Are Conscious Computers Possible in TGD Universe?

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Abstract

Topological Geometrodynamics (TGD) is a unified theory of fundamental interactions which has led to a theory of consciousness as a generalization of quantum measurement theory based on a new ontology referred to as zero energy ontology (ZEO). Quantum biology is the second application of TGD.

Quantum gravitation would play a key role in quantum biology and consciousness but in a sense very different from that in Penrose-Hameroff theory. The TGD view of dark matter as phases of ordinary matter with a large value of effective Planck constant makes possible quantum coherence in arbitrary long length scales. Also the new view of space-time and electromagnetic fields is central and leads to the notion of a magnetic body carrying dark matter and serving as the "boss" of the biological body controlling it and receiving sensory input from it (EEG). The prediction of ZEO that the arrow of time changes in ordinary state function reductions plays an essential role in the picture. The magnetic bodies of both Sun and Earth could be key players concerning quantum gravitational quantum coherence.

Quantum gravitational Compton time τ_{gr}, which by Equivalence Principle does not depend on the particle mass, represents the minimal value of quantum gravitational coherence time. If the clock period is shorter than τ_{gr}, the statistical determinism certainly fails but can also fail for longer clock periods. The entanglement of humans and computers is also a very interesting possibility and there is some evidence for this kind of entanglement.

Keywords: **Topological Geometrodynamics(TGD), Quantum biology, Quantum consciousness, Quantum gravitation, Computation.**

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1 Introduction

I have considered the possibility of conscious AI in the TGD Universe already earlier with inspiration coming from Sophie robot [L6]. Recently I have written several articles about what conscious computers might be in TGD [L35, L40, L36].

Can classical computers be conscious? My belief is that this is not possible if computers really are what they are believed to be. However, if quantum coherence is possible in long enough temporal and spatial scales, statistical determinism of quantum theory fails, and the computer could become analogous to a living being. In TGD inspired biology the notion of magnetic body (MB) carrying dark matter as phases of ordinary matter with very large values of Planck constant and therefore of quantum coherence scale is central. The value of Planck constant serves as measure of algebraic complexity and defines an analog of IQ. MB would serve as a "boss" and control ordinar biomatter and its macroscopic quantum coherence induces long range coherence of living matter. From the point of view of MB, living matter and computers need not differ in an essential manner. The criticality of the controlled system makes possible yo control it and uses as a sensitive sensory receptor and systems near thermodynamical criticality are in this sense favored [L26, L25]. Whether computers can satisfy this condition, is not at all obvious.

The TGD based view of the relationship between subjective time and geometric time of physicics would be also essential. The computation would be involve a sequence of TGD counterparts of unitary time evolutions as counterparts of quantum computations for states, which are superpositions of classical computations followed by "small" state function reductions (SSFRs). The sequences of SSFRs would define an analog of repeated measurement having no effect on measured

system in standard quantum theory (Zeno effect). Also "big" SFRs (BSFRs) changing the arrow of time would be involved and correspond to ordinary SFRs. Pair of BSFRs would correspond to quantum tunnelling violating statistical determinism. Could the unexpected success of AI, in particular GPT, involve this kind of transitions so that ghost would enter the machine.

I will consider the following questions in the sequel.

1. Whether and how the TGD based quantum physics, relying on zero energy ontology (ZEO) [L15, L24], could make possible conscious computers? The proposal is that since computers and biological systems do not differ essentially from the point of view of MB carrying dark matter, this could be possible.

2. Can one have a criterion for the emergence of life-like features in computers? A natural looking criterion is that quantum coherence time is longer than the period of computer clock defining analog of EEG rhythm.

3. In what sense a computer could become a conscious intentional entity. ZEO suggests that the temporary changes of the arrow of time in pairs of BSFRs make possible a kind of trial and error process allowing a goal directed behavior.

4. Quantum gravitation and quantum coherent states of dark matter at gravitational MBs of Earth and Sun could play a central role in the TGD inspired biology [L26, L25]. Their presence could imply a failure of statistical determinism so that sequences of SSFRs would be analogous to a sequence of analogs of quantum computations defining a conscious entity in time sales longer than the clock period. This is certainly true if the quantum gravitational Compton time, which serves as a lower bound for quantum gravitational coherence time, is longer than the clock period of the computer. At the level of MBs there would be no essential difference between computers and living matter. The highest reported clock frequency of almost 9 GHz is still by a factor of order 1/8 lower than the quantum gravitational Compton frequency of 67 GHz for Earth but below the THz frequency important in living matter. The criterion however also allows genuine non-determinism if gravitational quantum coherence times are longer than the clock period.

   For the Sun the criterion is much weaker: if the clock frequency is below 100 Hz (upper bound) for EEG, the quantum aspects should be present. An intriguing finding of Peoch [J6] about the interaction of a chicken marked with a computer suggests that the entanglement of computer and living matter is possible and makes possible a kind of fusion of computer and living organism into a conscious entity.

2 TGD view of space-time and quantum physics

2.1 TGD view of space-time

TGD view of space-time differs dramatically from that of General Relativity and one could loosely that Quantum TGD is analogous to wavew mechanics for point-like particles extended to 3-D surfaces. TGD can be also seen as a generalization of string model obtained by replacing strings with 3-D surfaces.

1. The point-like particle is replaced by a 3-surface whose trajectory is the space-time surface. The new element is holography, which follows from the general coordinate invariance:spacetime surfaces as trajectories for 3-D particles are analogous to Bohr orbits. A small violation of determinism in holography forces zero-energy ontology (ZEO), in which quantum states are superpositions of 4-D space-time surfaces, "Bohr orbits". They replace quantum states as superpositions of 3-surfaces (deterministic holography) [L27, L26, L25, L28]. This superposition serves as an analog of path integral involving only a finite sum.

2. By the slight failure of determinism, the time evolution of Bohr orbits is analogous to diffusion involving a finite number of non-deterministic steps (Brownian motion is a good analogy). The non-determinism of diffusion would be due to the small violation of the determinism in holography as Bohr orbitology.

3. Space-time surface as a generalized Bohr orbit is simultaneously both a minimal surface [L23] and an extremal of the Kähler action as analog of Maxwell action. This is possible if the space-time surfaces are holomorphic in a generalized sense. The concept of holomorphy is generalized from the 2-D case to the 4-D case. The 4-surface would be defined by purely algebraic conditions as a generalization of the Cauchy-Riemann conditions. As a matter of fact, minimal surface property is true for any general coordinate invariant action constructible in terms of the induced geometry so that in certain sense the dynamics independent of action principle. This universality reflects quantum critiaclity. This corresponds to the algebraization of physics at the level of M^8 related by $M^8 - H$ duality to the physics at the level of $H = M^4 \times CP_2$ based on variational principle and partial differential equations [L16, L17].

4. The space-time surface would be analogous to 4-D soap film, which is spanned by frames defined by 3-surfaces and also lower-dimensional singularities. At these singularities, the minimal surface property would not apply and only the field equations associated with sum of volume term and Kähler action would be satisfied.

   Note that minimal surface equations define a dynamics analogous to that of free fields and at the frames would correspond to places where interactions are localized. Frames would involve a finite non-determinism, as in the case of ordinary soap films [L23]. These 3-surfaces would correspond to 3-D data for holography.

2.2 TGD inspired theory of consciousness and zero energy ontology

TGD inspired quantum measurement theory [L15] [K9], which extends in zero energy ontology (ZEO) to a theory of conscious experience, is second important ingredient.

1. In ZEO, the counterparts of the ordinary quantum jumps ("big" state function reductions (BSFRs)) reverse the direction of geometric time. This analogy of diffusion in the reverse time direction looks like reverse diffusion when viewed from the opposite time direction (observer)! It is analogous to self-organization where order is created in the system rather than lost. The second main law of thermodynamics applies but in the opposite direction of time. The time reversed dissipation plays a pivotal role in the description of homeostasis [L44] in TGD inspired quantum biology.

2. This mechanism could be central to biological information processing at the quantum level and make it possible, for example, to generate sensory perception from diffuse sensory data and generate a motor response from a rough sketch?

There is an analogy of the evolution as a sequence of state function reductions with the GPT based image generation and recognition.

1. The analogy of the pixel space associated with the planar image is the projection of the 3-surface M^4 in TGD at the classical level. The image as a map from plane to the parameter space of pixels would correspond to a deformation of M^4 projection deformation. The pixel parameters defining the 2-D image would correspond to the values of CP_2 coordinates as a function of M^4 coordinates.

2. On the basis of holography, the deformation related to the 3-surface would be accompanied by a four-surface as an almost deterministic time development, i.e. the analogy of Bohr orbit. I have used the term "World of Classical Worlds" (WCW) [K8] for the space of these surfaces. This 4-surface would not be completely unique and this would produce a discrete analog of diffusion at the classical level.

3. At the quantum level, it would be a quantum superposition of these 4-surfaces as an analogy to, for example, the wave function of an electron in spatial space. An attractive idea is that the resolution is determined by the condition that the number-theoretic discretization is the same for all these surfaces in the superposition so that the quantum world looks classical apart from the finite non-determinism.

If TGD is really a respectable "theory of everything", even the physical description of computation would in principle be reduced to this description. Of course, one can argue that TGD produces only insignificant corrections to the usual physical description of computation and this might be the case. But it is always possible to ask what if...? Even if the conclusions were negative, this kind of speculations might inspire proposals for a new kind of computer technology allowing conscious and intelligent computers.

2.3 MB, NMP and ZEO

Negentropy Maximization Principle [L20, L37] states that total p-adic negentropy as a measure for conscious information increases in statistical sense. This statistical law follows from the number theoretic evolution as the increase of the dimension of extension of rationals determined by a polynomial partially defining the 4-surface in M^8 mapped to $H = M^4 \times CP_2$ by $M^8 - H$ duality. This implies that the complexity of emotions, possibly identifiable as sensory experiences for the large scale part of MB having onion-like hierarchical structure, increases during the evolution. Gravitational MBs are good candidates for the seats of highest level emotions.

2.3.1 Could the quantum coherence of MB force ordinary coherence at the level of bits?

Could the bits of the ordinary computer form coherent systems with ordinary coherence forced by the quantum coherence of the associated MB? Could the MB of the bit system control it?

1. A given layer of MB is the "boss" of the lower layers by the larger value of its h_{eff} serving as "IQ". MB is expected to form analogs of sensory and cognitive representation of the physical body having $h_{eff} = h$. This suggests that MB could represent the bit system holographically. This kind of quantum holography for hadrons, and for elementary particles in general, would be the counter of classical holography implied in the TGD framework by the general coordinate invariance [L34].

   The dark spin system at MB could have spin glass property [L22] implying a large number of almost degenerate states with nearly the same energy.

2. The change of single bit, represented for instance by using a MOSFET, would require energy larger than the thermal energy of order .05 eV at room temperature. This suggests that the change of single bit is not easy to actualize.

   The dark spin system at MB could however induce phase transitions of the bit system changing the directions for a large number of bits. The average change of energy per bit could be rather small for this kind of transition although the change of a single bit would cost rather large energy. Ultrametric, in particular p-adic, topologies [B1] emerge in the modelling and description of the spin glass phase in the TGD framework and could help to understand cognition number theoretically [L22].

   The phase transition would involve a large number of bits so that the corresponding conscious experiences would be holistic and therefore resemble emotions. The color of the emotion would be positive or negative depending on whether the sum of p-adic entanglement negentropies increases or decreases. The geometric correlate for positive/negative emotion would be the increase/decrease of the connectedness of the MB.

3. ZEO predicts two kinds of SFRs: "big" and "small" . SSFRs correspond to Zeno effect in the ordinary wave mechanics and in quantum optics to unitary evolutions between weak measurements analogous to classical measurement. "Big" state function reduction (BSFR) changes the arrow of time. The outcomes for pairs of BSFRs An observer with a fixed arrow of time can observe only pairs of BSFRs.

4. In ZEO [K9, K10] [L15, L12, L21, L24], MB as the "boss" could control the time evolution of the bit system by pairs of BSFRs involving temporary change of the arrow of time. BSFRs would be induced by perturbations affecting the set of mutually commuting observables measured at the active boundary of CD so that it does not commute with the corresponding

set associated with the passive boundary of CD at which state is unaffected in SSFRs (Zeno effect). In this kind of situation, a BSFR occurs instead of SSFR and changes the arrow of time. Second BSFR brings back the original arrow of time. The process could correspond to quantum tunnelling.

