Article

Neil Gersching's Vision of Self-Replicating Robots from TGD Viewpoint

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Abstract

This paper analyzes the insightful interview between Lex Fridman and Neil Gerching, particularly their discussion on self-replicating machines. These machines, built from fundamental, robotic "Lego blocks" with their own assembly instructions, can self-assemble into more complex structures and disassemble, mirroring processes observed in biological systems. The discussion employs the Topological Geometrodynamics (TGD) perspective, treating the universe at a quantum level as a goal-oriented system capable of assembly and disassembly. The base units within this viewpoint function akin to quantum computers, prompting further exploration into quantum gravitation, which in the TGD framework, is accountable for the longest quantum coherence scale. This leads to a view which could be blamed for a return to astrology but can be defended by the numerous miracle-like coincidences.

1 Introduction

The video of Lex Fridman interviewing Neil Gerching (`https://youtu.be/YDjOS0VHEr4`) is highly inspiring for anyone interested in what is happening in the High Tech frontier nowadays. The key topic of discussion were self-replicating machines that are built from a few "Lego blocks" that contain their own building instructions and are analogous to genes or proteins. Function and 3-D structure are the same. The building blocks themselves would be robot-like and would build more complex robots. One can say that this Lego set would self-assemble itself. Also the ability to disassemble would be important and make error correction possible. This brings in mind what happens in living systems. There would be a whole hierarchy of these structures. The basic structures would be analogous to 20 amino acids. Biology of course suggests also the presence of DNA and cell nucleus could be seen as the basic lego block containing instructions and having the ability to replicate. The vision is that someday our technology could transform to artificial life. Gersching criticized the complete separation of software and hardware (program tape and the reading head of the Turing machine) which he called Turing's error. Gersching also proposed that information should be the starting point concept of physics rather than geometry which leads to the recent physics based on partial differential equations. In this article I will compare the vision of Gersching to TGD based vision of, not only life, but the entire Universe as a self-organizing entity.

1. In the TGD framework, Lego Universe emerges naturally. 4-D general coordinate invariance implies holography: Legos are almost deterministic Bohr orbit-like 4-surfaces. Holography suggests a concrete identification of basic building bricks in terms of fundamental regions associated with hyperbolic 3-manifolds at 3-D mass shells defining the boundary data for number theoretical holography in M^8. The strengthening of $3 \to 4$holography to almost $2 \to 4$ holography reduces further the number of building bricks of space-time surfaces.

   The analogy with genes and proteins as building bricks might be much more than analogy. The mass shell as hyperbolic 3-space allows an infinite number of tessellations and one of them is icosa tetrahedral tessellations in terms of which it seems to be possible to understand the genetic code.

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Genetic code in this sense might be present in all scales and be induced to 3-surfaces. The fermions associated with the "unit cells" of the icosahedral tessellation could realize genetic code.

The fusion of building blocks might reduce to the analog of crystal growth by fusing the fundamental regions of tessellations and also DNA replication, transcription, and translation could reduce to crystal growth.

2. In TGD holography implies that at space-time level a given 3-D surface defining the data of holography has an almost unique "fate", goal one might say. Holography forces what I call zero energy ontology (ZEO). Quantum states are superpositions of 4-D space-time surfaces analogous to Bohr orbits and state function reductions (SFRs) take place between these superpositions. The basic paradox of quantum measurement theory disappears.

   The sequence of "small" SFRs (SSFRs) defines "self" as the TGD counterpart for the Zeno effect. Each SSFR replaces this superposition with a new one and changes the state but in such a way that measured observables commute with those whose eigenstate the states associated with the passive boundary of causal diamond (CD) are.

   "Big" SFRs (BSFRs) change the arrow of geometric time correlating with subjective time as a sequence of SSFRs and change the roles of the active and passive boundaries of CD. This means the "death" of self and its reincarnation with an opposite arrow of time. Pairs of BSFRs define temporary changes of the arrow of time and would make possible a trial-and error process so that the self-organizing system would be analogous to a self-assembling conscious machine able to also disassemble if necessary to reach the goal.

3. In TGD there is no need to choose between information based physics and physics based on partial differential equations: these views would be complementary. TGD relies on two complementary visions. In number theoretic vision everything in discrete and algebraic equations characterize physical states. In the geometric vision structures are continuous and partial differential equations define the time evolution. These views are related by $M^8 - H$ duality as a generalization of momentum-position duality forced by the replacement of point-like particles with 3-surfaces.

