE. I have spoken about "Akashic records" as a kind of Universal library.

2. DNA-cell membrane system could be basic realization for Akashic records. According to the DNA as topological quantum computer model nucleotides would be connected by magnetic flux tubes with the lipids of nuclear or cell membrane or both. The braiding of flux tubes would make possible topological quantum computation. The charged particles at the ends of flux tubes would be negentropically entangled by unitary matrix defininig the computation.

The Fock space of fermions defining WCW spinor space is hyperfinite factor of type II_1 (HFF) [K3]. In this case rays of Hilbert space are replaced with infinite-dimensional subspaces and it is not possible to reduce the state to Hilbert space ray. The entanglement inside this kind of sub-space correspond however to unit matrix but with trace which is finite unlike for factors of type I for which it is just the infinite dimension of Hilbert space. Finite measurement resolution usually regarded as a loss of information would force negentropic entanglement!

For entangled HFF factors one can never perform state function reduction to a ray of Hilbert space and the outcome is always an entangled system with infinite number of degrees of freedom in the usual sense of the word. From the theory of Jones inclusions with included factor having interpretations as the space which replaces Hilbert space ray, the dimension D of the space of quantum states modulo measurement resolution is fractal and given as a power $D_{II_1} = B_n^m$ of Beraha number $B_n = 4cos^2(\pi/n)$. The usual entanglement negentropy is given by the p-adic formula $N = -log(1/D_p)$, where D_p is the p-adic norm of the dimension for prime for which it is maximum. A generalization to the case of HFF could be obtained by replacing with the p-adic norm of the fractal dimension D_{II_1}. Negentropy would be equal to $m \times log(N_p(4cos^2(\pi/n))$. The p-adic norm inside the logarithm is well-defined if one introduces an algebraic extension containing $exp(i2\pi/n)$. It is quite possible that the p-adic norm reduces always to that for $p = 2$. This generalizes also the situation when D_{II_1} is product of Beraha numbers associated with several integers n.

2.3.2 How to make information conscious?

How to make this information conscious?

1. If quantum jump is the "elementary particle" of consciousness, one should state function reductions measuring this information but not destroying NE. One possibility is interaction free measurement [B1] (`http://en.wikipedia.org/wiki/ElitzurVaidman_bomb_tester`), which would manage to get information about NE but via state function reductions in another system. This would be reading of Akashic records.

2. Second possibility - not necessary excluding the first one - is based on the precise formulation of quantum measurement theory in the framework of ZEO. The basic building bricks of zero energy states are pairs of positive and negative energy states with opposite total conserved quantum numbers and localized at the boundaries of causal diamond (CD, intersection of future and past directed light-cone with CP_2 as added Cartesian factor). The counterpart in positive energy ontology is the pair of initial and final states of physical event. Zero energy state involves also a quantum superposition over different CDs characterized by proper time distance between its CDs and discrete subgroup of Lorentz boosts acting on CD and preserving this distance. One can speak about average temporal distance between the tips for a given zero energy state.

   State function reduction involves a localization of either boundary of CD in the superposition of CDs to some future/past directed light-cone boundary whereas the second boundary remains delocalized. What would happen after this? In ordinary quantum measurement theory repeated reductions leave the state unaltered and indeed occur (Zeno effect). In the same manner, after the first state function reduction the reductions leave the fixed boundary as such and also the parts of zero energy states at it remain unchanged. The superposition for opposite boundaries however changes in each reduction in TGD framework. Also the state at this boundary changes and is subject to the conservation laws and the fact that the space-time surfaces in the superposition are preferred extremals of Kähler action (the attribute "preferred" might not be needed in ZEO whereas in positive energy ontology it would be necessary).

   The sequence of repeated state function reductions during which the situation at fixed boundary does not change is a correlate for the existence of self as something invariant under quantum jumps and remaining unentangled. The superposition of the opposite boundaries changes and since essentially the analog for diffusion inside cone is in question, the average temporal distance between the tips increases. This corresponds to the increase of psychological time. Also the arrow of time emerges. Self in turn is simple the sequence of state function reductions on the same boundary - NMP eventually forces reduction to and localization of opposite boundary of CD - and the lifetime of self is the increase of the average distance between the tips of CD in the superposition. The original assumption was that self corresponds to sequence of general quantum jumps something binding to form a coherent unit: how this occurs remained an open question.

   The repeated state function reduction ot same boundary of CD could be the counterpart for the interaction free measurement and perhaps its TGD variant. Maybe the quantum jumps at opposite boundary could be interpreted as interaction free measurements.

3. The eventual reduction to the opposite boundary of CD - it should be forced by NMP - would induce change of the arrow of psychological time at some level in the hierarchy of CDs. It would also correspond to the act of free will inducing a genuine state of consciousness. The subself at this level of hierarchy would move to the opposite boundary of CD in question and localize it. Act of free will would be essentially selection of future from the superposition of possible futures. This quantum jump would mean "death" of self and one can ask whether biological death and falling asleep reverses the arrow of geometric time at some level of self hierarchy. If so, reincarnation would be literally a rebirth at opposite boundary of CD. During sleep memories would be from geometric future of wake-up state and could make possible precognition. This precognition would explain why we we can predict our future to some extend but we usually regarded this ability as something completely trivial.

2.3.3 Information transfer physically

Q2: What, if any, could be the most likely physical candidates of information transfer between systems? Is consciousness itself information, or an emergent property of universal information?

A: Personally I do not see consciousness as information - at least in the sense that information content would measure the amount of consciousness assumed to be some kind of substance.

If NE is identified as a potential source of conscious information then the transfer of NE would be the candidate. NE is however many-particle property: at least 2-particles are needed to define it.

1. One could think that the transfer of information is just a transfer of negentropically entangled particle pairs. Metabolism could correspond to this transfer. In this framework higher energy phosphate bond would correspond to a NE assignable to a pair of subsystems inside phosphate.

2. The information could be also between the transferred particle and some larger system. This option looks more natural in the framework in which living matter is Indra's net with various structures connected by magnetic flux tubes and NE appearing in wide length scale range. The braiding of flux tubes could serve as a space-time correlate for the entanglement since it would characterize the unitary (and thus negentropic) entanglement between the braids defined by the ends points of flux tubes in topological quantum computation.

3. One can assign NE *effectively* to single particle if second "particle" involved is some larger and fixed system, call it X. The system could be cell membrane and even gravitational Mother Gaia, as some numerical co-incidences and huge anomalous gravito-magnetic effect claimed by ESA collaboration [E1, E2] and explainable in terms of gravitational Planck constant (effect is proportional to $\hbar^2$) suggests allbhgrprebio. If this is the case nutrients would have NE with X mediated by magnetic flux tubes. The transfer of phosphate would induce the transfer the second end of the magnetic flux tube to the acceptor molecule from ATP.

   Metabolism would be therefore much more than we usually understand it to be. The "ordered" of "ordered energy" would correspond to NE. Collectlve levels of consciousness would be also absolutely essential for life.

4. The DNA- nuclear/cell membrane system with flux tubes connecting nucleotides with lipids suggested to serve as a topological quantum computer is a good example. The recent finding that DNA might have "humble" origins as metabolic energy storage (each nucleotide involves phosphate). In TGD framework the interpretation would be that Akashic records were there even before standard mechanisms of metabolism evolved.