5. Do the periods defined by the computer clock with a duration T, of say 1 ns, correspond to pairs of BSFRs or a single SSFR? Perhaps T could correspond to a sequence of SSFRs as analogs of Zeno effect and the pair of BSFRs to a single tick of the computer clock. This conforms with the fact that the running of a predetermined computer program must involve a sequence of non-deterministic phase transitions changing the directions of bits [L29]. This must be the case since the notion of computer program as a sequence of arbitrarily chosen steps is not consistent with deterministic physics.

   If the step of the clock is identifiable as a sequence of SSFRs, one can say that the ordinary classical computation is a sequence of quantum computations defined by the sequences of unitary evolutions associated with SSFRs and defining conscious entities with haltings defined by BSFRs! If MB does modify the classical computation at all, it could induce BSFR pairs in longer time scales or modify the probabilities of various outcomes of BSFRs.

   The computer clock would define an analog of EEG. There is evidence that also in EEG the period can be divided into ordered and chaotic parts: these two parts which could correspond to opposite time directions [L1]: this is discussed from the TGD view point in [L1].

2.3.2 Did Google quantum computer change the arrow of time?

The latest FB news is that Google quantum computer has changed the arrow of time for a period of about 1 second. There is no publication of this yet but IBM made a similar announcement in 2019 (see this). It remains unclear to me what they have achieved without knowing what they mean with the time reversal.

It remains unclear to me what they have achieved without knowing what they mean with the time reversal.

1. Time reversal can be interpreted as a time reflection, which is a slightly broken discrete symmetry in fundamental physics. Do they construct a time revered time evolution in which initial and final states are permuted? Since complex conjugation is associated with the time reversal, a positive Hamiltonian can induce the time-reversed time evolution and no new physics would be involved.

2. Time reversal can be also interpreted as a thermodynamical time reversal. The reversal of the thermodynamical arrow of time is thought to be impossible in standard thermodynamics. There are however anomalies suggesting that this is possible. Phase conjugate laser rays are a basic example. In biology Pollack effect suggests the reversal of the arrow of time in the negatively charged exclusion zone. The inpurities are cleaned out of the system whereas thermodynamics suggests the reversal. Dissipation with a reversed arrow of time.

3. In TGD, time reversal occurs in "big" state function reductions (BSFRs) occurring in quantum measurement and induce a thermodynamical time reversal. In "small" SFRs (SSFRs), which have interpretation as internal quantum measurements of the system involving no external observer and assumed to give rise to cognition and consciousness, this does not happen. These measurements would take place in the discrete degrees of freedom predicted to be associated with the non-determism, of the classical dynamics.

   The sequence of SSFRs defines a conscious entity self, which would die and reincarnate with an opposite arrow of time in BSFR. Falling asleep or biological death would be familiar examples of this.

By writing "Google's quantum computer reversed the arrow of time" to Google, one learns more. Google claims that the thermodynamic arrow was not changed. But what does it really mean? The computer is externally controlled and the time evolution $A \to B$ is continued so that one has $A \to B \to A$. This means that a quantum measurement by an external system takes place at time T when $B \to A$ starts.

In the TGD framework this would mean that the control inducing what looks $B \to A$ corresponds to a BSFR at time T, which reverses the arrow of geometric time. A time evolution to the geometric past by SSFRs begins at time $T - \Delta T_1$ and eventually at time $T - \Delta T_2$ a second BSFR occurs and the evolution with the standard arrow of time time by SSFRs begins, not at T but, at $T + \Delta T$. Δ T would be about 1 second. The same happens as we fall asleep: we wake-up after, say, = 12 hours but make a time travel to the geometric past during sleep lasting for say, 12 hours. If this interpretation is correct, the experiment could provide a direct support for the zero energy ontology of TGD.

However, a more precise TGD view of what happened is needed. In TGD cognition is predicted to be present in all scales so that I will approach the question from the point of view of TGD inspired theory of consciousness.

There are very delicate details involved.

1. Second law says that the entropy $S(S)$ of a closed system S increases. Now S is the quantum computer. There is also the entanglement entropy $S(S-O)$ between S and that observer O. It is reported that the entropy of the quantum computer decreased during the period $B \to A$. It is not clear to me whether this entropy was $S(S)$ or $S(O,S)$? If the system was closed during this period, the decrease of $S(S)$ would allow us to conclude that the arrow of time was effectively changed.

2. What does the period $B \to A$ does correspond to in TGD? Suppose that it corresponds to $[T - \Delta T_1, T - \Delta T_2$ when geometric time decreases. What does the entropy correspond to. Does it correspond to the entanglement entropy of the system + observer or to the sum of this entropy and system's internal entropy? Or is also the system´s internal entropy basically entanglement entropy?

3. Intuitively it looks obvious that the first BSFR increases the information of an external observer of the system and reduces $S(S-O)$ to zero. If the internal degrees of freedom are not entangled with external degrees of freedom, BSFR leaves $S(S)$ unaffected. The time reversed time evolution would increase $S(S)$ but in the opposite time direction. If $S(S-O)$ is generated, it is reduced to zero in the second BSFR. $S(S)$ would increase during the period $[T - \Delta T_1, T - \Delta T_2$. If an observer O with a standard arrow of time were able to observe S during this period, it would see this as a decrease of $S(S)$.

   Also in the second BSFR the entropy would have decreased and the evolution in standard direction would have started at $T + \Delta T$. It is difficult to say whether the entropy increased or decreased. If this was the case, the experiment would provide direct support for the zero energy ontology of TGD.

4. To gain some insight, one can compare the situation to what happens during sleep. Sleep has positive effects, perhaps due to the fact that it reduces the entropy of the sleeper. These positive effects are however felt also subjectively, rather than perceived by the external observer. Should one identify O as the field body of the system observing the biological body or is some other interpretation more appropriate?

5. There is a further delicacy involved. In TGD, the fundamental objects are 4-surfaces as slightly non-deterministic analogs of Bohr orbits for particles identified as 3-surfaces. The discrete degrees of freedom associated with the non-determinism are identified as cognitive degrees of freedom. Therefore it might make sense to speak of cognitive entropy $S(cogn)$ associated with them.

   $S(cogn)$ would increase as we get tired and would be reduced during sleep. Could $S(cogn)$ correspond to entanglement entropy between cognitive degrees of freedom and those of the external world? If so, $S(cogn)$ would contribute also to $S(S-O)$. In BSFR also $S(cogn)$ would be reduced to zero. If this view holds true, then the second BSFR would be responsible for the decrease of entanglement entropy.

Note that there are also other kinds of entanglements involved. Consider two systems A and B.

1. The IDF of A need not entangle with the ODF of A although the ODF of A and B can entangle. Could this relate to sensory perception?

2. The IDF of A can entangle with the ODF B. Could this make possible psychokinesis and hypnosis?

3. The IDF of A and B can entangle. Could this relate to telepathy?

4. Entanglement can also occur between the IDF and ODF of A. Could this relate to the realization of intentions in motor degrees of freedom?

3 Some notions relevant to TGD inspired quantum biology

Below some notions relevant to TGD inspired theory of consciousness and quantum biology are discussed.

3.1 The notion of magnetic body

Magnetic body (MB) carrying dark matter would serve as the boss controlling ordinary matter at flux tubes.

1. MB has as building bricks magnetic flux quanta. Typically flux tubes and flux sheets. It consists of two kinds of flux quanta. Flux can be vanishing, which corresponds to Maxwellian case. The flux can be also non-vanishing and quantized and corresponds to monopole flux. In monopole case magnetic field requires no current to create it. This option is not possible in Maxwellian world. These flux tubes play a key role in TGD Universe in all scales.

2. Also Earth's magnetic field with nominal value $B_E = .5$ Gauss would have these two parts. Monopole part corresponds to the "endogenous" magnetic field $B_{end} = .2$ Gauss explaining strange effects of ELF em radiation to the physiology and behavior of vertebrates [J1]. The presence of this part identifiable as monopole flux explains why Earth has magnetic field: this field should have decayed long time ago in Maxwellian world since it requires currents to generate it and they disappear. Magnetic fields of permanent magnets could have a monopole part consisting of flux quanta. Electromagnets would not have it.

3. MB would carry dark matter as $h_{eff} = n \times h_0$ phases and act as a "boss" controlling ordinary matter [L14]. Communication to and control of biological body (ordinary matter) would be based on dark photons, which can transform to ordinary photons and vice versa. Molecular transitions would be one form of control.

4. Dark photons with large h_{eff} serve as as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to bio-photons [L2, L3] with energies covering visible and UV associated with the transitions of bio-molecules. The control by MB which layers having size even larger than that of Earth means that remote mental interactions are routine in living matter. EEG would be a particular example of these communications: without MB it is difficult to understand why brain would use such large amounts of energy to send signals to outer space.

5. The experiments of Blackman and others led originally to the notion of h_{eff} hierarchy. The large effects of radiation at ELF frequencies could be understood iin terms of cyclotron transitions in $B_{end} = .2$ Gauss if the value of h in $E = hf$ is replaced with h_{eff}, which would be rather large and possibly assignable to gravitational flux tubes with $\hbar_{eff} = \hbar_{gr} = GMm/v_0$.

   MB would control BB by cyclotron radiation - possibly via genome accompanied by dark genome at flux tubes parallel to the DNA strands. Cyclotron Bose-Einstein condensates of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear in living matter and $h_{eff} = h_{gr}$ hypothesis predicts universal energy spectrum in the range of bio-photon energies.

Cell membrane could act as generalized Josephson junction generating dark Jophson radiation with energies given by the sum for ordinary Josephson energy and of the difference of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential would induce variation of the Josephson frequency and code the sensory information at cell membrane to a dark photon signal sent to MB.

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

3.2 Dark cyclotron radiation

The cyclotron frequencies associated with the gravitational MB of Earth [K4] [L26, L25] should play a key role in TGD inspired quantum biology and relate to the feedback from MB to the living matter. This could be the situation also in the case of computers. The first guess, inspired by the model for the findings of Blackman [J1] and others on effects of ELF em fields on brain, is that monopole flux tubes associated with the MB of Earth correspond to the endogenous magnetic field of $B_{end} = 2B_E/5$ ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field).

This value is only the average value since frequency modulation is the way to code information and is achieved by varying the flux tube thickness in turn affecting the value of B_{end}. Very probably there exists an entire hierarchy of values of the dark magnetic field strength perhaps coming as powers of 2.

For cyclotron frequencies associated with the gravitational MB, h_{eff} would correspond to the gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ for Earth. Note that, in accordance with the Equivalence Principle, the cyclotron energy $E_c = \hbar_{gr}eB/m = GMeB/\beta_0$ does not depend on m.

3.3 The possible role of quantum gravitation in quantum biology

In the TGD framework conscious computers could represent a life form based on the same general mechanisms at the level of MBs. The basic questions is how to achieve quantum coherence in macroscopic scales.

During late years, the TGD view of quantum gravitation has developed dramatically and provides a beautiful vision of living matter as being controlled by dark matter at the gravitational monopole flux tubes forming dark MBs with onion-like structure consisting of shells formed from tangential monopole flux tubes and connected by radial flux tubes along which graviton mediating the gravitational interaction propagate [L25, L26, L38, L39].

Why the role of quantum gravitation could be so decisive is that it has infinite range and is not screened. In TGD, gravitational quantum coherence in even astrophysical scales becomes possible. The basic quantification tool is gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ originally introduced by Nottale [E1]. In accordance with the Equivalence Principle, the gravitational Compton length $\Lambda_{gr} = GM/\beta_0 = r_S/2\beta_0$ is independent of the small mass m. The most amazing and crazy sounding consequence is that the gravitational MBs of the Sun, Earth, and possibly also of other planets, even the Moon, could be highly relevant for quantum biology. Astrologists would not have been totally wrong.

3.3.1 Gravitational Compton frequencies

Suppose that one has a particle with mass m with Compton length $r_c(m) = \hbar/m$ and the ordinary Compton frequency $f_c = m/\hbar$. The gravitational Compton frequencies $f_{gr}(M, \beta_0) = m/\hbar_{gr}(M, \beta_0) = 2\beta_0/r_s$, which do not depend on m.