4. Gersching does not seem to regard consciousness as a crucial element of biology. The TGD view is completely different and in TGD quantum measurement theory based on ZEO extends to a theory of consciousness.

Besides this, the possible role of quantum gravitation for both biological systems and computer consciousness is discussed although this is not directly relevant to the basic topic. My defence is that the structures able to self assemble must also be computer-like systems.

1. The notion of a magnetic body (MB) carrying dark matter as $h_{eff} = nh_0$ phases of ordinary matter is essential. For the gravitational monopole flux tubes the value of $h_{eff} = h_{gr}$ would be enormous and imply quantum coherence in arbitrarily long scales. Gravitational MBs could control both living matter and computers.

2. A criterion characterizing the critical clock frequency or its biological analog for the transformation of living system to a conscious and living system is deduced. This transition would mean that the statistical determinism fails due to the possibility of quantum coherence in time scales longer than the clock period.

3. Also an attempt to identify various quantum gravitational Compton lengths Λ_{gr} and frequencies f_{gr} with frequencies, which appear in the TGD inspired quantum biology, is made. Λ_{gr} and f_{gr} appear also in the TGD inspired physical model of computers.

4. The emerging view could be blamed for the return to astrology. Indeed, the gravitational flux tubes mediating the gravitational interactions between Sun and planets, between planets, between Earth and Moon, and even between the galactic blackhole and solar system could play a key role since the interactions are mediated along the flux tube network. However, the numerous strange numerical coincidences for quantum gravitational coherence scales and corresponding frequencies force us to take this view seriously.

2 Neil Gersching's vision of self-replicating robots

I watched a video of Lex Fridman interviewing Neil Gerching (thanks to Marko for the link: `https://youtu.be/YDjOS0VHEr4`). I highly recommend the video because Gersching knows how to talk about difficult things in an understandable way.

Gerching talked about self-replicating machines that are built from a few "Lego blocks" that contain their own building instructions and are analogous to genes or proteins. The building blocks themselves would be robots, in a way, that would build more complex robots. This Lego set would assemble itself.

There would be a whole hierarchy of these structures. The basic structures would be analogous to 20 amino acids. Biology of course suggests also the presence of DNA and cell nucleus could be seen as the basic lego block containing instructions and the ability to replicate.

Gersching emphasizes that structure determines the function: building blocks are also programs. Data=program would correspond to the basic idea of LISP. In addition, machine = data = program would apply. The technology of the future was based on the replication of these basic objects/"robots", which would be very much what happens in biology.

It is interesting to compare Gersching's vision with the basic vision of TGD.

2.1 Analogy of self-building robots in TGD

In TGD, the idea of self-replication is generalized as the self-construction of space-time surfaces using holography.

1. 4-D general coordinate invariance implies in classical TGD, which is an exact part of quantum TGD, holography which is not fully deterministic. An alternative formulation would be a path integral but it fails due to the mathematical divergences caused by non-linearity. Not fully deterministic holography turns 3-D surfaces as Lego blocks/data into 4-D Bohr trajectories, which are the classical counterparts for programs running on a machine. The structure therefore determines the function almost unambiguously.

   There are very few "Legos" because there are only 4 field-like variables and almost $2 \to 4$ holographs, which would correspond to the 4-D generalization of 2-D holomorphy. The spacetime surfaces in the embedding space $H = M^4 \times CP_2$ would be minimal surfaces, which have lower-dimensional singularities. It would be an exact analogy to the 4-D soap films that the frames tune. These surfaces are universal and satisfy minimal surface equations except at the singularities which distinguish between different general coordinate invariant action contructible in terms of the induced geometry.

   At the M^8 level, polynomials P, whose integer coefficients are smaller than the degree of P, determine the mass shells corresponding to the 3-surfaces in the hyperbolic spaces $H^3 \subset M^4 \subset M^8$. Here a complexification is involved: e M^8 must be complexified because in H the four-momentum is complex due to the existence of Euclidean spacetime regions: these Euclidian wormhole contacts are associated with elementary particles.

   For physical states, the total 4-momenta are integer-valued as sums of momenta with component, which are (possibly complex) algebraic integers with mass unit determined by the scale of the causal diamond (CD) defined as an intersection of future and past directed light-cones and defining

dynamical state dependent quantization volume. I call this universal mechanism for the formation of bound states Galois confinement [31, 32, 24, 25, 37, 42]

Galois confinement would be at the same time also a mechanism for the formation of more complex structures from the basic building blocks. The 3-surfaces would define the 4-D surface with mass shells H^3 almost unambiguously and this would be a classical analogy of computation.