2.4 Defining notions like memory, learning, and conditioning

Before trying to answer the questions one must define notions like memory, behavior, learning, conditioning, problem solving, etc... in TGD framework.

1. Neuroscience identifies memories as behavior patterns and learning is adoption of behaviors assigning to stimuli predictable behaviors. Emotions are involved since usually the response is determined by the minimization of un-necessary pain. Memories are in these sense imply change in the system, say synaptic connections.

   It seems necessary to distinguish learned behaviors from genuine conscious memories, say episodal or declarative memories. In TGD framework declarative memories would involve communications with geometric past involving temporary change of the arrow of time for some space-time sheet in the hierarchy and serving as a correlate for the recalled mental images. Time-like quantum entanglement might be involved with episodal memories, if they correspond to direct sharing of sensory mental image of geometric past rather than just communications "by bits". Recall however that the feedback from brain to sensory organs can transform symbolic representations to genuine sensory experiences. In case of phantom pain, this cannot however explain the sensory percept and one must assign sensory percept to either brain or to geometric past where the limb still existed.

2. How to define behavioral patterns physically? In ZEO this process can occur since pairs of space-like 3-surfaces at the boundaries of CD are the basic object and are accompanied by almost unique space-time surfaces (apart from non-uniqueness having interpretation in terms of hierarchy of Planck constants). Therefore zero energy states corresponds to time evolutions, temporal patterns classically since vacuum functional is strongly concentrated on those pairs of 3-surfaces for which the

real part of Kähler action from Euclidian regions (generalized Feynman diagrams- the matter) is maximum and its imaginary part from Minkowskian regions - the classical fields - is stationary. One could loosely say that zero energy state is quantum superposition of behaviors. The sequence of repeated state function reductions can be seen as a self-organization process leading to an asymptotic state which is now not a 3-D system but entire 4-D temporal pattern, behavior. The new element is that the entire spatio-temporal pattern - including past - changes in the scale of given CD. This explains the finding that conscious action is preceded by neutral activity without giving up free will. Fractal hierarchy of patterns is predicted.

In ZEO negentropic entanglement of say positive energy parts of zero energy states corresponds to negentropic entanglement of corresponding automatic behaviors. Temporal patterns would entangle. Usually one talks only 3-D states. Negentropic entanglement of behaviors could be crucial for understanding how society emerges when the behaviors of individuals are entangled and therefore strongly correlated.

How to define learning in TGD framework?

1. Learning involves automatization. Something requiring conscious attention gradually changes to an automatic process. Learning would correspond to a process in which quantum jumps gradually lead to a situation in which initial state leads to the desired final state automatically without any quantum jumps at any level of CD hierarchy so that the behavior is not anymore conscious. Magnetic body is excellent candidate for the system which stores the learned skills.

   As a matter of fact, the notion of braiding and topological quantum computation based on it generalizes. The orbits of flux tubes idealizable as string world sheets and also accompanied by them can get knotted in 4-D space-time surface: one speaks of 2-braiding and 2-knotting. 2-braiding involves reconnection as additional topological vertex which can lead to a violent opening of ordinary knots/braids and thus even their trivialisation. Standard construction of knot invariants is indeed based on this kind of trivialisation. The behavioral patterns would correspond to 2-braiding patterns.

2. Learning process involves consciousness but in the ideal situation the learned behavior is consciousness at least at the level of learning systems. Consciousness might be present in the lower levels of hierarchy but for ensembles of sub-..-subselves and thus as something predictable by quantum statistical determinism. If so, the memory would survive only if there is analog of metabolic energy feed to the system. In biological systems this is obviously the case.

3. Learning can be seen also as conditioning. Conditioning would take place when system responds to a stimulus in such a manner that it avoids loss of its negentropy sources. The loss induces negative emotions and pain. System would gradually find automatic occurring behavioral pattern avoiding the loss of negentropic entanglement. Biological systems are indeed fighting for negentropic entanglement.

   Conditioning creates associations. What is the quantum correlate for association is. One candidate a zero energy state connecting two space-like 3-surfaces at the opposite boundaries of CD and representing geometrically the pair form by the initial state of the system + stimulus and response of the system.

   Another view is that association corresponds to negentropic entanglement. Negentropic entanglement between the temporal pattern defined by the stimulus and behavioral pattern would the outcome of the learning and possible state function reduction eventually occurring would lead to a behavior which minimizes negentropy losses. Magnetic flux tubes between the systems involved would thus serve as the geometric correlate for the formation of the association.

4. Emotions are strongly related to the learning process, which usually is guided by the avoidance of negatively colored emotions. One should have some idea about about physical correlates of emotions. Emotions certainly involve negentropy gradients providing them their positive/negative coloring (peptides as information molecules). They should accompany any evolution of self according to ZEO and induced by the flows of quantum numbers and negentropy between subsystems.

Quantum number flows between subsystems at the opposite boundary of CD (superposition of of opposite boundaries to be precise) would give rise to qualia and negentropy transfers to emotions.

Negentropy transfer would be directly related to metabolism if its function is NE transfer - perhaps with mother Gaia - from nutrients to molecules. Emotions have at least biological correlates as metabolic effects and something similar is expected in emotional imprinting of "research space".

Every consciousness theorist encounters sooner or later a difficult question: "What is the physical correlate for problem solving?". Just as a joke one can ask whether the topological correlate for solving a problem could be a 2-braiding leading from non-trivial knot at first end of space-time surface to a trivial knot at the second end! Could this idea be more than a funny whim? Could problems be mapped at the level of space-time physics to 2-braidings so that solution would transform non-trivial 1-braid to trivial one?

2.5 Hierarchy of Planck constants and dark matter

The hierarchy of Planck constants identified as labeling phases of dark matter has become corner stone of TGD inspired theory of consciousness.

I started originally from two alternative formulations for the hierarchy of Planck constants.

1. The notion of gravitational Planck constant introduced by Nottale did not assign to it anything genuinely quantal. The basic formula reads as $h_{gr} = GMm/v_0$, where v_0 is parameter with dimension of velocity. The velocity parameter $v_0/c \sim 20^{-11}$ predicting satisfactory the radii of 3 inner planets from Bohr orbit hypothesis corresponds to the constant orbital velocity of distant stars around galaxy. For outer planets one would have $v_0 \to v_0/5, that is fifth sub-harmonic of v_0$.

   Whether v_0 is universal constant - as the identification with the velocity of distant stars around galaxy having TGD based explanation in terms of cosmic strings suggests - or whether it is a parameter with same order of magnitude as a typical rotation velocity in the system considered remains an open question.

   The possibility of sub-harmonics make actually these options mutually consistent. If v_0 is a universal constant, it corresponds to a rotation velocity in gravitational field of magnetic flux tube perhaps identifiable as the rotation velocity of dark matter around it. Magnetic flux tubes populate TGD Universe so that this option sounds reasonable. In

   astro I have proposed a mechanism giving rise to the sub-harmonics of v_0.