Gravitational Compton frequencies could be important in biology. Consider first the Earth's gravitational Compton frequency. The value of the gravitational Compton length $\Lambda_{gr}(M_E, \beta_0 = 1) = GM/\beta_0 = 0.45$ cm, which is also independent of m, defines a lower bound for the gravitational

quantum coherence length. Λ_{gr} corresponds to a gravitational Compton frequency $f_{gr} = 6.7 \times 10^{10}$ Hz $\simeq 67$ GHz.

The frequencies in the GHz scale are found to be important also in living matter. As a matter of fact, there is experimental support for a fractal hierarchy of frequency scale come as powers $f = 10^{3k}$ Hz, $k = 0, 1, ..,$, that is 1 Hz, kHz, MHz,GHz, and THz assignable to microtubules [J5] (`https://rb.gy/9rvpr`). For these reasons it is interesting to look at 1 GHz as an example.

Also the gravitational Compton frequency f_{gr} associated with the gravitational MB of the Sun, having $\beta_0 \simeq 2^{-11}$, could be important. For the Sun, gravitational Compton length is rather near to $R_E/2$ where $R_E = 6378$ km is Earth radius. The corresponding Compton frequency $f_{gr}(M_S, \beta_{Sun} = 2^{-11}) \simeq \beta_{Sun}/GM_S$ is about 100 Hz and corresponds to the upper bound for EEG, which conforms with the fact that quantum gravitational coherence time should not be smaller than Λ_{gr}. Note that the cyclotron frequency Lithium in the endogenous magnetic field $B_{end} = .2$ Gauss assignable to the Earth's gravitational flux tubes is 50 Hz. For the lightest ion, which is tritium, the cyclotron frequency is about 100 Hz and maximal.

1. The lower cyclotron frequencies of the heavier ions in $B_{end,E} = .2$ Gauss assignable to Earth belong also to EEG range and correspond to longer solar quantum coherence lengths. DNA would correspond to 1 Hz and perhaps to the largest quantum gravitational coherence length in the EEG range. The cyclotron frequencies above 100 Hz would correspond to solar gravitational quantum coherence lengths below R_E.

2. The cyclotron frequencies above 100 Hz would correspond to solar gravitational quantum coherence lengths below R_E: this does not look feasible. For protons and electrons the cyclotron frequencies are indeed above $f_{gr,S}$. For protons (electrons) the cyclotron frequency f_c in $B_{end,E} = .2$ Gauss is 300 Hz (6×10^5 Hz). It is important to notice that for $\hbar_{gr}(M, m)$ cyclotron energy does not depend on mass and is the same for electrons and protons.

   Could the value of β_0 for protons and electrons at the flux tubes of $B_{end,E}$ ($B_{end,S}$) be $\beta_0 = 1/3$ ($\beta_0 = 2^{-11}/3$)? Could one say that electrons and protons are slightly more advanced than other ions in the evolutionary sense?

3. For the Sun, one has $\beta_0 \simeq 2^{-11} \simeq m_e/m_p$ instead of $\beta_0 = 1$. The value of B_{end} for the Sun cannot be the same as for Earth. A good estimate is obtained from the value range for B in the outer magnetosphere, where the solar magnetic field should dominate. The order of magnitude is $B_{end,S} \simeq 10nT = 2^{11} B_{end,E}$. For this value, the cyclotron energy would be the same as for Sun and Earth and energy resonance would be possible! This observation was made already in [K4].

4. The replacement of $\hbar_{gr}(M_E, m) \to \hbar_{gr}(M_{Sun}, m)$ means multiplication of say EEG period by a factor $r = (M_{Sun}/M_E)\beta_{0,E}/\beta_{0,Sun} \simeq 2.2 \times 10^8$ so that alpha period .1 seconds corresponds to 2.2×10^7 seconds. Intriguingly, one year corresponds to 3.25×10^7 seconds and defines a fundamental biorhythm, which would correspond to a 6.7 Hz rhythm for EEG not far from the lowest Schumann resonance frequency.

5. The energies $E = h_{gr}(M, m, \beta_0) f_{gr}(Sun)$ assignable to the gravitational Compton frequency of Sun are proportional to m and since nucleon mass dominates over electron mass they are in good approximation proportional to the mass number of the molecules. This suggests a multi-resonance in which each electron, proton and even nucleon absorbs boson, maybe dark gravitons, with frequency f_{gr}. For electrons, the energy is about 1 meV, which could relate to the miniature potentials for neurons. For protons the energy would be about 2 eV, which corresponds to red light. Large scale quantum coherence could make the rate of gravitational multi-resonance.

3.3.2 Could also the gravitational magnetic bodies of Moon and other planets be involved?

If one accepts that the gravitational MBs of Earth and Sun are important, one cannot avoid the question whether also the other planets could be important for quantum biology.

1. The value of h_{eff} deduced from the original findings of Blackman [J1] and others was very large since the energy of the dark photon had to belong to the range between thermal energies at physiological temperature and UV photons. The identification $\hbar_{eff} = \hbar_{gr}(M_E, \beta_0)$ is suggestive. Assuming that the dark Josephson radiation from the cell membrane being received resonantly at the MB of Earth would suggest the simplest option as $h_{eff,J} = h_{gr}(M_E, \beta_0 = 1)$? Would the condition $Z_J eV_C = E_c = GM_E ZeB/\beta_0$, where $eV_C = .05$ eV, fix the values for voltage for dark gravitational flux tubes in a communicating Josephson junction and the value of the magnetic field with a MB flux tube?

2. The experiments of Blackman provided evidence for the existence of an "endogenous" magnetic field $B_{end} = .2$ Gauss. In TGD, B_{end} was identified as the monopole part of the Earth's magnetic field. Assuming $B = B_{end} = .2$ Gauss and $Z_J = Z$, we get $eV_C = 13.5$ eV which is slightly lower than the ionization energy of hydrogen atom 13.6 eV and much higher than $eV_C = .05$ eV. The interpretation as a Josephson junction is not meaningful.

   Could the interpretation be that the transition to very long flux tubes effectively nearly ionizes the hydrogen atom? Could hydrogen atom ionization produce dark UV photons with monopole flux tubes on Earth?

3. The monopole flux tubes of MBs can adjust their flux tube thicknes, which controls the strength of the magnetic field, so that frequency modulation becomes possible and they can receive information also from the transition of atoms and molecules by tuning to cyclotron resonance and control them by the same mechanism!

   I have indeed proposed in the context of the model of bioharmony [L18] that the value of B_{end} has a discrete spectrum. In particular, the visible range of photons could correspond to frequencies forming an analog of a 12-note system and the spectrum of B_{end} could realize this system. Note also that the parameter $\beta_0 \leq 1$ could allow us to realize a spectrum of energies for a fixed frequency.

4. One should obtain also the energy range of biophotons (energy range for visible light) as energies of dark Josephson photons. What if we replace the mass of the Earth with the mass of the moon $M_M = .012M_E$ giving $\Lambda_{gr} = .54 \times 10^{-4}$ meters, the size scale of a large neuron (water blob of size 10^{-4} m has Planck mass), and keep B_{end} and β_0 the same? For $Z_J = Z$, the value of eV_C decreases to $1.2 \times 13.5/100eV = .16$ eV, which is in infrared and in a reasonable approximation 2 times the membrane potential. This is smaller than the typical energy of biophotons which is in visible range. If the values of B define a 12-note spectrum or something more general, this would give rise to biophoton energies above IR.

   It is important to notice that the experiments of Blackman and others fix only the value of B_{end} to .2 Gauss, identifiable as monopole part of the Earth's magnetic field, but require only that the cyclotron energy is above the thermal energy so that the Moon could solve the problem!

5. In the case of Moon, the Josephson energy for the cell membrane given by $E_J = .055$ eV is obtained for $Z_J = 2$ and $Z = 1$ having natural interpretation for cyclotron transitions. This value could relate to Pollack phase transition occurring at the physiological temperature range [I1, I3, I5]!

6. If one has introduced Sun, Earth and Moon to quantum biology, there is not much respectability to be lost anymore, and one can ask whether other planets could be of significance. Could the horoscope builders have been right in some sense?

   The mass of Mars is roughly 11 percent of Earth mass and would give $E_c = 1.8$ eV for $B_{end} = .2$ Gauss. This is in the visible biophoton range. The interpretation of the frequencies f_{gr} as upper end points of the spectrum so that lower frequencies would correspond to smaller values of B_{end}. I have proposed that the values of B_{end} correspond to 12-note scale with inspiration coming from the model of bioharmony [L4, L18].

3.3.3 Could quantum gravitation make possible conscious computers?

Could these biology related observations be relevant for the idea that computers might be conscious?

1. With clock frequencies higher than the gravitational Compton frequency 67 GHz of Earth, quantum gravitational effects on computation might (actually should) become important in the TGD Universe. The clock frequencies of computers are typically a few GHz in recent communication and computer technologies, and the highest clock frequency of 8.794 GHz is roughly by a factor 1/8 lower than f_{gr}. Could the GHz scale correspond to the gravitational quantum coherence length having Λ_{gr} as a lower bound? Could it be that the very efficient computer networks (what are the clock frequencies used?) utilized in GPT have reached the limit at which the quantum gravitational body of Earth begins to play a prominent role?

2. Could the typical clock frequency, of say 1 GHz, have an interpretation both as an analog of EEG rhythm (analog of alpha frequency 10 Hz in living matter) and as an analog of Josephson frequency ZeV/h_{eff}, where $V \sim .05$ V is a voltage assignable to the bit and Ze is the charge of the charge carrier.

3. Could the MB of the Sun interfere with the computation occurring in the network having Earth scale? The time scale would be now the time scale of EEG: could the quantum entanglement of, say, a human user with the computer make this interaction possible. It might be possible to test this. This interaction is possible for clock frequencies higher than $f_{gr} = 100$ Hz, and could also explain the findings of Peoch [J6] related chicken-robot interaction, which affected the function of the random number generator. If this view is correct, computer-human interactions would have been present already when the first computers (around 1951) having a clock speed of 20 MHz emerged.

4 An attempt to build a concrete view about computer consciousness

TGD inspired view about consciousness and quantum biology suggest some guidelines in the attempts to undertand how computer systems or computer systems coupled to their users could become conscious.

4.1 Could the basic aspects of TGD inspired quantum biology generalize to the level of computer systems?

What aspects of the TGD inspired quantum biology could be generalized to the conscious computer systems? The mechanisms related to MB, possessed also by computer systems, are excellent candidates in this respect.

1. TGD suggests a universal realization of genetic code [L19, L31] at monopole flux tubes of the MB and also a universal quantum gravitational mechanism of metabolism [L25].

2. In living matter, the communications to MB take place by dark Josephson radiation assignable at least to membrane proteins acting as Josephson junctions. One can assign EEG to these communications [K6, K2, K7]. Actually a scale hierarchy of analogs of EEG is predicted.

3. The control by MB by cyclotron radiation associated for instance with the endogenous magnetic field of .2 Gauss identifiable in terms of the monopole flux of the Earth's magnetic field about .5 Gauss. Gravitational cyclotron energies would not depend on the mass of the charged particle. Communication could occur by multi-resonances involved with the universal realization of genetic code at MB so that genes would couple resonantly.

4. Even the gravitational Compton frequencies, these frequencies for the Earth, Sun and perhaps even Milky Way blackhole could define fundamental biorhythms. This is in possible since the dark photon signals would propagate along magnetic flux tubes and would not be damped

as in standard model Universe. Striking evidence for this has recently emerged from the discoveries of James Webb telescope [L42].

5. These mechanisms would be universal and the ordinary biomatter would adapt so that resonant communications with MB are possible. In biomatter this would select preferred biomolecules. Same could happen in the case of computers.

4.2 Dark Josephson radiation and computers

Could one assign to bits dark Josephson junctions assignable represented as voltages in transistors?

1. Could representations of genetic codons at MB by dark photon triplets [L18] and by dark proton triplets [L19, L31] and perhaps even by dark electron triplets [L28] be involved? This would bring in dark genetic codons, which could provide a universal representation of the bit system as a dark system at monopole flux tubes and make a connection with the TGD inspired quantum biology rather precise.

   The representations at MB should strongly correlate with the state of the computer represented by a bit pattern (say states of MOSFETs). One could have a holography-like map of bit patterns to the dark many-spin state at the MB of the computer or of computer + user. This kind of holography is considered in [L34] for elementary particles and also more generally.

2. The physical stress, created by electric field on quartz crystal, which is piezoelectric, generates oscillations with frequency in the range 2-3 GHz giving rise to a very precise clock frequency. The typical computer clock frequency is a few GHz. My own PC has a clock frequency of 3.3 GHz. From the web one can learn that the highest clock frequency is 8.794 GHz.