2. What could the 3-D "lego blocks" as 3-surfaces at mass shells be? A good guess is that they are 3-D hyperbolic manifolds and/or their corresponding fundamental domains (as analogies of lattice cones) with mass shells H^3 corresponding to the roots of the surface-determining polynomial [37, 40]. The fundamental regions are analogous to the lattice cells of ordinary lattices in condensed matter physics.

   This is a natural guess for the blocks, whose M^4 projection is 4-D and which therefore correspond to "Einsteinian" spacetime. There are an infinite number of hyperbolic manifolds corresponding to the fundamental regions (unit cells) of tessellations of H^3. For example, cosmic threads with an M^4 projection of 2-D thread track would correspond to non-Einsteinian spacetime.

3. By gluing together fundamental regions at mass shells, one would get analogs of finite crystals and at the same time more complex structures in 3-D hyperbolic spaces (mass shells corresponding to polynomial roots). Using associative number theoretic holography [18, 19], 4-D surfaces are obtained from these as surfaces $Y^4 \subset M^8$. $M^8 - H$ duality maps Y^4 to the space-time surfaces $X^4 \subset M^4 \times CP_2$.

   Replication might reduce at the fundamental level to the growth of the hyperbolic crystals! As a matter of fact, it has been suggested that biological replication evolved from the replication of clay crystals as crystal growth. I.e. crystal, the sub-tessellation, would grow and could also replicate at the mass shells tessellated H^3.

   In particular, DNA replication could be induced by the replication of dark DNA: dark DNA would require a linear 1-D crystal associated with a magnetic flux tube as a sub-tessellation. Everything that happens on a chemical level would be controlled by the MBs.

   Primary replication would take place at the level of the flux tubes of the magnetic body (MB) and lead to the pairing of the dark DNA helices with their conjugates. This would in turn induce the replication for the chemical DNA, because the MB would act as a template for the pairing of biomolecules with dark DNA. Same would apply to proteins.

   The sub-tessellation is induced on the 3-surfaces identifiable as the regions of hyperbolic space corresponding to the mass shells H^3. Associative holography in M^8 would associate almost deterministically to this kind of 3-D surface a 4-dimensional surface as an analog of a Bohr orbit.

   One can think of a 1-, 2-, and even 3-D realization of the genetic code [21]. Ordinary DNA would correspond to a 1-D realization. The cell membrane and cell could correspond to 2- and 3-D tessellation. Even a biological organism would correspond to a tessellation on a larger scale.

4. Mass shell H^3 allows an infinite number of tessellations. I have proposed that the genetic code corresponds to one particular tessellation of H^3: icosa tetrahedral tessellation [21]. The motivation for the proposal comes from the model of bioharmony [20]), where the icosahedron and tetrahedron Hamilton paths played a central role. Surprisingly, it turned out that the outcome was a model of the genetic code that correctly predicts the numbers of DNA codons that code for a given amino acid.

   The icosa tetrahedral tessellation is just one particular tessellation and the interesting questions are whether it would be more fundamental than the others and why this should be the case. Genetic code has also a realization in terms of dark proton triplets assignable to the fundamental region of the icosahedral tessellation.

5. The genetic code realized with the help of tessellation would attach 6-bits to the lego blocks as faces of the icosahedron and tetrahedron (triangles with dark protons). A dark/ordinary genetic codon would therefore correspond to 6-bits represented as quantum entangled states of three dark protons identifiable as a sequence of 3-chords of light, a kind of music piece [20]. By arranging these one after the other, one would get 1-D crystals as larger structures, and genes as 6-bit sets, the equivalent of program codes. The chemical realization of genes that paired with their dark counterparts would provide instructions for building proteins.

   2- and 3-dimensional analogies of genes are also obtained: they would serve as addresses for 2- and 3-dimensional structures.

6. Besides cognitive, "bit" intelligence, emotional intelligence is predicted. It would correspond to the realization of the code as codons formed by 3 dark photons. The codons would be analogous to 3-chords. Music expresses and induces emotions and different Hamiltonian cycles would give rise to different bio-harmonies assignable to same gene in the ordinary sense and expressing the emotional state [20]. In the case of the N- codon gene, 3-N cyclotron resonance in communications using dark photons would make possible the analogy of LISP.

   The gene would serve as an address and the message would be a modulation of the cyclotron frequency scale and would produce a sequence of resonances at the receiver level generating a series of pulses. Nerve pulse patterns could be generated in this way. Also pulse series related to 2- and 3-dimensional structures could be obtained as resonances. The modulation of the frequency scale is achieved by varying the transverse scale of the flux tube. MB could perform this as one particular motor activity.