   This formula generalizes to the case of non-gravitational interactions in rather obvious manner. The reason why for the hierarchy of Planck constants would be following. If the interaction strength $GMm/\hbar$ for gravitation and $Z_1Z_2e^2/4\pi\hbar$ for em interaction is larger than say unity, perturbation series does not converge. Nature could have solved the problem in favor of theoretician by a phase transition to a phase in which real or effective Planck constant $\hbar_{eff}$ so large that the coupling strength is so small that perturbation series converges. The question is however how the resulting states differ from those in the original situation.

2. I also ended up with hierarchy of Planck constants $h_{eff} = n \times h$ from the observations about effects of ELF em fields to vertebrate brain.

   I introduced covering space of imbedding space as a manner to describe the hierarchy of Planck constants suggested to obey spectrum $h_{eff} = n \times h$. n would characterize the number of sheets of the covering which is singular at the ends of causal diamonds in the sense that the sheets co-incide there.

   It turned out that one can understand h_{eff} as genuine or effective Planck constants (depends on taste) and reduce it to the dynamics of TGD so that there is no need to introduce the covering of imbedding space except as a convenient auxiliary tool. The non-determinism of Kähler action explains the effective multi-sheetedness of the imbedding space.

   In ZEO space-time surfaces connecting two space-like 3-surfaces at boundaries of CD can have n branches which co-incide at ends. Actually n would be the number of conformal equivalence

classes of the space-time surface connecting the 3-surface. This picture conforms with the idea about quantum criticality as something accompanied by non-determinism assignable to the basic variational principle and long range quantum fluctuations assignable to large value of h_{eff}. Negentropic entanglement would be between two systems with $h_{eff} = n \times h$ and state degeneracy would correspond to n-fold discrete degree of freedom brought in by non-determinism. This would predict that also sub-harmonics of v_0 appear in Nature. The outer planets indeed correspond to the fifth sub-harmonic of v_0 for the inner planets.

3. $h_{gr} = h_{eff}$ hypothesis unifies the two approaches - at least in the case of microscopic system. The proportional of h_{eff} particle mass implies that the spectrum of cyclotron energies is universal having no dependence on mass of the charged particle. The hypothesis could be seen as a condition for the quantal interactions between gravitational fields and bio-electromagnetic fields: the gravitational and electromagnetic tubes would have same Planck constant and could reconnect and fuse.

2.6 Biophotons and remote mental interactions

In TGD framework bio-photons are identified as decay products of dark photons with large value of $h_{eff} = h_{gr}$ guaranteeing that the energy spectrum of dark photons is universal and same as that of dark photons. The condition $h_{eff} = n \times h$ implies that v_0 is proportional to inverse of integer.

Fluctuations of biophoton intensity are known to correlate with those of EEG in turn reflecting consciousness. In TGD framework dark photons serve for as a communication and control tool for magnetic body. This suggests that various remote mental interactions involving interaction with biological systems (remote viewing, extrasensory perception, healing, etc.) involve dark photons having same energy spectrum as biophotons. Since biophotons are in visible and UV range, this mechanism could be very general mechanism of matter mind interaction. Dark photons have typically frequencies in EEG frequency range and above it so that they could transfer energy to acoustic oscillations in this range. This transformation could play crucial role in the formation of associations between auditory and visual perceptions. Also dark phonons can be considered and would propagate at magnetic flux tubes as oscillations of dark matter density. The spectrum of audible frequencies would correlate rather directly with that of magnetic field strengths.

It could also explain the effects on REG could be also understood in this picture. When the functioning of REG relies on electron tunnelling, dark photons producing with energies in visible and UV range could transform to ordinary photons and induce a transition kicking electron to conduction band making possible tunnelling. The Coulomb energies involved are indeed in eV range from the condition of thermal stability. The operator should be able to tune the energy of the dark photons requiring tuning of the strength of the magnetic field that is the thickness of a magnetic flux tube involved. Flux tube should be U-shaped and should reconnect with a flux tube accompanying RGE so that the dark photons signal could propagate along "massless extremal" associated with the flux tube. U-shape also makes possible formation of Cooper pairs of high T_c bio-superconductor with members of pair at parallel flux tubes. Large value of h_{eff} makes possible large binding energy for the pair identified as spin-spin interaction energy.

If biophotons result in cyclotron transitions with frequencies inversely proportional to the mass of the charged particle, also their spectrum is universal and in visible-UV range required also by the condition that dark photons from magnetic body can induce transitions of biomolecules: essential for biocontrol. Only the spectrum of magnetic field strengths would affect the spectrum! For large values of h_{eff} involved the frequencies could be in the range of audible frequencies. Dark photons could thus have audible frequencies and visible energies! This suggests obvious connection between hearing and vision. Dark photons associated in visible energy range induce acoustic oscillations in audible range! Note that visible photons span range of one octave which is fundamental for hearing of musical sounds!

2.7 Time and length scales of consciousness

TGD suggests several fundamental time and length scale hierarchies relevant of consciousness.

1. p-Adic time scales comes as primary, second,... time scales and n-ary time scale is proportional to $\sqrt{p}^n$, with $p \simeq 2^k$ (p-adic length scale hypothesis) the p-adic prime in question. The values of p

for elementary particles are large. $p = M_{127} = 2^{127} - 1$ for electron predicts that secondary p-adic time scale in this case is .1 seconds defining the fundamental biorhythm. This strongly suggests that electrons are fundamental for consciousness. In TGD framework scaled variants of QCD in the scales of living matter are possible and therefore also corresponding time scales for quarks could be important.

2. Cyclotron frequencies define time scales which do not depend on h_{eff} and $B_{end} = .2$ Gauss suggested by the experiments of Blackman gives time scales in EEG range for ions. Cyclotron energies are universal if $h_{eff} = h_{gr}$ holds and in the range of bio-photon energies. Note that each ions would be at its own magnetic flux tube so that that dark part of living matter would be far from being a random soup of particles. The spectrum of bio-photons involves a wide range which requires that B_{end} has also spectrum, possibly the spectrum of audible frequencies which spans 10 octaves for humans. For bio-photon energies this would give upper bound of order keV.

3. Josephson energy identified as Coulombic energy $E = ZeV$ for say cell membrane regarded as superconductor defines naturally an energy scale which does not depend on Planck constant. Josephson time is however inversely proportional to h_{eff} so that the hierarchy of Planck constants would define naturally a hierarchy of time scales of consciousness. In the recent model of cell membrane as generalized Josephson junction Josephson energy - that is energy of photon emitted by junction defined by transmembrane protein - contains the difference of cyclotron energies of ion at both sides of the membrane. In the typical case the electrostatic energy gives only a small contribution to the generalized Josephson energy so that the corresponding time depends only weakly on h_{eff}.

4. Compton time $T_C = h_{eff}/m$ for a generic value of $h_{eff} = n \times h$ defines a hierarchy of time scales which could relate to the time scales of memory and to frequency spectrum of EEG and its possible generalizations in other frequency ranges. The larger the value of h_{eff}, the higher the evolutionary level of the subsystem, and the longer the time scale of memory and planned interaction. If one assigns EEG frequencies with cyclotron frequencies assigned to $B = .2$ Gauss as Blackman's experiments suggest, one can estimate the value of h_{eff} from the time scale of memory duration.