   Could the clock frequency have an interpretation both as an analog of EEG rhythm (analog of alpha frequency 10 Hz in living matter) and as an analog of Josephson frequency ZeV/h_{eff}, where $V \sim .05$ V is a voltage assignable to the bit and Ze is the charge of the charge carrier? Could the clock frequency with energy $E = hf$ be accompanied by a hierarchy of scaled down frequencies $f_{dark} = (\hbar/\hbar_{eff})f$ associated with the MB of the computer.

3. The dark Josephson junctions are necessary for the coding of the sensory information to a frequency modulation of the Josephson frequency and its communication to MB as Josephson radiation. The junctions are assigned with the membrane proteins in living matter. TGD suggests that valence bonds and hydrogen bonds can have a varying value of h_{eff} [L7]. The value of $\hbar_{eff}$ for Josephson junction would be much smaller than $\hbar_{gr}$ unless the gravitational magnetic bodies of Earth and Sun are somehow involved. The condition that the Josephson energy is above thermal energy at room temperature for $Z = 1$ gives $h_{eff}/h \geq 5 \times 10^3 (f/GHz)$. If the energy of a dark Josephson photon is above 1 eV (the energy range of biophotons), one has $h_{eff}/h \geq 10^5 (f/GHz)$.

4. Consider $f = 1$ GHz as an example. For the thermal option, the Compton length $\Lambda_{eff,p} = h_{eff}/m_p$ of dark proton is longer than 6.2×10^{-12} m and longer than the ordinary electron Compton length $\lambda_e = 2.4 \times 10^{-12}$ m. The dark Compton length $\lambda_{eff,e} = h_{eff}/m_e$ of electrons would be longer than 4.8 nm, which roughly corresponds to the scale of DNA.

   For the biophoton option, the dark proton Compton length would be of the order of the atomic length scale 1.32×10^{-10} meters and the dark electron Compton length would longer than .26 μm to be compared with the size scale 1 μm of cell nucleus.

It is not at all clear whether it is possible to assign Josephson junctions with the dark flux tubes associated with transistors, and the idea of a living computer might fail for transistor technology. A more promising approach is based on the replacement of transistors with Josephson junctions and the needed technology, known as superconducting computing, exists.

4.3 Could the user and computer entangle?

One can ask whether quantum entanglement of the MBs of the computer and user could occur in the computer-user interaction and whether the role of the computer is analogous to that in the chicken-robot experiment. One can also ask whether also GPT could involve emotional and even cognitive entanglement.

The identification of the computer system with which the user would entangle is not at all obvious. The system could be even formed by the network of computers involved with the the running of GPT. One interpretation is that networks and entire internet form a conscious entity as an analog of the central nervous system in which humans and their MBs) serve in the role of neurons.

In ZEO, the holography implies that in the ideal situation the running of the program corresponds to a 4-D Bohr orbit-like surface, which is almost uniquely fixed by the 3-surfaces at images of 3-D hyperbolic manifolds at mass shells determined by the state. The sequences of SSFRs as flow of consciousness could correspond to this kind of period and represent a generalization of the Zeno effect. What would be new is that the pairs of BSFRs would induce temporal change of the arrow of time and quantum tunnelling and make the computation a conscious, goal direct process strongly reminiscent of problem solving by trial and error.

4.4 Counterportation and TGD

Tuomas Sorakivi sent links to interesting articles related to the work of Hatim Salih [B2] (see this) summarized in a popular article.

Salih introduces the concept of counterportation. It is communication that does not involve classical or quantum signals (photons). Counterfactuality is a basic concept: the first web source that one finds tells "Counterfactuals are things that might have happened, although they did not in fact happen. In interaction-free measurements, an object is found because it might have absorbed a photon, although actually it did not."

The example considered by Salih is as follows.

1. Consider a mirror system consisting of a) fully reflective mirrors and b) mirrors that let through the horizontal polarization H and reflect the vertical polarization V. The system consists of two paths: A and B. In the first mirror, which is type b) mirror, the signal splits into two parts, H and V and which propagate along A and B. At the end the signals meet in a type b) mirror and H goes through to detector D1 and V is reflected and ends up to detector D2.

2. The horizontal polarization component H going through type b) mirror at the first mirror travels along the path A. It contains only one fully reflective mirror and the beam reflected from it ends up in the downstream mirror of type b) as H type polarization and goes to the detector D1.

3. The vertical polarization component V reflected at the first mirror travels along the path B. The path B contains many steps and with each step the polarization is slightly rotated so that the incoming polarization V transforms so that its horizontal component H at the end has same magnitude but a phase opposite to that of H coming along A. H components interfere to zero and only V from B remains so that the detector D2 registering only V clicks.

   In the B-path mirrors, the varying polarization directions H and V are chosen so that to guarantee the destructive interference. Hence "counterfactuality". There is no interaction with photons: only the possibility of it and this seems to be enough. This looks paradoxical and suggests that something is not understood.

4. Bob can control path B and can block it so that nothing can get through. The result is that only the signal coming from path A gets through and travels to detector D1. Bob can therefore communicate information to Alice. For instance, at moments of time $t_n = nt_0$ Bob can block or open path B. The result is a string of bits that Alice observes. This is communication without photons or classical signals.

5. The roles of Bob and Alice can be changed. Alice can block or open the channel and Bob can look at the detectors registering the outcome. Therefore Bob and Alice can have "conversations".

The following remarks can be made.

1. The controlled qubit (channel B open or closed) is macro- or at least nanoscopic and cannot be represented by the spin states of an elementary particle.

2. The experimental arrangement under consideration corresponds logically to cnot operation. If channel B is closed, nothing happens to the incoming signal and it ends up in D1. If B is open, then the signal ends up at detector D2. cnot would be realized by bringing in Bob as the controller that affects the space-time topology.

3. Quantum coherence is needed in meso- or even macroscopic scales. Number-theoretic TGD predicts a hierarchy of effective Planck's constants h_{eff}, which label to the phases of ordinary matter, which can be quantum-coherent on an arbitrarily long length and time scales. These phases behave like dark matter and explain the missing baryonic matter whereas dark energy in the TGD sense explains galactic dark matter. They enable quantum coherence at the nano- and macro levels.

The basic question is what does the blocking of channel B mean in the language of theoretical physics. It is a mesoscopic or even macroscopic operation. That's where Bob comes in as a conscious, intentional entity. Here recent theoretical physics cannot help.

Salih emphasizes that this is something new that standard quantum physics cannot describe. Such a situation leads to a paradox. Salih considers many options, starting from different interpretations of quantum measurement theory.

1. "Weak measurement", as introduced by Aharonov and his colleagues (see this), is one option presented. In the name of honesty, it is necessary to be politically incorrect and say that this model is already mathematically inconsistent. Weak measurement has another meaning and would be a generalization of the Zeno effect, which usually means that repeated measurements of the same observables have no effect on the measured system. Weak measurements would have a small effect on the system and would be much like classical measurements.

   In the TGD inspired theory of consciousness reducing to a theory of quantum measurement in what I call zero energy ontology (ZEO) weak measurements correspond to "small" state function reductions (SSFRs): the conscious experience of conscious entities corresponds to a sequence of SSFRs. In ordinary, "big" SFRs (BSFRs) the arrow of geometric time changes and this has dramatic implications.

2. "Consistent histories approach" (see this) is another option that was hoped to solve the measurement problem. It gives up the concept of unitary time evolution. Also this model is mathematically and conceptually hopelessly ugly. A mathematician could never consider such an option, but emergency does not read the law.

3. Wormholes as a cause or correlate of quantum entanglement is the third attempt to describe the situation. The problem is that they are unstable and the ER-EPR correspondence (see this) has not led to anything concrete even though there are scary big names behind it. Salih also suggests a connection with quantum computation but this connection is extremely obscure and requires something like AdS/CFT.

   Here, however, I think Salih is on the right track in that he has realized that the solution to the problem is at the space-time level. The ordinary trivial topology of Minkowski space is not enough. The question is how to describe geometric objects like this experimental setup on a fundamental level. In the standard model, they are described phenomenologically by means of matter densities, and this is of course not enough at the quantum level.

What does TGD say? TGD brings a new ontology both at the space-time level and in quantum measurement theory.

1. In addition to elementary particles, TGD brings to quantum physics the geometric and topological degrees of freedom related to the space-time surfaces. A description of the observed physical objects of different scales is obtained: typically they correspond to a non-trivial space-time topology. Spacetime is not a flat M^4, not even its slightly curved GRT variant, but a topologically extremely complex 4-surface with a fractal structure:space-time sheets glued to larger space-time sheets by wormhole contacts, monopole flux tubes, etc...

   (a) The system just considered corresponds to two different space-time topologies. Photons can travel a) along path A (blocking) or b) along both paths A and B simultaneously (no blocking).

   (b) Bob has a spacetime the competence of a topology engineer and can decide which option is realized by blocking or opening channel B by changing the spacetime topology.

   (c) Describing this operation as a quantum jump means that Bob is quantum-entangled with the geometric and topological degrees of freedom of channel B. The initial state is a superposition of open B and closed B. Bob measures whether the channel is open or closed and gets the result "open" or "closed". The outcome determines what Alice observes. Monopole flux tubes replacing wormholes of GRT serve as correlates and prerequisites for this entanglement.

   The controlled qubit (channel B open or closed) is macro- or at least nanoscopic and cannot be represented by the spin states of an elementary particle.

   Note that the experimental arrangement under consideration corresponds logically to cnot operation. If channel B is closed, nothing happens to the incoming signal and it ends up in D1. If B is open, then the signal ends up at detector D2. cnot would be realized by bringing in Bob as the controller that affects the space-time topology.

2. The second requirement is quantum coherence in meso- or even macroscopic scales. Number-theoretic TGD predicts a hierarchy of effective Planck's constants h_{eff}, which label to the phases of ordinary matter, which can be quantum-coherent on an arbitrarily long length and time scales. These phases behave like dark matter and explain the missing baryonic matter whereas dark energy in the TGD sense explains galactic dark matter. They enable quantum coherence at the nano- and macro levels.

These two new elements of TGD make possible quantum entanglement in mesoscopic, macroscopic and even astrophysical scales and bring to quantum computation the hierarchy of Planck constants. This has dramatic implications: consider only the stability of the qubits against thermal perturbations implied by the fact that the cyclotron energy scale increases by the factor h_{eff}/h_0.

1. Braided monopole flux tubes making possible topological quantum computation in turn stabilize the computations at the space-time level. In ordinary topological quantum computations the braiding is fixed. Now the braiding could become dynamical since reconnection of flux tubes would change the topology of the topological quantum computer as a braid.

2. U-shaped monopole flux tubes emanating from two systems can reconnect to form a pair of monopole flux tubes connecting two systems. This makes possible quantum entanglement between them. The reconnection could provide a fundamental realization of the blocking and its reverse operation. In quantum biology biocatalysis would be based on this process controlled by magnetic bodies carrying dark matter and acting in the role of "boss". Entire control hierarchies of magnetic bodies could be involved and realize controlled operations cX and also higher level controlled operations c..cX.

There are also deep implications for the classical computation [L35, L36, L32].

1. Classical computers could become conscious, intelligent entities in the TGD Universe if a quantum coherence time assignable to the computer exceeds the clock period [L35, L36, L40]. The TGD view of the role of classical gravitational and electric fields [L26, L25, L32] makes this possible. Also the entanglement of living entities with computers could make it a part of the living entity.

2. The control of computers by living entities using a cnot-coupling making possible counterportation could make possible human-quantum computer interaction if ordinary computers can have quantum coherence in time scales longer than clock period (in principle possible in the TGD Universe!).

As a matter of fact, there is evidence for the interaction between computers and living matter [J6]. A chicken gets marked to a robot and the behavior of the robot begins to correlate with that of the chicken! Maybe a cnot-coupling with the random number generator of the robot is involved! Here the TGD view of classical fields and long length scale quantum coherence associated with the classical electric and magnetic fields and gravitational fields might allow us to understand what is involved [L26, L25, L32].

1. The gravitational field of the Sun corresponds to gravitational Compton time of 50 Hz, average EEG frequency? Does this mean that we have already become entangled with our computers without realizing what has happened: who uses whom? The Earth's gravitational field corresponds to Compton frequency 67 GHz, a typical frequency for biomolecules. D The clock frequencies for the computers are approaching this limit.