5. $h_{gr} = h_{eff}$ reduces the spectrum of $T_C = T_{gr} = h_{gr}/m = GM/v_0$ to that for v_0, which should have spectrum coming as inverses of selected integers: $v_0(n) = v_0(1)/n$. This would also determine the spectrum of magnetic field strengths at flux tubes.

   For instance, if M is Earth's mass, and if T_{gr} defines time scale of memory, the spectrum for the time scales of memories reduces to that for v_0. It is important to notice that $T_{gr} = h_{gr}/m = h_{eff}/m$ - does not depend on particle mass unlike the ordinary Compton time. The naive expectation from Uncertainty principle does not hold true now: T_{gr} is not inversely proportional to the mass but is independent of it.

   The independence of L_{gr} and T_{gr} on particle is expected to be crucial for gravitational quantum coherence by $h_{gr} = h_{eff}$ also for em quantum coherence. This implies also the universality of biophoton spectrum if identified as decay products of of dark cyclotron photons with $h_{eff} = h_{gr}$. This and the fact that the spectrum is in the range of molecular excitation energies would make biophotons ideal for communication and control purposes.

It is of considerable interest to study in detail the time and length scales of consciousness suggested by $h_{gr} = h_{eff}$ hypothesis. Since neither gravitational Compton length nor acceleration does not depend on m, Bohr orbitology for planetary orbit requires the hypothesis only for microscopic objects. The independence of L_{gr} on particles involved is ideal concerning macroscopic quantum gravitational coherence.

1. For particle-Sun system using $v_0/c = 2^{-11}$ implied by Nottale's model, L_{gr} would be $.5 \times 10^6$ m roughly one tenth of Earth radius, which suggest that dark matter at some level of hierarchy is in macroscopic quantum state in the gravitational field of Sun with size scale of L_{gr}. The corresponding time scale is $T_{gr} \simeq 1.5$ ms and corresponds to the time scale of nerve pulse, which might not be an accident.

2. Consider next particle-Earth system.

   (a) One could also interpret v_0 as a universal velocity parameter and assign $v_0/c \simeq 2^{-11}$ also to particle-Earth system, In this case one would $T_{gr} = .52$ ns and $L_{gr]=15}$ cm.

   (b) From $M_E/M_{Sun} = 3 \times 10^{-6}$, from solar Schwartschild radius $r_S(Sun) = 2GM_{Sun} = 3$ km and assuming v_0 to the the Earth's rotational velocity 465.1 km/s arounds its axis one has $T_{gr} = GM_E/2\pi v_0 = (2GM_E/4\pi v_0) \sim .17$ μs. Gravitational Compton length would be $L_{gr} = cT_{gr} \simeq 51$ m. The corresponding gravitational Compton length would be 3 m, which is same order of magnitude as largest sizes for a animal bodies.

   (c) Can one say anything about the velocity parameter $v_0 = 1$ m/s introduced by Joey? The velocity of nerve pulse along axon varies from 1 m/s to 100 m/s. Could this correspond to some rotational velocity assignable to say say magnetic flux tubes? For particle-Earth system the velocity $v_0 = 1$ m/s would correspond to $T_{gr} = 80$ μ s and $L_{gr} \simeq 8$ km. For particle-Sun system one would have $T_{gr} = .7$ seconds, which corresponds to frequency of 1.4 Hz. The cyclotron frequency assignable to DNA strands (possessing constant charge density due to phosphates) is around 1 Hz.

   (d) The angular velocity for the motor defined by the ATP synthase can be estimated from the size scale of the ATP synthase of order $L(151) = 10$ nm and from the rotation velocity of the shaft of the ATP motor which is about few turns per second. A rough estimate for the velocity is of order 10^{-8} m/s and from this one obtains $T_{gr} \sim 8 \times 10^3$ seconds for particle-Earth system and $T_{gr} \sim .7 \times 10^8$ seconds - of order one year - for particle-Sun system.

3. The values of cyclotron energies universal. Consider just for convenience electron. For Joey's proposal $v_0 = 1$ m/s, one would have $h_{gr}(m_e, M_E) \simeq 8.9 \times 10^{16}$. Cyclotron energy would be

$$E = \frac{GM_E}{v_0} \times ZeB = \frac{c}{v_0} \times \frac{r_{S,E}}{4\pi L_c(e)} E_c(e) \quad ,$$
$$r_{S,E} = 2GM_E = 3 \times 10^{-6} r_{S,Sun} = 9 \times 10^{-6} \ \ km \ . \quad E_c(e) = \hbar eB/m_e$$

   ,

   This would give $E \simeq 5.9$ MeV for $B_E = .2$ Gauss (2/5 of the Earth's magnetic field). This energy is by an order of magnitude higher than electron's rest mass and seems definitely too high.

   This suggests a considerably higher value of v_0 at magnetic flux tubes. $v_0 = 465.1$ m/s would give $E \simeq 13$ keV, which still is too high. Corresponding value of h_{eff} would be $heff \simeq 1.9 \times 10^{14}$.

   For $v_0/c = 2^{-11}$ - that is $v_0 = 1.5 \times 10^5$ m/s - assignable to Earth-Sun system and distant stars (also particles at Earth) orbiting galactic nucleus one would have $E \simeq 40$ eV, which looks rather reasonable. Could the rotation velocity around galactic nucleus determine the biophoton energy spectrum? This makes sense if this velocity corresponds to the rotation velocity in the gravitational field of magnetic flux tube. This indeed populate the entire cosmos.

   Lower values of B_{end} would correspond to lower values of biophoton energies. If the energy spectrum spans 10 octaves as in case of audible frequencies, the highest energies would be around keV if lowest energies are at the end of infrared. Magnetic field values would vary from $.5 \times 10^{-3}$ Gauss to 5 Gauss.

2.8 Relation of magnetic body to morphic fields of Sheldrake

In TGD Universe morphic fields of Sheldrake [**?**]bioSheldrake,Sheldrake1 are replaced with field body: magnetic body and the "topological light rays" serving as correlates of dark photon beams are involved and are parallel to flux tubes and topologically condensed at them.

Magnetic body and even more so topological light rays are essentially 4-D objects, a temporal pattern of topologically quantized fields associated with a pair of 3-D magnetic bodies at the opposite boundaries of CD. Magnetic body having an ion-like structure would serve as template for the biological system and its evolution. The lowest layers of the onion would correspond to flux tubes connecting biomolecules. DNA and nuclear and cell membranes would have magnetic bodies having connections to larger magnetic bodies, such as magnetic Mother Gaia.

The findings of Levin [**?**] and others about what happens to cut planaria can be understood if the replication of of magnetic body precedes the replication of the biological body [**?**]. The replication of magnetic body would be analogous with the decay of particle in the vertex of Feynman diagram (particles are replaced with 3-surfaces in TGD). The experiments indicate that also memories interpreted as learned behaviors are replicated and replication of magnetic body in the sense of ZEO would explain this (the pair of 3-surfaces at opposite ends of CD would replicate). The replication of behaviours could be seen as replication of memes. This would help to understanding how skills can be discovered by several individuals simultaneously and how learning of skill becomes easier when it is already possessed by several individuals.

The following is an attempt to define morphic resonance using language of TGD.

1. Morphic resonance would relate to the presence of collective levels of consciousness. They could have direct counterparts as a hierarchy of genomes in which genomes of cells could form coherent units in the sense that their magnetic bodies fuse to larger ones. Also the genomes of different organisms could fuse to single super-genome in this manner. In this case, then morphic resonance could manifest itself as a collective gene expression. One manifestation would a discovery of same thing in separate places simultaneously due to the fact that the problem solving would also take place at collective level.

2. Negentropic entanglement resources generated in the quantum evolution would give rise to "Akashic records", which would serve as universal library from which any-one could loan a book. Independent discovery of same idea at different places and times would not be actually independent since the needed information could derive from "Akashic records".

3. In ZEO 3-D self-organization becomes 4-D self-organization for spatio-temporal patterns since also the geometric past changes in quantum jump. At space-time level this means that space-time surfaces representing temporal patterns of various fields would becomes the basic patterns. Quantum states would correspond to superpositions of these temporal patterns. This would mean that morphic resonance would be essentially 4-D: behaviors/skills could be learned from "Akashic records".

4. Morphic resonance would also correspond to resonance in concrete sense. Only the flux tubes of two magnetic bodies having the same value of magnetic field and thus same cyclotron frequency scale and same thickness could fuse by reconnection. Also the values of h_{eff} should be same. This might also explain $h_{eff} = h_{gr}$ as a condition guaranteeing the resonant interaction between biological organisms with conscious entities in scale of Earth and Sun.

3 Space

3.1 Questions related to information and entanglement

Q1. What is the relationship between information as a fundamental unit and the observed universe? What possible role could fundamental physical processes (e.g., electromagnetism) play in the conditioning of information?

A: I am not quite sure what content to give to "conditioning" of information and information as fundamental unit. Conditioning brings in my mind Pavlov and learning formation of associations between stimulus and reaction, and the idea that conditioning that is learning might occur even in non-biological systems. Conditioning implies correlations as does also quantum entanglement so that also NE could be seen as "quantum conditioning".

I do not believe on the existence of information as something analogous to matter or some kind of substance. I think that conscious information is at the fundamental level the only real information and assign it with quantum jumps which is between two states of Universe/sub-Universe and therefore cannot be defined in materialistic ontology which would see information as property of something or as some substance.

For instance, one can assign information measure to a bit sequence but whether bit sequences generates any conscious response in the receiver, depends on receiver. Conscious information is thus not something absolute but always something assignable to a relationship between systems.

Additional question: And is there a way to answer this question empirically? Can there be consciousness or an effect of consciousness in the absence of matter in which case one could surmise that perhaps consciousness is embedded into space-time?

In TGD framework consciousness in in the quantum jump between quantum states - that is between states of material systems. The absence of matter would perhaps correspond to vacuum state. Consciousness in absence of matter would translate to vacuum-to vacuum quantum jump, which does not seem to give to any qualia citeallbqualia.

The embedding of consciousness to space-time would conform with materialistic view but is impossible in TGD framework, where consciousness represents its own ontological level no reducing to space-time or to a property of a physical state. The contents of consciousness of course have space-time correlates by quantum classical correspondence and space-time dynamics would be like representation of contents of consciousness by written language.

3.2 Excess correlations as entanglement?

Q3: Do experimentally observed excess correlations between physically isolated systems correspond to an entanglement between the physical objects in space-time, or between the very space-time they occupy? How could an experiment be designed to investigate this distinction? Do data currently exist to support one side or the other?

A: In TGD framework particles reduce to topology and geometry of space-time classically so that it is possible to talk about entanglement between space-time regions.

1. In the many-sheeted space-time of TGD physical systems correspond to space-time quanta. At elementary particle level regions of space-time with Euclidian signature and size of about 10^4 Planck lengths would be the fundamental objects identified as wormhole contacts carrying monopole flux. Elementary particles would be pairs of these and identifiable as closed flux tubes running at two space-time sheets connected by wormhole contacts. They would be accompanied also by string world sheets carrying spinor fields: this follows from the condition that em charge is well-defined quantum number.

2. The entanglement between elementary particles is an experimentally verified fact and in TGD framework could be seen as entanglement between space-time regions representing particles. I proposed long time ago that braided magnetic flux tubes could serve as correlates for this entanglement and actually make it possible. The idea would be realized in the model of topological quantum computation. The entangled states would be at the ends of magnetic flux tubes connecting two systems. The analog of this proposal has been made recently for black holes by Maldacena [**?**] (`http://www.ias.edu/about/publications/ias-letter/articles/2013-fall/maldacena-entanglement`).

The problem with testing TGD based view is that all experiments are analyzed nowadays in the framework provided by special or general relativity. When one goes from TGD to GRT, one lumps together the sheets of the many-sheeted space-time and replaces it with piece of Minkowski space with effective metric determined as sum of Minkowski metric and deviations of the metrics of space-time sheets from Minkowski metric. The same procedure is applied to gauge potentials to get standard model gauge fields. All information about many-sheetedness is lost!

Many-sheeted space-time makes itself therefore visible only via anomalies.

1. We indeed see everywhere outer boundaries: they could be identifiable as effective or genuine boundaries of space-time sheets in TGD framework: this depends on whether one adds to Kähler action a boundary term allowing the presence of boundaries or not. If not, the space-time sheets are pairs of sheets glued together along would-be boundaries. Seeing is however not believing. We must somehow measure the presence of space-time sheets before we can take them seriously!

2. In many-sheeted space-time signal from say supernova an come along several space-time sheets simultaneously and the arrival times depend on the sheet. In case of SN1987A [**?**]frSN1987A this effect was observed for neutrinos and photons as one can also learn from Wikipedia article (`http://en.wikipedia.org/wiki/SN_1987A`). The "dropping" of particles from smaller to larger

space-time sheet at the boundary of smaller one provides a possible mechanism of metabolism since the zero point kinetic energy decreases.

3. Biology is a huge treasure trove of anomalies and this is the reason why I am applying TGD to biology!

Q4: The Greek philosopher Heraclitus wrote: You could not step twice into the same river. Scientists generally assume that space is homogeneous and of negligible concern during experiments. However, experimental evidence displays strong shared space laboratory results. Do the Earth's orbital velocity (30 km/s) and the Sun's orbital velocity ($\simeq$ 220 km/s around the Galaxy) indicate that we are never truly in the same space twice?

A: In TGD framework space-time is certainly not homogenous nor isotropic. Particles are space-time quanta and we see by bare eyes the huge complexity of space-time topology: TGD is indeed topological geometrodynamics. The imbedding space $M^4 \times CP_2$ in which space-times are imbedded as 4-D surfaces (one has quantum superposition of them) is homogenous and isotropic and possess maximal symmetries necessary for the existence of quantum TGD and to explain standard model symmetries.

Consider first the velocities. The identification of gravitational Planck constant $h_{gr} = GMm/v_0$ involves velocity parameter v_0 which for solar system is of the same order of magnitude as the velocities of distant stars around galaxy in the Nottale's model for planetary orbits as Bohr orbits. This model predicts the orbital velocity of Earth in good approximation.