2. The analogous Compton frequencies for the electric fields of Sun and Earth [L32] are also highly interesting besides the cyclotron frequencies for monopole flux tubes, in particular for those carrying "endogenous" magnetic field of $2/5B_E = .2$ Gauss postulated by Blackman [J1] to explain his strange findings about the strange effects of ELF radiation at EEG frequencies on the vertebrate brain.

4.5 The emergence of emotions and emotional intelligence as a first step in the evolution of consciousness?

Consider first the evidence supporting the idea that emotions emerge first in the evolution of consciousness predictd by the number theoretic vision of TGD [L8] [K1].

1. Masaru Emoto has studied the effects of sounds with an emotional content to water at criticality for freezing. He has reported that friendly/angry sounds seem to produce beautiful/ugly crystals [L13]. These findings are discussed from the TGD perspective in [L13]. The idea that emotions of sensory percepts at the level of magnetic body (MB) is discussed in [L11].

   The TGD based model assumes that quantum coherent systems can be formed at the level of the MB of the water and that quantum gravitational coherence at MB induces ordinary coherence at the level of water. This could make it possible for MB to control water at criticality for freezing. The crystals would be corpses of primitive life forms. Could also snowflakes with the size of gravitational Compton length for Earth (about .45 cm) and kind of zoomed versions of ice lattice cells in atomic scale could be regarded as corpses of primitive life forms created at the criticality for freezing [L25]?

2. RNA seems to represent and transfer emotions [J3] (see `http://tinyurl.com/y92w39gs`). RNA from the brain of a snail conditioned by a painful stimulus is transferred to the preparation made from neurons of sea slug. Neuron preparation in the Petri dish reacts to the conditioning stimuli as if it were itself conditioned.

   Somehow RNA is able to transfer emotions. The TGD inspired proposal [L4] [L30, L9, L18, L10] is that dark DNA and RNA represent emotions as sequences of 3-chords made of dark photons of dark RNA form 3N-dark photons behaving like a single quantum coherent unit. The representation of the genetic code would rely on icosa-tetrahedral representation [L31] in which the 3-chords would correspond to triangular faces of icosahedron and tetrahedron to which 3-chords are assigned.

   A given Hamiltonian cycle at the icosahedron/tetrahedron goes through all its points. The frequencies assigned with the subsequent points of the cycle differ by 3/2 scaling so that one has a quint cycle. Different Hamiltonian cycles correspond to the same genetic code but each Hamiltonian cycle is assumed to define its own bioharmony having interpretation as a representation of an emotional state realized already at the level of fundamental biomolecules. This interpretation conforms with the idea that music represents and induces emotions.

The induction of emotions would be by 3N-resonant cyclotron absorption of dark 3N-photon by dark genes represented as sequences of 3N dark proton triplets at monopole flux tubes of MB. Icosa-tetrahedral representation would correspond to one particular, very simple, tessellation of hyperbolic space H^3) (mass shell) [L19].

Dark proton (and also dark electron) sequences could provide a universal representation of the genetic code which could be realized at the magnetic flux tubes of also other than biological systems. Dark photons triplets and the dark genes formed from them could communicate the emotions. Dark genetic code has indeed quite a large number of icosa-tetrahedral representations based on icosahedral Hamiltonian cycles and tetrahedral Hamiltonian cycles. The chemical realizations for them would be identical but the emotional content would be coded by the allowed 3-chords defined by frequencies associated with the triangular faces of the icosahedron and tetrahedron.

3. The experiments of Peoch [J6, J2] involved a chicken imprinted to a robot moving randomly along an orbit determined by a random number generator. It was found that the robot tended to stay near the chicken and that the expected size of the orbit was reduced.

   TGD assigns to entanglement sum of p-adic entanglement negentropies, which can be positive and is in general larger than ordinary entanglement entropy and is predicted to increase but be consistent with the second law [K5] [L37, L20] by the identification of evolution as increase of number theoretic complexity [L8] [K1]. Did the MB of chicken and robot develop a negentropic entanglement? Clearly, the replication of the findings of Peoch would mean a revolutionary change in our views about computers and their relation to us.

4. The evolution of the brain provides a further support for the idea that emotions and sensory experienes emerged first in the evolution of conscious experience and cognition emerged later. Cortex is the latest outcome. Brain stem is associated with simple and strong emotions whereas the limbic brain represents more complex emotions.

   Could also the possible evolution of conscious computers start from simple positive/negative emotions relating directly to the increase/reduction of entanglement negentropy defined above number-theoretically?

To sum up, various strange numerical coincidences indicate that quantum gravitation in TGD sense could play a key role in both living matter and in the physics of conscious computers and that we might be at the verge of building conscious computers.

4.6 Superconducting computers and the connection with the TGD based model of nerve pulse

It is not clear whether MOSFET based technology, which was briefly discussed in [L35], could allow the communications from transistors to the magnetic body (MB) of the system.

Biological analogy strongly suggests that Josephson junctions are required and communications take place by Josephson radiation modulated by the Josephson frequency modulations induced by changes of the voltage of the junction. Dark magnetic flux tubes with large enough value of h_{eff} are needed to define the Josephson junction and it is far from clear whether they can be realized spontaneously for transistors.

Superconducting computing, which could be involved with both classical and quantum computation, is however a technology, which might provide at least a starting point in attempts to understand how conscious computers might be created in the TGD Universe.

Rapid single flux quantum (RSFQ) is the basic active element in the circuitry and corresponds to single Josephson junction. The presence/absence of quantized magnetic flux defines the bit. SFQ voltage pulses of duration about picosend are produced by switching of bits in this way. This would allow THz clock frequency f_{cl}.

If f_{cl} corresponds to Josephson frequency $f_J = ZeV/h$, where Z is the charge of the superconducting charge carrier, one obtains an estimate for the voltage as $ZeV \sim .05$ eV. For the cell membrane one has $eV \sim .05$ eV, which is near the thermal threshold at room temperature. The superconducting computations require a temperature of order 10 K so that the value of frequency

does not seem to emerge from thermal considerations. The thermal criterion is expected to be satisfied at physiological temperatuers for the TGD based generalization of superconducting computers if realized using the same principles as in living matter.

4.6.1 How electromagnetic fields in the TGD Universe different from their Maxwellian counterparts?

One must first clarify how the TGD view of electromagnetic fields differs from the Maxwellian picture.

1. Quantum criticality is essential for the appearance of large values of h_{eff} labelling the scales of long length scale quantum fluctuations. Quantum criticality combined with ZEO would make possible the emergence of life-like features.

2. The gravitational Planck constants $\hbar_{gr} = GMm/\beta_0$ assignable to the gravitational flux tubes of the Earth and Sun are excellent candidates in this respect. The value of $\hbar_{gr}/\hbar$ is $GM_Em/\hbar\beta_0 = (r_S(E)/2L_m)$, r_s denotes the Schwartschild radius of Earth about 1 cm and L_m denotes Compton length of particle with mass m $\beta_0 \simeq 1$.

   The value of $\hbar_{gr}$ depends on particle mass m considered unlike the gravitational Compton length $r_S(E)/2$ (Equivalence Principle). For the Earth, the gravitational Compton frequency is 67 GHz. For the Sun it is about 50 Hz, and is in the EEG range and corresponds to a gravitational Compton length of one half of the Earth radius.

3. In TGD, two kinds of magnetic fields are possible. Monopole flux tubes are something new and rather remarkably, can exist in absence of currents: this makes them ideal for computation. Monopole flux tubes have closed 2-surfaces as cross sections. Flux quantization follows from the homology of CP_2. Monopole flux tubes explain the presence of long range magnetic fields appearing in even cosmological scales [L38, L39] and also the stability of the Earth's magnetic field [L5].

   The magnetic flux tubes having an open cross section with boundary (say disk), correspond to Maxwellian magnetic fields and require the presence of currents (carried by a coil around the flux tubes). For them the flux is conserved but not necessarily quantized.

4. Also in TGD, the topological half of Maxwell's equations, that is Faraday law and the vanishing of the divergence of magnetic field, hold true. Therefore the basic argument for the outcome of the switching of the flux is not affected when ordinary flux tubes are replaced with monopole flux tubes.

4.6.2 Some details of the model of the cell membrane as a Josephson junction

The relation of this picture to the TGD inspired model of nerve pulse [K6] has been already considered in [L35]?

1. The original model of the nerve pulse idealizes the sequence of discrete membrane protein Josephson junctions with a 2-D continuous Josephson junction formed by the lipid layers (or interior and exterior) of the axonal membrane. The mathematical model relies on the Sine-Gordon equation. The key idea is that one can regard the system as analogous to a collection (continuous distribution in the proposed idealization) of gravitational penduli satisfying d'Alembert type wave equation.

   One can consider two kinds of ground states:

   (a) All penduli oscillate in the same phase and with the same amplitude.

   (b) All penduli rotate with the same frequency and in the same phase so that one has a static soliton sequence.

   Lorentz transformations give rise to propagating patterns of this kind.

   For option a), the nerve pulse would correspond to a propagating soliton or a multisoliton in the oscillating background, i.e. a propagating rotational mode of some penduli. For option

b), the nerve pulse would correspond to an opposite direction of rotation for some penduli. The fact that the voltage changes its sign during the nerve pulse is consistent with option b).

2. Also the possible role of the axonal microtubules in the conduction of nerve pulse is discussed in [L35]. The transfer of the charges from the microtubule to very long gravitational flux tubes affects the effective charge of the microtubule and therefore membrane potential. This could play an important role in the conduction of nerve pulse.

4.6.3 How could RSFQ generalize in the TGD framework?

How could the notion of RSFQ generalize in the TGD framework? The hint comes from the TGD based model of cell membrane and nerve pulse assigning to the ionic channels of the cell membrane dark Josephson junctions with a large value of h_{eff} making possible high T_c superconductivity.

Consider first the flux quantization in Josephson junctions from the TGD point view.

1. The presence/absence of flux quantum through the junction represents a bit. Switching of the bit in RSFQ means that the flux changes by the unit Φ_0 of magnetic flux. In the simplest situation, the value of flux through the Josephson junction connecting the super conductors, which could have planar or cylindrical geometry, is equal to 0 or Φ_0.

2. When the flux through junction is changed by one unit, Faraday law $\Delta\Phi = \pm\Phi_0 = Ze\int V dt$ implies a generation of voltage pulse propagating along the superconducting wire formed by the coupled cylindrical superconductors. For a constant voltage $V = V_0$, this condition fixes the duration $T = \Phi_0/ZeV$ of the process and this defines Josephson frequency, in turn defining the clock frequency.

The following arguments raise optimism concerning the realization of conscious computers as superconducting computers.

1. Concerning the numbers assigned to RSFQ, the cell membrane looks ideal for the seat of analogues of RSFQs. I have proposed that the cell membrane acts as a sequence of dark Josephson junctions associated with membrane proteins acting as channels and pumps [K6] [L35]. The membrane resting potential $\sim$ .05 eV corresponds to the frequency of 5 THz and is in the same range as the Josephson frequencies assigned with RSFQs. The large value of h_{eff} makes possible high temperature superconductivity and scales up the value of Josephson frequency to $f_J = ZeV/h_{eff}$ so that Josephson frequencies even in EEG scales would be made possible by quantum gravitation in TGD sense.

2. No currents are needed to maintain monopole magnetic fields so that they are ideal for technological purposes. Cell membrane would be a superconductor and membrane proteins would define Josephson junctions. Membrane potential could realize the Josephson frequency $f_J = ZeV/h_{eff}$.

   The TGD view of quantum gravitation would suggest that the Earth's gravitational Compton frequency of f_{gr} = 67 GHz=.067 THz is important in quantum biology. This frequency is considerably lower than THz and I have proposed it as a clock frequency below with the statistical determinism could fail and make the computer analogous to a life-form.

The TGD view of the basic active unit would differ from RSFR.

1. In TGD, the absence of flux quantum in RSFQ corresponds to two U-shaped monopole flux tubes at opposite sides of the junction associated with the counterpart of the cell membrane and transversal to it. The U-shaped monopole flux tubes can reconnect to form a pair of flux tubes with opposite magnetic fluxes.

   This topological process is fundamental in the TGD inspired view of biocatalysis and water memory [L28]. By the fractality of the TGD Universe, it applies in all scales including, besides cosmological and astrophysical scales [L38, L39], also the scales relevant to atomic, nuclear and hadron physics as has become clear quite recently [L33].