The notion of magnetic body might allow to rephrase "shared space" using TGD conepts. Shared space would have very complex magnetic body having flux tubes to large number of external systems. Biological systems would serve as basic example about this. Sharing would have as magnetic flux tubes and negentropic entanglement as a correlate.

As a matter fact, I have identified sharing of mental images as negentropic entanglement between sub-selves of unentangled selves (this makes sense in many-sheeted space-time) [K2]. These disjoint space-time sheets associated with selves would have topologically condensed smaller space-time sheets represented by sub-selves and connected by flux tube. Stereo vision could be due do this kind of sharing of visual mental images of right and left visual fields.

3.3 Em fields and information

Q5: Could the natural electromagnetic environment in which the entire planet is constantly immersed (e.g., geomagnetic field/Schumann resonance) provide a consistent system conducive to promoting shared spaces via electromagnetic field applications and excess correlations?

A: The magnetic body of Earth - magnetic Mother Gaia - could serve as a correlate for collective consciousness in Earth scale and generate coherence and entanglement between sub-systems. Schumann resonances could define collective EEG rhythms, which together with coherent collective gene expression could serve as experimental signatures for collective consciousness. One could even speak of super and hyper-genomes assignable to organisms and even populations of them rather than only single cell. The magnetic flux tubes of personal magnetic bodies could reside inside flux tubes of magnetic Mother Gaia, and form a kind of fractal structure with flux tubes inside flux tubes.

One basis of his field studies Callahan [I2, I4, I1] has claimed that the strength of Schumann resonance correlates with the social situation in a given region. Weak Schumann resonance would correlate with the presence of social incoherence. Callahan also suggests that highly paramagnetic materials should help to establish Schumann resonance in the case of plants and in this manner promote plant growth.

Q5: What is the evidence for information transfer and retrieval by means of the geomagnetic field? How does this relate to non-local psi information transfer associated with consciousness, such as that observed in remote viewing or psychokinesis?

A: Information transfer could be interpreted in TGD framework as a transfer of negentropic entanglement between transferring object and a fixed structure so that receiver and fixed structure are entanglement in the final state. Gravitational Mother Gaia is a good candidate for the fixed structure but also other candidates are allowed by $h_{gr} = h_{eff}$ hypothesis. Entanglement with Gravitational Mother Gaia could be interpreted as a potential to have conscious information and necessary to be living system.

3.4 Does space learn and remember?

Q7: What are your experiences with unique effects in a certain space? Has a specific experimental result been more easily obtained in a unique space? Can a particular space, with its background sounds and subtle fields, induce particular types of imagery? How susceptible is our mentation to the environment around us?

A: The notion of space in TGD framework differs dramatically from that in standard framework as I have already discussed in the introductory section.

1. Space-time sheets representing physical system would be counterpart for "space" in TGD framework. Space-time sheets are subject to topological dynamics in all length scales since they correspond directly to the physical objects. Hence space ceases to be a passive arena and becomes the key active player of geometro-dynamics.

2. Second new element is field body (magnetic body). In TGD inspired biology one must add to environment - system pair also the magnetic body of the system and those of systems in its environment.

I already considered the basic notions such as learning, conditioning, learned behaviors in TGD framework. Since physical systems correspond to space-time sheets and actually to their time evolution in the time scale of corresponding CD, one can say that space indeed learns in the sense that certain pairs of space-like 3-surfaces at the ends of CD are selected and connected by behavioral patterns. The external stimulus on space forces it to find an automatic behavior minimizing negentropy losses, since these losses induce negatively colored emotions. There is no deep reason to say that only biological systems are conscious and have emotions since NMP and negentropic entanglement are completely universal principles.

I have constructed a simple model for Tiller's findings (`http://matpitka.blogspot.fi/2008/08/experimental-work-of-william-tiller.html`). Intentionally induced pH fluctuations and temperature fluctuations serve as examples. Denote the two systems involved by a and b and their magnetic bodies by A and B. Who applies intention? a or A or both together? Does the intentional imprinting affect first B which then affects b? Do the em signals (dark photons) flow from A to B to b? Clearly, the formation of flux tube connection from A to be b would the "effect on space". Reconnection of flux tubes of A and B would be the natural candidate for the basic interaction and I have proposed this mechanism to explain the findings of Persinger group related to biophotons earlier.

Q8: Does the recurrence of behaviours (human or animal models: verbal, ambulation, etc.) occur more often in highly used research space? Do effects disappear if a space is tampered with? What are the residual effects of emotions on a space? How long do they persist? Do re-experiencing emotions in a particular place (e.g., church or pain clinic) help reinforce and maintain this type of space-conditioning?

A: Emotions are essential for learning. Let us assume that certain space, call it S, is to some extent a conscious entity. Experiencing of strong emotions in certain space, call it S, affects the behavioral patterns of the experiencer (call it E) and E's magnetic body. If E is entanged with S and E's magnetic body and that of S form a single entity, then also the "behavioral modes" of S - this must sounds totally outlandish in the ears of neuroscientist - are affected. Especially so if the fusion of magnetic bodies of of E and O is permanent as might be the case if E visits the place often and has strong emotional binding with S. Re-experiencing of these emotions could refresh the behaviors learned by S (or rather S+E).

The presence of water would be important S to be a living entity. Water indeed seems to be affected by expression of emotions (Emoto's experiments [I7] `https://www.youtube.com/watch?v=tAvzsjcBtx8`). TGD based model for water memory [K1]assumes that water is living system in the sense that dark protons form analogs of DNA sequences and give rise to water memory and primitive prebiotic life. If so also water would have metabolic activities correlating with the negentropy transfer. In particular, it would have emotions.

Pollacks's experimental work [**?**, I3] gives support for this picture. Pollack talks about fourth phase of water realized as water containing negatively charged exclusion zones. In TGD framework EZs would be formed as fraction of protons go to the exterior to the magnetic flux tubes with large h_{eff} and forms dark proton sequences defining the analogs of biomolecules. The process requires feed of energy and visible light can induce it. Free energy is a cursed word for serious scientists but the notion of Brown gas (there

are many other terms) is very similar to the notion of fourth phase of water and involves also negatively charged regions of water. The transfer of protons obviously changes also the pH of the water. In TGD framework EZs together with their magnetic bodies are interpreted as primordial life forms.

In this framework emotional imprinting might be possible in water, say spring water. One of the references tells about an experiments in which specific rotating patterns of magnetic field were applied to two water samples with simultaneous addition of acetic acid to the first sample with the consequence that the pH of also second sample was changed. When the magnetic field patterns were applied to both systems next day but without any feed of acetic acid the pH was changed. One can say that pH was conditioned to the field pattern representing stimulus. The interpretation could be in terms of formation of the EZs as a responses to the magnetic field pattern and this would change pH.

Living system is able to maintain the memory and behavior pattern. Living systems are subject to a continual feed of metabolic energy - negenropic entanglement- making possible for mental images to stay alive. If the place is in some respects "living", the same should hold true. Could the visitors of "sacred" place increase the negentropic entanglement resources of the spiritual place by a mechanism similar to that used in metabolism: that is by attaching ends of flux tubes to the place having other end attach to somewhere, call it X.

Q9: Aside from the electromagnetic field-induced space-memory research, many additional studies have indicated forms of apparent space-memory associated with persistent anomalous subjective experience and other physical anomalies. These include various cross-cultural phenomena, particularly those associated with sacred spaces. Could these processes be related by quantifiable physical factors?

A: I already mentioned Callahan's work [I2, I4, I1]. The quantifiable physical factor studied by him was strength of Schumann resonance correlating with paramagnetism and possibly assignable to the entanglement with "magnetic Mother Gaia". Quartz crystals are highly paramagnetic, which might relate to their claimed health effects.

TGD mechanism for remote mental interactions involves both magnetic reconnection, whose occurrence might be promoted by using rotating magnetic fields as in the experiments of Persinger's group ([**?**, **?**] Besides this dark photon radiation with energy spectrum of biophotons and frequencies belonging to the cyclotron frequency spectrum of the magnetic body of the target are involved.

The studies of water memory [**?**] concentrate on low frequency spectrum of water possible explainable in terms of cyclotron frequencies of the magnetic bodies of the primitive lifeforms defined by EZs and their magnetic bodies [I8, I5, I6]. The effects of intentional trying to induce change of pH of "sacred" water might be interesting since they could directly relate to the generation of EZs by intentional action. Recall that some fraction of protons from the EZ would go to the magnetic body of EZ and induce the change of pH. Operator could also try to generate EZs directly by intentional action. This process requires feed of energy so that intentional action would involve feed or energy, maybe from the metabolic sources of the operator.

Q10: Are there temporal limits to space-memory? If there is a limit (e.g., three-day window), what are the implications for this increment of time? Is there something fundamental to these potential limits?

A: I will identify "space-memory" corresponds as analog of a learned behavior. The learning process involves consciousness but in the ideal situation the learned behavior itself is non-conscious at least at the level of learning system. Consciousness might be present in the lower levels of hierarchy but for ensembles of sub-..subselves and for the ensemble of lower level systems the behavior would be predictable by quantum statistical determinism. Memory would survive only if there is analog of metabolic energy feed to the system.

The duration of "space-memory" in this sense would be the lifetime of self at the appropriate level of self hierarchy. One could also speak of wake-up period of system. In living matter one can identify natural candidates for this period from the condition that there is feed of metabolic energy/negentropic entanglement during this period to the system.

Q11: How does the concept of space-memory, particularly in light the electromagnetic field results, relate to Sheldrakes theory of morphic resonance? If these concepts are related, what is it that becomes conditioned in the context of biological memory? Could a form of collective consciousness be involved in morphic resonance and space-memory? How is this information accessed?

A: As I already discussed, in TGD magnetic body replaces morphic field as a basic concept and would be also behind replication of living systems [**?**]. Morphic resonance would utilize "Akashic records" identified as negentropic resources assignable to the dark matter realized as $h_{eff} = n \times h$ phases defining

kind of universal library. This information could be accessed by interaction free quantum measurement or by a sequence repeated state function reductions on same boundary of CD defining self: self would represent the mental image giving conscious information about "Akashic record". Collective consciousness could be involved and one manifestation would be a hierarchy of coherent genetic expressions [K4].

Q12: There are experimental results which suggest that biophoton emissions (BPE) are related to anomalous deviations in random event generator (REG) data output. There are also results indicating that group activities such as meditation produce changes in BPE profiles, while these activities have further been associated with significant deviations in a nearby REG device. Collective religious experience and other group behaviors could produce much greater biophoton fields than those observed in mundane settings; could this account for the REG deviations observed in proximity to these group events? How might photon emissions affect a specific space? Which aspect of BPE, in either individual or group settings, would be the most important in this context?

A: I already discussed the TGD based model for bio-photons as decay products of dark photons. Reconnections of magnetic flux tubes fusing magnetic bodies followed by resonant interaction with the mediation of dark photons would be the basic mechanism and cold allow to understand these mechanism. Modification of space would be to the formation of flux tube connections. Stronger biophoton fields would be due to stronger dark photon emissions in highly emotional situations. I proposed also a mechanism for REG deviations caused by the same mechanism.

4 Time

4.1 Questions related to morphic resonance

Q13: If the concept of morphic resonance relates to a form of space-memory for biological systems, what factors could account for the gradual loss of species without later re-emergence? Could there be a contamination of the space associated with a given species blueprint? Does this relate to the anomalous occurrence of strange organisms being found occasionally?

Q14: History has demonstrated that lost ideas are often rediscovered, and some concepts may be invented by multiple individuals at around the same time (e.g., calculus, theory of evolution). Could the theory of morphic resonance and space memory account for the rediscovery of ideas throughout the history of civilization? How might non-local information transfer associated with conscious experience relate to simultaneous discovery of a similar idea between separated individuals or groups?

A: I have already made an attempt to define morphic resonance in TGD framework. The basic elements are "Akashic records" as collective information resources which accumulate continually and from which individuals can in principle receive information leading to discovery of new ideas. Magnetic body as morphic field allows to understand various strange organisms as outcome of something going wrong in the replication of the magnetic body or of its part. Loss of species could relate to a death of the collective magnetic body associated with it.

"Akashic records" could the simultaneous discovery of same idea simultaneously. One can however argue that existing "Akashic records" are not all that is needed, new ideas generate new Akashic records and also mean generation of higher abstractions which at the level of negentropic entangelement mean larger number of n of entangled state pairs and large value of $h_{eff} = h_{gr}$. The "heureka quantum leap" would give rise also to genuinely new ideas, maybe realized as temporal patters associated with 4-D magnetic body, behaviors/skills. These are then coded to negentropic entanglement.

The definition of what "discovery" means looks rather difficult since one cannot give formula for discovery. Quantum jump creating something new is in question. One might however hope that also this process has space-time correlate, maybe topological. A crazy idea already mentioned is that it could have direct coding to opening of a knot represented as a 2-knot having non-trivial and trivial knot at its ends at the opposite boundaries of CD. If so, the construction of knot invariant by trivialising the knot (a rather violent procedure!) would represent a universal manner to solve a problem!

4.2 Does time-like entanglement make sense

Q15: Many experiments by the NRG have demonstrated that the fundamental space or fabric of space can be manipulated in order to elicit an excess correlation or macro-entanglement. Since both space and

time are intertwined in the fabric of space-time, what effects might this change in space elicit with respect to the time domain? Would it be possible to entangle points in time and thus allow for brief frames by which information from a particular time can be transferred to this point in the time line (time travel)?

Q16: If one concedes the possibility of a time-like excess correlation, how could that change our perception of time? Would there be a limit to the amount (duration) of a time-like entanglement and what would the likely duration of this phenomenon be?

A: Zero energy ontology in principle allows time like entanglement between positive and negative energy states. There are some arguments supporting the notion of time-like entanglement.

1. In the first state function reduction to a given boundary of CD a reduced state occurs in the sense that the say positive energy state has well-defined quantum numbers. This state be regarded as a state having time-like entanglement with the opposite boundary of CD since the positive energy states in the superposition would have same conserved quantum numbers. As a matter of fact, time like entanglement would be certainly present between the members of pairs of 3-surfaces since complete localization to single 3-surface is not possible in quantum fluctuating degrees of freedom.