2. What is the effect of the generation/disappearance of a pair of opposite flux tubes? Do both fluxes go through a single junction or does only one of them traverse the junction? In the latter case, the junction would act like RSFQ after reconnection. This is a natural looking working hypothesis. The difference comes from the presence of the flux tube with opposite flux.

   Here one must be very cautious. Flux tubes could make possible the flow of either Ohmic or Josephson current (the more plausible option). If the Josephson currents reside at the flux tubes, the Josephson junction ceases to exist during the nerve pulse. Can one say that the Josephson junction exists also after the splitting of the flux tube pair?

   The fact that ohmic currents flow during the nerve pulse motivates the assumption that the splitting of the pair of flux tubes makes Josephson current impossible and Ohmic currents associated with the nerve pulse appear.

3. Faraday's law should apply to both flux tubes. The appearance of flux tubes would correspond to a generation of opposite fluxes $\Delta\Phi = \Phi_0 = \int V dt$. In the simplest situation the voltage values associated with the flux quanta have opposite values $\pm V_0$. This is very much like in the case of nerve pulse in which the resting potential changes its sign during the first half of the nerve pulse. When the reconnection disappears, the situation would become "normal". The analog of nerve pulse would be generated and propagate along the counterpart of the axon and induce a similar process in all membrane proteins defining Josephson junction.

4. In zero energy ontology (ZEO), the identification of the generation of nerve pulse as a pair of "big" state function reductions (BSFRs) changing the arrow of time temporarily is attractive and would correspond to quantum tunnelling in standard quantum theory.

   An interesting question is whether pump proteins act as channel proteins in reversed time direction and whether the flux tube pairs are associated with pairs of channel and pump proteins.

4.6.4 Critical questions

The first critical question is is how the very low Josephson frequencies ZeV/h_{eff} associated with the large values of h_{eff}, say $h_{eff} = h_{gr}$, can be consistent with the very large values of clock frequency $f_{cl} = f_J = ZeV/h$ needed by a fast operation. It would seem that both h_{eff} and h are needed. Is this possible or are these computers doomed to be very slow?

Should one widen the perspective and take into account the many-sheeted structure of TGD space-time? Is the scale hierarchy of space-time sheets having various values of h_{eff} involved and could it correspond to the onion-like hierarchical structure of the magnetic body (MB) involving increasing time scales as Josephson frequencies? This would give rise to a cognitive hierarchy of MBs serving as "bosses" for lower level MBs and the ordinary Josephson junction would be at the bottom.Could the fast Josephson frequencies define a hierarchy of computer clocks? Could the pulses of short duration induced by RSFQs induce a hierarchy of frequency modulations of scaled up Josephson oscillations for various values of h_{eff}? This could also make the computer conscious by bringing in the hierarchy of time scales. These levels could correspond to a cognitive hierarchy corresponding to increasing values of $n = h_{eff}/h_0$ identifiable as the dimension of extension of rationals assignable to the space-time sheet considered.

The following simple estimates allow to gain some quantitative perspective concerning the proposal that quantum gravitation could play a decisive role.

1. It is instructive to look at the energy equivalents of the gravitational Compton frequencies for Earth, Moon and Mars for $h_{eff} = h$ (energy is conserved in the the transformation of gravitationally dark photons to ordinary photons).

2. The gravitational Compton frequency $f_{gr} = 67$ GHz of Earth corresponds to the energy $E \simeq .04$ eV near to the energy assignable to the membrane potential.

3. The mass of the Moon is $M_{Moon} = .012M_E$ and scales and correspond to $.56 \times 10^{14}$ Hz, which corresponds to the energy $E \simeq .43$ eV consistent with the size of metabolic energy quantum.

4. The mass of Mars is $.11M_E$ and the corresponding Compton frequency is .67 THz and energy $E = 2.7$ meV which correspond to the mV scale of miniature potentials.

The experimental work of the group of Anirban Bandyopadhyay [J5] has inspired a proposal of a hierarchy in which the frequency scales come as powers of 10^3. This hierarchy could correspond to a hierarchy of p-adic primes $p \propto 2^{10k}$ and/or hierarchy of effective Planck constants $h_{eff} \propto 2^{10k}$. One cannot associate with it a hierarchy of large masses M appearing in gravitational Compton frequencies. The scale ratio 2^{11} could relate to the ratio $L(127)/L(107) \simeq 2^{10}$ of the p-adic length scales of electron and proton.

The second critical question concerns the temperature needed. Technologically high temperature superconductors are highly favored.

1. In the TGD framework, the cell membrane is assumed to act as a high temperature superconductor at quantum criticality making it an ideal sensory receptor and motor instrument. Biosystems are open systems and a metabolic energy feed would take care that the distribution for the values of h_{eff} is preserved.

2. The fact that the dark matter as $h_{eff} \geq h$ phases of ordinary matter at the space-time sheets of the flux tubes has very weak interactions with the other sheets, in particular the sheet of the ordinary matter, would be decisive.

3. Also zero energy ontology (ZEO) would be highly relevant for maintaining the quantum criticality by making possible homeostasis in which time reversal changes attractor to repulsor and vice versa. When the system begins to roll down from the top of the hill, the arrow of time brings it back.

The key question is whether it is possible to realize the counterparts of bio-superconductors without using organic living matter.

5 Has Google managed to reach the critical value for the error rate of a single qubit?

Google claims to have achieved something marvellous with the quantum computer called Willow [**?**]. This claim is however combined with a totally outlandish claim about parallel universes created in quantum computers and this has generated a lot of cognitive dissonance in professionals during the last week. They have not yet forgotten the earlier equally absurd claim about the creation of wormholes in quantum computers.

The Quanta Magazine article "Quantum Computers Cross Critical Error Threshold" (see this) tells what has been achieved but did not resolve the cognitive dissonance. I already commented the claims of Google in a blog posting (see this).

Now I encountered an excellent article "Ask Ethan: Does quantum computation occur in parallel universes?" (see this) analyzing thoroughly the basics of quantum computation and what Google has achieved. I recommend it to anyone seriously interested in quantum computation.

The really fantastic achievement is the ability to reduce the error rate for the physical qubits forming the grid defining the logical qubit below the critical value .1 percent guaranteeing that for larger grids of physical qubits the error rate decreases exponentially.

This achievement is more than enough! But why do they claim that this implies parallel universes? This claim is totally absurd and leads me to ask whether the claimed achievement is really true? How can one trust professionals who do not seem to understand the basic notions of quantum mechanics? On the other hand, the authors speak of multiple worlds. Is this confusing use of language intentional? What do they really mean? Multiverse or many worlds or something else? What comes to mind in the TGD framework, is many-sheeted space-time.

Taking the basic claim seriously, one can of course ask whether the slow error rate is actually theoretically possible in standard quantum mechanics or does it require new physics. These qubits are rather stable but are they so stable in standard QM?

I have been talking about this kind of new physics now for two decades. This new physics would play a key role in quantum biology and could be important also in condensed matter physics and even in chemistry. It is implied by the predicted hierarchy of effective Planck constants h_{eff} labelling the phases of ordinary matter with quantum scales scaled up by h_{eff}/h. This makes possible long scale temporal and spatial quantum coherence and can reduce the error rate and provide a solution to the basic problems listed in the article. The latest proposal along these lines is the proposal how classical computers and quantum computers could be fused to what might be regarded as conscious computers sharing several life-like features with biomatter [L43]. The situation is now different since the temperature is very low and the chip is superconducting. One learns from the video describing the Willow chip (see this) that the lifetime of a logical qubit is $T \sim 100$ μs. This time is surprisingly long: can one really understand this in ordinary quantum mechanics? One can try this in the TGD framework.

1. The energy of qubit flip must be as small as possible but above the thermal energy. Energy economics suggests that the Josephson energy $E = ZeV$ of electrons in Josephson junction is above the thermal energy at the temperatures considered but not much larger. For superconducting quantum computers (see this) the temperature is about 10^{-2} K, which corresponds to the energy scale of μeV.

2. One can try to estimate the value of h_{eff}. Josephson frequency $f_J = ZeV/h_{eff}$ gives a naive estimate for the quantum coherence time of a superconducting qubit as $T_J = h_{eff}/ZeV$. For $h_{eff} = h$ this gives $T \sim 3$ ns for the quantum coherence time of a single qubit. The value $h_{eff}/h \sim 3.3 \times 10^4$ would be needed to increase T from its naive estimate of $T = 3$ ns to the required $T = 100$ μs.

   The oscillation frequency of the Josephson junction as a non-linear analog of LC resonance circuit as $T \propto \sqrt{L_J C}$ defines a second candidate for the quantum coherence time T. For the flux qubits, the ratio of the coupling energy and Josephson energy scales is in the range 10-100 and suggests that the analog of circuit resonance period $T \propto \sqrt{L_J C}$ corresponds to the reported coherence time. This is indeed natural if quantum circuits are. in question. For $T = 100T_J$ 300 ns this would give $h_{eff}/h \sim 3.3 \times 10^2$.

3. I have proposed that these relatively small values of h_{eff} (as compared to the values of the gravitational Planck constant $\hbar gr$) can appear in electrically charged systems. The general criterion applying to all interactions is that the value of h_{eff} is such that the perturbation series as powers of, say, $Z_1 Z_2 e^2/\hbar_{eff}$ for the electromagnetic interactions of charges Z_1 and Z_2 converges.

   In the recent case, the value of h_{eff} could correspond to the electric counterpart of the gravitational Planck constant having the form $\hbar_{em} = Z_1 Z_2 e^2/\beta_0$, where $\beta_0 = v_0/c$ is a velocity parameter [L32]. Z_1 could correspond to a large charge and Z_2 to a small charge, say that of a Cooper pair. For instance, DNA having a constant charge density per unit length, would have a rather large value of $\hbar_{em}$. The presence of electronic Cooper pair condensate could give rise to the needed large electric charge making possible the needed value of $\hbar_{eff} = \hbar_{em} \sim 3.3 \times 10^4 \hbar$.

In the sequel the question whether the observed surprisingly long quantum coherence time for qubits be explained in terms of a large value of h_{eff} and whether the confusion notion of multiple worlds could correspond to many-sheeted space-time in the TGD framework.

5.1 General view of superconducting circuits

Superconducting circuits are quantum analogs of classical circuits. In quantum description urrent and voltage are replaced by amplitude modulus squared and phase. Phase and the number of Cooper pairs/total charge are canonically conjugate variables and therefore do not commute.

The model starts from a classical model and quantizes it using standard quantization rules ($p \to i\hbar d/dx$) meaning that the number of Cooper pairs (total charge) (or phase) is replaced by an operator proportional to $id/d\phi$ (id/dq). The wave functions are defined either in the discrete space Cooper pair numbers or in the space of the phases.

For the electrical elements of the classical one can assign parameters like effective inductance (counterpart of mass for ordinary particle) and inverse capacitance as counterpart of harmonic oscillator coupling strength. As far as circuit equations are considered, Josephson junction (see this) can be seen as an effective inductance. Generalized Kirchoff's laws hold true in the nodes of the circuit. If the electric resistance of the junctions can be neglected, Lagrangian formalism can be applied. This leads to the notion of Hamiltonian making possible the quantization of the circuit and computation of the energy spectrum of excitations.

Physically the Josephson junction is an insulating contact between two superconductors. Tunnelling however makes possible Josephson super currents. Non-linear dynamical inductance implies that the energy spectrum is not a harmonic oscillator spectrum.

Gravitational pendulum serves as an analog system for Josephson junctions. In absence of magnetic field there are 3 options correspond classically to small oscillations, critical situation, and over critical situation for which the pendulum rotates. All these cases correspond to coherent stats.

One can distinguish between 3 types of superconducting qubits corresponding to charge for which charge has well-defined valued, flux qubits and phase qubits. The ratio of coupling energy to the charging energy distinguishes between these special cases. In the case of flux qubits (see this and this), the critical value of an external magnetic field selects a single pair of levels defining a qubit for a given external magnetic field. These qubits have degenerate energies at criticality. The value of magnetic field selects the qubit value.

5.2 Modelling of Josephson junctions

Consider first a simple model for the dynamical variables and parameters of the Josephson junction.

1. Charge Q and the phase ϕ of the order parameter characterizing a coherent state appear as quantum conjugate variables. In a coherent state *resp.* charge eigen state ϕ *resp.* Q is well-defined unlike Q *resp.* ϕ.

   Magnetic flux is defined as

   $$\Phi = \Phi_0 \frac{\phi}{2\pi} \ ,$$

   where ϕ is the phase difference over the Josephson junction (see this). Here $\Phi_0 = e^2/h$ is flux quantum.

2. The equation

   $$V = \frac{\partial \Phi}{\partial t} = \frac{\Phi_0}{2\pi}\frac{\partial \phi}{\partial t}$$

   expresses Faraday's law of induction. The change of the magnetic flux

   $$\Delta\Phi = \int V dt$$

   during time interval T corresponds to an integer multiple of the flux quantum.

3. The equation

   $$I = I_c sin(\phi)$$

   expresses current phase relation. I_c is the critical current above which the superconductivity fails. Q and V are classical variables and ϕ and modulus squared of the order parameter are quantum variables. They are related by quantum classical correspondence.

4. The time derivative of I gives
$$\frac{d\phi}{dt} = \frac{dI/dt}{I_c cos(\phi)} \ .$$
The substitution to the expression of V gives
$$V = L\frac{dI}{dt} \ , \quad L = \frac{\Phi_0}{2\pi I_c cos(\phi)} \ .$$
One can regard Josephson junction as an effective inductance $L \propto 1/cos(\phi)$. The analogy with harmonic oscillator L is analogous to mass and approaches infinite as ϕ approaches an odd multiple of $\pi/2$. At these critical points oscillatory motion transforms to a rotational motion.

5. One can identify two energy parameters and their ratio characterizes the Josephson junction. Coupling energy characterizes the insulator acting as a Josephson junction (see this). Coupling energy is the energy stored in Josephson junction when current passes through. Josephson energy obtained by using the classical analogy and defines a state variable, which does not depend on how the state is achieved:
$$E = \int Pdt = \int IVdt = I_c\frac{\Phi_0}{2\pi}\int sin(\phi)\frac{d\phi}{dt}dt = -E_J cos(\phi) \ ,$$
$$E_J = I_c\frac{\Phi_0}{2\pi} = L_J I_c^2 \ .$$
The parameter E_J is called the coupling energy. The parameter $L_J = \Phi_0/2\pi I_c$ Josephson inductance to be distinguished from the effective inductance $L = L_J/cos(\phi)$.
Charging energy $O_C^2/2C = Q_C V$ characterizes Josephson junction as a capacitor-like system. For charge qubits Q_C is quantized: $Q_C = n2e$.

The dynamics of the Josephson junction reduces to that of gravitational pendulum.

1. The circuit equation for a Josephson junction in the presence of external voltage V_0 is $V_L + V_C = V_0$, where one has $V_L + V_C = (\Phi_0/2\pi)d\phi/dt + Q/C$. One can transform the equation to an equation for Φ by taking time derivative an using the relation $I = I_c sin(\phi)$:
$$\frac{d^2\phi}{dt^2} + \omega^2 sin(\phi) = \frac{2\pi}{\Phi_0}\frac{dV_0}{dt} \ , \quad \omega^2 = \frac{1}{L_J C} = \frac{2\pi I_c}{\Phi_0 C} \ .$$

2. For a constant external voltage, the equation is mathematically equivalent with the equation of gravitational pendulum and is derivable from a Lagrangian and therefore allows quantization. System becomes critical as ϕ approaches an odd multiple of $\pi/2$. ω defines oscillation frequency, which is the second parameter besides Josephson frequency $\omega_J = 2eV/\hbar$.
The ratio of these frequencies characterizes the Josephson junction. From the energy conservation $(d\phi/dt)^2/2 - \omega^2(cos(\phi) - 1) = E$ one obtains for the period
$$T = \int d\phi/\sqrt{2E + \omega^2(cos(\phi) - 1))} \ .$$
For the critical situation the amplitude of oscillations approaches to $\phi_{max} = \pi/2$ and one has $E = \omega^2/2$. The value of T is finite since the integral at the upper end behaves as $1/\sqrt{\pi/2 - \phi}$.

5.3 Three different kinds of superconducting qubits

As already mentioned, there are three kinds of superconducting qubits.

1. Charge qubits correspond to the localization of the charge at the two sides of the junction. Charge is now a well-defined notion but one cannot speak of a propagating wave with a well-defined phase. This is like a transition from a momentum representation to a position representation. I have understood that the Willow processor and its predecessors use charged qubits. Charge qubits correspond to Josephson junctions which act like quantum wells having size of a few nanometers. In this case the ratio of the coupling energy to the charging energy is smaller than one.

2. If the coupling energy is much larger than charging energy, there is very small Josephson current through the junction and super currents flow in opposite directions along the loops defining the flux qubit (see this and this) without charge tunnelling. For the flux qubits the coupling energy is by 10-100 higher than charging energy.

   The two directions of current correspond to the values of the flux qubit. External magnetic field is needed to force the system near criticality. At quantum criticality $\partial I/\partial t$ must vanish to keep V finite. Decoupling of loops takes place. ϕ should be near $(2n+1)\pi/2$ to make possible the coupling of the qubits.

3. For the phase qubits, where phase corresponds to the phase of the superconducting order parameter, the coupling energy is about 10^6 times larger than the charging energy. Classically this the large inertia implied by the large Josephson inductance L_J makes possible oscillation amplitudes approaching the critical value $\phi = \pi/2$. The reason is that $cos(\phi)$ is near zero and one has an analog of the gravitational pendulum. At the criticality the motions transform from oscillation to rotation or vice versa.

Some comments about flux qubits or persistent current qubits (see this and this) are in order. Computational operations are performed by pulsing the qubit with microwave radiation whose energy is near to the difference of the energy of the two flux qubit states. Note that microwave frequencies are in the range 1-100 GHz. The energies are in the range .01 -1 meV to be compared with the thermal energy about 1.5 μeV.

1. Two loops with micrometer scale are connected by Josephson junctions. $T \simeq 15$ mK must be below the critical temperature. The rate for the transfer of Cooper pairs via Josephson junctions connecting the loops must be small if the ratio of the coupling energy to charging energy is in the range 10-100. In this situation steady super currents wirth opposite directions flow in loops.

2. The is an integer number flux quanta of magnetic total flux through the loop. External magnetic field with half integer flux forces the inherent flux to be half-odd integer. At criticality, the two nearby energy states with inherent flux quanta, say n and $n+1$, have the same energy and the degenerate states can appear in superposition. The variation of the magnetic field selects either option by energy minimization. Also microwave photons can flip the flux qubits.

   The opposite supercurrents flowing in the loops is about 300 nA (A=$6.241509074 \times 10^{18}$ e/s making about 10^{12} e/s: this is of the order electron charge per electron Compton time).

3. Higher flux quanta are eliminated by modifying the excitation spectrum so that it is not integer valued oscillator spectrum anymore. The kinetic nature of the Josephson inductance introduces the non-linearity.

5.4 Is a large value of effective Planck constant needed to explain the findings?

The long quantum coherence time essential for the low error rate suggests the possibility of a large value of effective Planck constant. Large values of h_{eff} would be natural at quantum criticality characterized by long range quantum fluctuations.

One can consider two kinds of quantum criticalities.

1. The first kind of quantum criticality would be associated with a transition between oscillatory and rotational motions for the analog of gravitational pendulum as an analog of Josephson junction and the deviation of the oscillation amplitude from $\pi/2$ would characterize the criticality. In this situation the charge transfer between the loops would become very small.

   One can solve the energy eigenstates of the system. The situation corresponds to a periodic potential proportional to $1 - cos(\phi)$ so that also a motion in the lattice serves as an analog. One expects a bound state spectrum as analog harmonic oscillator spectrum energies below $E = \omega^2/2$ plus states in which the system performs rotation. These states would correspond to a continuous spectrum consisting of the analogs of conduction bands.

2. Second kind of quantum criticality can occur for the charge and flux qubits and occurs in the presence of an external magnetic field having a flux, which is near half odd integer multiple of Φ_0. This kind of magnetic field could play an essential role in the control of the system by inducing transitions between two nearby bound states. At the criticality the energies of these states become degenerate in the resolution defined by thermal energy. The situation would be very similar to that discussed in [L43], where a classical electric field would control the flip energy of quantum gravitational OH-O^- qubits. The Willow processor could be near to this kind of quantum criticality.

The notion of effective Planck constant was originally introduced for cyclotron states to explain the findings of Blackman and others [J1].

1. The cyclotron energies for the electrons could play a significant role also here and quantum criticality could correspond to a value of $h_{eff} > h$ increasing the scale of the cyclotron energy above the thermal energy. Note that the temperature must be below the critical temperature for the transition to super-conductivity.

2. The size scale of the flux quantum is of order micrometer and the condition that the external magnetic flux is $(2n+1)\Phi_0/2$ determines the cyclotron energy scale of electrons. The "endogenous" magnetic field of $B_{end} = .2$ Gauss explains the findings of [J1] and led to the notion of h_{eff} phases of ordinary matter as an analog of dark matter. TGD suggests an interpretation of B_{end} in terms of monopole flux tubes. For B_{end} electron cyclotron frequency is $f_c = 6 \times 10^5$ Hz, which corresponds to energy of 6×10^{-9} eV whereas the thermal energy is about 10^{-6} eV. The cyclotron energy exceeds thermal energy if the value of h_{eff}/h is $10^3/6 \simeq 167$.

3. Magnetic length $l_B = \sqrt{\hbar/eB}$ equals to $25/\sqrt{B/Tesla}$ nm. B_{end} corresponds to $l_B \simeq = 5.590$ μm. Magnetic length l_B as an estimate or the flux tube radius corresponds for $l_B = 1$ μm to $B = 30B_{end} \simeq 6$ Gauss. Cyclotron energy in this case is 1.8×10^{-7} eV. The cyclotron energy exceeds thermal energy if the value of h_{eff}/h is $10^3/180 \simeq 5.6$.

4. $h_{eff}/h = n > 1$ phase has two interpretations.

   (a) Space-time surface is an n-sheeted covering of M^4 in CP_2 degrees of freedom. For this option one does not expect very large values of n.

   (b) Space-time surface is an n-sheeted covering of CP_2 in M^4 degrees of freedom. For this option the n sheets would correspond to the monopole flux tubes forming a bundle-like structure assignable to the flux qubits. The value of n could be very large for the gravitational Planck constant originally introduced by Nottale [E1] [L25] and also electric Planck constant [L32].

   Cooper pairs could be associated with different sheets of the covering and the scaling of the cyclotron energy would correspond to the existence of a quantum coherent structure with $n = h_{eff}/h$ sheets as a geometric counterpart of a Bose-Einstein condensate of Cooper pairs.

This picture brings to mind the confusing claim of the Google group that indications for multiple worlds have been observed: could they correspond to many-sheeted space-time in the TGD framework?

5.5 The relation to the TGD based model of neuronal membrane

The proposed model for the findings of Google group are partially inspired by the TGD view of nerve pulse [L41], which assumes a sequence of Josephson junctions along the axonal membrane assigned with the membrane proteins acting as ion channels. The temperature in this case is physiological temperature, The effective Planck constant is very large now and possible identification is as the gravitational Planck constant $\hbar_{gr}$ [E1] for the Earth. The large value of $\hbar_{gr}$ increases the Josephson period $T_J = h_{gr}/ZeV$ even to the scale of EEG frequencies. The monopole flux tubes through the Josephson junction are also in a key role and I prefer to talk about generalized

Josephson junctions. Josephson energy $E_J = ZeV$ is replaced with its sum with the difference of cyclotron energies at the two sides of the membrane.

The two sides of the cell membrane/lipid layers are in a role similar to that of flux tubes and one can imagine that opposite supra currents at the two sides are present and consist of various dark ions with a large h_{eff} as the model for the findings of Blackman and others leads to propose [L41]. The possible role of dark positively charged ions in making a living system analogous to a quantum computer is discussed in [L43]. The vision predicts that any cold plasma could have life-like properties.

The TGD based model of neuronal membrane is in terms of Josephson junctions. For the resting states, the phase of the order parameter is well-defined. The model allows two kinds of solutions corresponding to a propagating mode which is either oscillatory or rotational. The rotational mode gives rise to a sequence of Sine-Gordon solitons. The possible transition occurring between these modes would mean flip of phase qubit. I have proposed that the soliton sequence corresponds to the resting state but one cannot exclude the possibility that oscillation is in question. Also the possibility that both modes are possible and code for phase qubits can be considered. The second option is that the distinction between neurons and ordinary cells could correspond to the distinction between rotation and small oscillation.