   To be precise, the entanglement would be light-like at space-time level since the partonic orbits are light-like 3-surfaces and the boundaries of string world sheets at them carrying fermions would be light-like or space-like. Light-likeness is the natural option. At imbedding space level is time-like.

2. In ZEO quantum theory can be regarded as square root of thermodynamics. p-Adic mass calculations assume p-adic thermodynamics assignable to the density matrix characterizing entanglement with Boltzmann weights proportional to the p-adic probabilities assignable with the system in question. In ZEO unitary process is characterized by unitary matrix between zero energy states and its rows are hermitian square roots of Hermitian density matrices and products of real square root of density matrix with unitary S-matrix identified as the target of interest of particle physicist. Could p-adic probabilities correspond to this density matrix characterizing the entanglement between them. Entanglement could be negentropic - that is described by unitary matrix - for sub-space of states with given conformal weight.

3. Coherent state in super conductor involves superposition of states with different numbers of Cooper pairs treated as bosons to form a coherent state. In standard ontology this state is problematic since it does not have well-defined fermion number. In ZEO this state does not break fermion number conservation since one can describe it as a state with time-like entanglement between positive and negative energy states.

4. One could model episodal memories as sharing of mental images with time-like temporal distance in terms of time-like negentropic entanglement.

The lifetime of self would correspond for the duration of time-like entanglement defined in the manner already explained.

Q17: While the concept of space-memory has been observed across a range of systems (e.g., photons, spring water pH), there has also been an apparent lag effect revealed in recent field studies using random event generator (REG) devices in proximity to group activities. Is it possible that the concept of space-conditioning could play a role in the significant REG effects which have been found to occur following an event of interest in the immediate environment?

A: Fluctuations of biophoton intensity are known to correlate with those of EEG in turn reflecting consciousness. In TGD framework dark photons serve for as a communication and control tool for magnetic body. This suggests that various remote mental interactions involving interaction with biological systems (remote viewing, extrasensory perception, healing, etc.) involve dark photons having same energy spectrum as biophotons. Since biophotons are in visible and UV range, this mechanism could be very general mechanism of matter mind interaction. Dark photons have typically frequencies in EEG frequency range and above it so that they could transfer energy to acoustic oscillations in this range. This transformation could play crucial role in the formation of associations between auditory and visual perceptions. Also dark phonons can be considered. The spectrum of audible frequencies would correlate rather directly with that of magnetic field strengths.

It could also explain the effects on REG could be also understood in this picture. When the functioning of REG relies on electron tunnelling, dark photons producing with energies in visible and UV range could transform to ordinary photons and induce a transition kicking electron to conduction band making possible tunnelling. The Coulomb energies involved are indeed in eV range from the condition of thermal stability. The operator should be able to tune the energy of the dark photons requiring the tuning of the strength of the magnetic field that is the thickness of a magnetic flux tube involved. Flux tube should be U-shaped and should reconnect with a flux tube accompanying RGE so that the dark photons signal could propagate along "massless extremal" associated with the flux tube.

The generation of flux tube contacts with the REG by reconnections would affect its magnetic body so that also now space-conditioning might take place.

4.3 Holding times for space-memories

Q18: Relative to holding times for space-memory, would the increment of space change the increment of time? Can a nm space hold for nanoseconds while a km space holds for kiloseconds?

A: Holding times could correspond to life-times of selves representing lifetimes of mental images defining the memories or behaviors. The temporal distance between the tips of the CD involved gives at least order of magnitude estimate. The increases of this distance during the state function reduction sequence defining self would give better estimate for the "holding" time as life-time of the mental image.

If holding times correspond to cyclotron times $T_c = h_{eff}/E_c$, they not depend on h_{eff} and are determined by cyclotron frequencies. The larger the mass of charged system, the longer the holding time proportional to mass would be. Weaker magnetic fields at flux tubes would correspond to longer memory spans. Magnetic fields with magnitude of femtotesla, which are associated with brain, would correspond to to time scale of order 10^9 seconds, which is of order of human life-time.

I have already considered Joey's proposal $v_0 = 1$ m/s is fundamental velocity like parameter but could not find a convincing interpretation in terms of h_{gr}. The predicted energy scale for biophotons for particle-Earth system would in MeV range and definitely too high. Situation changes completely if the large mass can be assigned with some smaller system.

Q19: Consider the idea of a multi-verse of outcomes or, similarly, a divergent theory of probabilities where at any point there are a myriad of possible superpositions in space-time. What energies would be necessary in order to phase a set of probable outcomes into another? How does consciousness relate to the collapse of the system and its observed state? Is there a likely candidate that would allow for spontaneous extra-dimensional or multi-dimensional entanglement?

A: First a comment about superpositions. In TGD framework "superpositions in space-time" are replaced with superpositions of space-times" at least below some scale where macroscopic quantum geometrical effects are important. Classical "superpositions in space time" appear classically as superpositions of fields at GRT-gauge theory limit of TGD. Quantum superpositions occur when when topological inhomogenities representing particles are idealized as point like particles: something in space-time instead of a topological feature of space-time. Handles glued to plane interpreted as particles would be a convenient illustration for what I have in mind. Also superpositions of induced spinor fields are possible but occur only at 2-D string world sheets at which the spinor modes are localized due to the condition that em charge is well-defined (this implies vanishing of weak fields at them and saves from unphysically large parity breaking).

I take liberty transform the question "What energies would be necessary in order to phase a set of probable outcomes into another?" to "What energies are necessary to learn an automatic behavior as a response to stimulus". This would require metabolic energy in the learning period when the response is conscious. In the final state it would be automatic at the level of learning system but could involve metabolic energy feed at lower levels of CD hierarchy as already discussed.

Concerning the question about consciousness. I have already summarized what consciousness and self would be in TGD framework. ZEO view about quantum jumps and self. Self as mental image of larger self would correspond to a sequence of state function reductions at same boundary of CD not changing it or anything at it. The quantum superposition of opposite boundaries would change and give rise to sensory perception and experience of time flow and arrow of time.

4.4 ESP, precognition, and sleep

Q20: There is a great deal of evidence suggesting that extrasensory perceptions (ESP) and precognitive phenomena are more prevalent during sleep, particularly dream states, compared to waking states of consciousness. What aspect of sleeping consciousness allows this state to be more conducive to apparent correlations between information about the future and awareness of this information? Could this be due to intrinsic neurophysiology or the simple fact that we may be too occupied with other thoughts during a waking state? What role does the geomagnetic field and Schumann resonance play in this phenomenon?

A: If one takes seriously ZEO based view about quantum measurement theory, sleep would involve reversal of the arrow of time at the level which corresponds to "wake-up me". The self would become the opposite boundary of CD and past would be now the geometric future of wake-up period. Precognition would be now memory recall and much easier as we know on basis of wake-up experiences. The only problem is to remember what was precognized. We usually regard our ability to anticipate as something trivial which it of course is need not be. Maybe precognition as memory recall during sleep is essential for our ability to survive.

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