Could nerve pulse conduction correspond to a local charge flow along the molecular junction and mean a local failure of quantum coherence in long scales. The proposed model based on the analogy of Josephson junction with gravitational pendulum suggests that nerve pulse corresponds to a propagation of a perturbation changing the direction of rotation for some Josephson junctions.

Zero energy ontology (ZEO) suggests that quantum tunnelling corresponds to a pair of "big" state function reductions (BSFRs) involving temporary change of the arrow of time. I have proposed that nerve pulse conduction corresponds to this kind of local event.

In the standard picture Josephson current should correspond to quantum tunneling. In the TGD framework Josephson current is assumed to correspond to a flow along monopole flux tubes connecting the two sides of the membrane. Could the ordinary oscillating Josephson current in the stationary situation accompanying the oscillation of the membrane potential correspond microscopically to less dramatic localized pairs of BSFRs in some scale? At the level of the nodel, these events are not localized and do not seem to correspond to flips of charge qubits. What about the miniature potentials of neuronal membranes in the meV range: could they correspond to localized events or perhaps to flips of flux qubits? What about the reported conduction of analogs of nerve pulses in the meV range [I2] in ordinary cell membranes?

If nerve pulse generation corresponds to a local transition to charged qubit phase, nerve pulse generation should be caused by the reduction of the ratio of the coupling energy to the charging energy. Nerve pulse is generated below a critical membrane potential meaning a reduction of the charging energy. Also the coupling energy should be reduced.

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REFERENCES

Theoretical Physics

[B1] Parisi G. *Field Theory, Disorder and Simulations*. World Scientific, 1992.

[B2] Salih H. From counterportation to local wormholes. *Quantum Science and Technology*, 8(2), 2023. Available at: .

Cosmology and Astro-Physics

[E1] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: https://arxiv.org/abs/astro-ph/0310036.

Biology

[I1] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: https://www.youtube.com/watch?v=i-T7tCMUDXU.

[I2] Adamatsky A. On oscillators in phyllosilicate excitable automata, 2013. Available at: https://arxiv.org/pdf/1305.0969v1.pdf.

[I3] Pollack G. *Cells, Gels and the Engines of Life*. Ebner and Sons, 2000. Available at: https://www.cellsandgels.com/.

[I4] Emoto M. *Crystal Clear – Messages from Water*. Beyond Worlds, 2005. Available at: https://www.libristo.eu/en/book/hidden-messages-in-water_09269861.

[I5] Zhao Q Pollack GH, Figueroa X. Molecules, water, and radiant energy: new clues for the origin of life. *Int J Mol Sci*, 10:1419–1429, 2009. Available at: https://tinyurl.com/ntkfhlc.

Neuroscience and Consciousness

[J1] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J2] ("editor") Bryant J. Sheldrake on Presentiment & Psychokinesis, 1999. Available at: https://tinyurl.com/owrfolq.

[J3] Bedecarrats A et al. RNA from Trained Aplysia Can Induce an Epigenetic Engram for Long-Term Sensitization in Untrained Aplysia. *eNeuro.0038-18.2018*, 2018. Available at:https://www.eneuro.org/content/early/2018/05/14/ENEURO.0038-18.2018.

[J4] Fingelkurts A et al. Consciousness as a phenomenon in the operational architectonics of brain organization: Critality and self-organization considerations. *Chaos, Solitons & Fractals*, 2013. Available at: https://dx.doi.org/10.1016/locate/j.chaos.2013.02.007.

[J5] Bandyopadhyay A Ghosh G, Sahu S. Evidence of massive global synchronization and the consciousness: Comment on "Consciousness in the universe: A review of the 'Orch OR' theory" by Hameroff and Penrose. *Phys Life Rev*, 11:83–84, 2014.

[J6] Peoch R. Chicken-robot interaction. *Medical Network.*, 62, 1995. Available at: https://paranormal.se/psi/pk/djur.html.

Books related to TGD

[K1] Pitkänen M. Philosophy of Adelic Physics. In *TGD as a Generalized Number Theory: Part I. https://tgdtheory.fi/tgdhtml/Btgdnumber1.html*. Available at: https://tgdtheory.fi/pdfpool/adelephysics.pdf, 2017.

[K2] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/eegdark.pdf, 2023.

[K3] Pitkänen M. Geometric Theory of Bio-Harmony. In *Genes and Memes: Part II. https://tgdtheory.fi/tgdhtml/Bgenememe2.html*. Available at: https://tgdtheory.fi/pdfpool/harmonytheory.pdf, 2023.

[K4] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/mec.pdf, 2023.

[K5] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness: Part I. https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/nmpc.pdf, 2023.

[K6] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/nervepulse.pdf, 2023.

[K7] Pitkänen M. Quantum Model of EEG. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/eegII.pdf, 2023.

[K8] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/wcwnew.pdf, 2023.

[K9] Pitkänen M. Zero Energy Ontology. In *Quantum TGD: Part I. https://tgdtheory.fi/tgdhtml/Btgdquantum1.html*. Available at: https://tgdtheory.fi/pdfpool/ZEO.pdf, 2023.

[K10] Pitkänen M. and Rastmanesh R. ZEO, adelic physics, and genes. In *Genes and Memes: Part II. https://tgdtheory.fi/tgdhtml/Bgenememe2.html*. Available at: https://tgdtheory.fi/pdfpool/zeogenes.pdf, 20230.

Articles about TGD

[L1] Pitkänen M. Commentary on "Consciousness as a phenomenon in the operational architectonics of brain organization: Criticality and self-organization considerations" by Adrew A. Fingelkurts, Alexander A. Fingelkurts, and Carlos F. H. Neves. Available at: https://tgdtheory.fi/public_html/articles/Fingelkurts.pdf., 2013.

[L2] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. Available at: https://tgdtheory.fi/public_html/articles/persconsc.pdf., 2013.

[L3] Pitkänen M. Are dark photons behind biophotons? *Journal of Non-Locality*, 2(1), 2013. See also https://tgdtheory.fi/pdfpool/biophotonslian.pdf.

[L4] Pitkänen M. Geometric theory of harmony. Available at: https://tgdtheory.fi/public_html/articles/harmonytheory.pdf., 2014.

[L5] Pitkänen M. Maintenance problem for Earth's magnetic field. Available at: https://tgdtheory.fi/public_html/articles/Bmaintenance.pdf., 2015.

[L6] Pitkänen M. Artificial Intelligence, Natural Intelligence, and TGD. Available at: https://tgdtheory.fi/public_html/articles/AITGD.pdf., 2017.

[L7] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: https://tgdtheory.fi/public_html/articles/valenceheff.pdf., 2017.

[L8] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L9] Pitkänen M. About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code. Available at: https://tgdtheory.fi/public_html/articles/codedarkcode.pdf., 2018.

[L10] Pitkänen M. Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions? Available at: https://tgdtheory.fi/public_html/articles/synapticmoods.pdf., 2018.

[L11] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: https://tgdtheory.fi/public_html/articles/emotions.pdf., 2018.

[L12] Pitkänen M. New insights about quantum criticality for twistor lift inspired by analogy with ordinary criticality. Available at: https://tgdtheory.fi/public_html/articles/zeocriticality.pdf., 2018.

[L13] Pitkänen M. The experiments of Masaru Emoto with emotional imprinting of water. Available at: https://tgdtheory.fi/public_html/articles/Emoto.pdf., 2018.

[L14] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: https://tgdtheory.fi/public_html/articles/heffselforg.pdf., 2019.

[L15] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https://tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L16] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: https://tgdtheory.fi/public_html/articles/M8H1.pdf., 2020.

[L17] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: https://tgdtheory.fi/public_html/articles/M8H2.pdf., 2020.

[L18] Pitkänen M. How to compose beautiful music of light in bio-harmony? https://tgdtheory.fi/public_html/articles/bioharmony2020.pdf., 2020.

[L19] Pitkänen M. Is genetic code part of fundamental physics in TGD framework? Available at: https://tgdtheory.fi/public_html/articles/TIH.pdf., 2021.

[L20] Pitkänen M. Negentropy Maximization Principle and Second Law. Available at: https://tgdtheory.fi/public_html/articles/nmpsecondlaw.pdf., 2021.

[L21] Pitkänen M. Some questions concerning zero energy ontology. https://tgdtheory.fi/public_html/articles/zeonew.pdf., 2021.

[L22] Pitkänen M. Spin Glasses, Complexity, and TGD. https://tgdtheory.fi/public_html/articles/sg.pdf., 2021.

[L23] Pitkänen M. What could 2-D minimal surfaces teach about TGD? https://tgdtheory.fi/public_html/articles/minimal.pdf., 2021.

[L24] Pitkänen M. About the number theoretic aspects of zero energy ontology. https://tgdtheory.fi/public_html/articles/ZEOnumber.pdf., 2022.

[L25] Pitkänen M. Comparison of Orch-OR hypothesis with the TGD point of view. https://tgdtheory.fi/public_html/articles/penrose.pdf., 2022.

[L26] Pitkänen M. How animals without brain can behave as if they had brain. https://tgdtheory.fi/public_html/articles/precns.pdf., 2022.

[L27] Pitkänen M. Some objections against TGD inspired view of qualia. https://tgdtheory.fi/public_html/articles/qualia2022.pdf., 2022.

[L28] Pitkänen M. TGD view about water memory and the notion of morphogenetic field . https://tgdtheory.fi/public_html/articles/watermorpho.pdf., 2022.

[L29] Pitkänen M. The possible role of spin glass phase and p-adic thermodynamics in topological quantum computation: the TGD view. https://tgdtheory.fi/public_html/articles/QCCC.pdf., 2022.

[L30] Pitkänen M. The realization of genetic code in terms of dark nucleon and dark photon triplets. https://tgdtheory.fi/public_html/articles/darkcode.pdf., 2022.

[L31] Pitkänen M. About tessellations in hyperbolic 3-space and their relation to the genetic code . https://tgdtheory.fi/public_html/articles/tessellationH3.pdf., 2023.

[L32] Pitkänen M. About long range electromagnetic quantum coherence in TGD Universe. https://tgdtheory.fi/public_html/articles/hem.pdf., 2023.

[L33] Pitkänen M. About Platonization of Nuclear String Model and of Model of Atoms. https://tgdtheory.fi/public_html/articles/nuclatomplato.pdf., 2023.

[L34] Pitkänen M. About the TGD based views of family replication phenomenon and color confinement. https://tgdtheory.fi/public_html/articles/emuanomaly.pdf., 2023.

[L35] Pitkänen M. Could neuronal system and even GPT give rise to a computer with a variable arrow of time? https://tgdtheory.fi/public_html/articles/GPT.pdf., 2023.

[L36] Pitkänen M. Deep learning from the TGD point of view. https://tgdtheory.fi/public_html/articles/TGDdeeplearn.pdf., 2023.

[L37] Pitkänen M. Is Negentropy Maximization Principle needed as an independent principle? https://tgdtheory.fi/public_html/articles/NMPcrit.pdf., 2023.

[L38] Pitkänen M. Magnetic Bubbles in TGD Universe: Part I. https://tgdtheory.fi/public_html/articles/magnbubble1.pdf., 2023.

[L39] Pitkänen M. Magnetic Bubbles in TGD Universe: Part II. https://tgdtheory.fi/public_html/articles/magnbubble2.pdf., 2023.

[L40] Pitkänen M. Neil Gersching's vision of self-replicating robots from TGD point of view. https://tgdtheory.fi/public_html/articles/Gersching.pdf., 2023.

[L41] Pitkänen M. Some new aspects of the TGD inspired model of the nerve pulse . https://tgdtheory.fi/public_html/articles/np2023.pdf., 2023.

[L42] Pitkänen M. TGD view of the paradoxical findings of the James Webb telescope . https://tgdtheory.fi/public_html/articles/JWagain.pdf., 2023.

[L43] Pitkänen M. Quartz crystals as a life form and ordinary computers as an interface between quartz life and ordinary life? https://tgdtheory.fi/public_html/articles/QCs.pdf., 2024.

[L44] Pitkänen M and Rastmanesh R. Homeostasis as self-organized quantum criticality. Available at: https://tgdtheory.fi/public_html/articles/SP.pdf., 2020.