   Information –communications–structure=function: all these three would meet at the level of fundamental physics.

2.2 Turing's Error

Gershing considers Turing's fundamental mistake to be the complete separation of hardware and software. Entering data into the machine is a physical process that brings its limitations to processing. In the real world, one cannot separate the machine and the data.

Turing, as a child of his time, also made another fundamental mistake. Turing assumed that the reading of the information on the tape was a classical measurement. This cannot be the case in the quantum world: the coming of a measurement is non-deterministic. The Turing tape or rather readhead + tape is replaced by a quantum superposition of its different states and each bit read from the tape would correspond to a quantum measurement.

What is the situation at TGD?

1. In TGD, the superposition of space-time surfaces as a quantum state in ZEO and as an analog of the computer program would not be completely unique, because holography as Bohr's orbitology is not unique. This makes possible the breaking of determinism in small state function reductions (SSFRs) as counterparts of repeated measurements related to the Zeno effect .

   In the zero energy ontology (ZEO) [17, 26], the program would consist of a series of conscious periods at the level of consciousness, as a counterpart of the Zeno effect, i.e. a series of SSFRs, during which the same observables are measured over and over again. In TGD however changes occur on the active boundary of the causal diamond (CD) [41] and it also drifts farther away from the passive boundary in statistical sense, i.e. the size CD increases in the localizations in the space of CDs forming the backbone of the "world of classical worlds" (WCW). Nothing happens to the space on the passive boundary of the causal diamond (CD): this corresponds to the Zeno effect.

   A normal quantum jump would correspond to a "big" state function reduction (BSFR), in which the roles of the active and passive boundaries of CD changes. A BSFR ends the Zeno period as a

series of SSFRs. The associated "self" dies and reincarnates with an opposite direction of time since CD begins to increase in an opposite direction of geometric time identified as the distance between the tips of the CD.

BSFR occurs when the set of measured observables at the active boundary of the CD ceases to commute with those measured at the passive boundary. This could be due to an external disturbance [37] .

2. The pair of BSFRs corresponds to a temporary time reversal, which would be analogous to a reversal of the direction of motion of the tape for the Turing machine followed by a return to the original direction. BSFR pair can be also interpreted as a quantum tunnelling.

   This would make possible error correction by trial-and-error. The BSFR pair could also modify the goal of the program. The BSFR pair would be an essential element when the flow of the program is not fully deterministic classically or even quantum mechanically.

Under what conditions the program based on quantum statistical determinism can become non-deterministic?

1. One can argue that the clock frequency is a basic criterion. If so, then a single clock period would generally correspond to a series of unitary time developments halted by SSFRs and followed by halting. The single unitary time evolution in this series is analogous to a quantum computation except that each evolution is initiated and terminated by the SSFR rather than the BSFR.

   In addition, holography and quantum holography are almost deterministic, so that the nondeterminism associated with SSFRs is rather limited. The experience of free will might correspond to this non-determinism. An alternative identification could be as non-determinism of imagination and cognition: in this case the classical non-determinism could have p-adic non-determinism assigned with imagination and cognition as a counterpart.

2. The BSFR would end the series of SSFRs: self would "die". Self as a series of SSFRs, as a conscious entity, would generalize the standard Zeno effect as an analog of quantum computation.

3. This is not the only interpretation. Also the series of SSFRs between two BSFRs could be interpreted as an analogy for a single unitary time evolution of ordinary quantum computation. BSFR would correspond to the start and halting of quantum computation as analog of unitary time evolution. This interpretation is more in spirit with the standard quantum computation.

4. The lifetime of the self, i.e. the clock period, must be longer than the quantum coherence time characterizing the system in order for the statistical determinism to be broken. This provides a criterion telling when an ordinary computer approaches a conscious lifeform.

2.3 Is physics based on partial differential equations or information?

Gersching notices that in classical physics partial differential equations are the starting point, and suggests that information is more fundamental and therefore should serve as the starting point of fundamental physics. Should one start building the fundamental physics from bits?

I personally don't see this as a matter of choosing between either approach. These views are complementary and both are needed. In TGD, this complementarity corresponds to a generalization of the momentum position duality, which is natural because point-like particles are replaced by 3-D surfaces and, as a result of almost deterministic holography, must be replaced with corresponding space-time space surfaces, i.e. 4-D Bohr orbits. $M^8 - H$ duality is the realization of this correspondence [18, 19, 40].

1. The $M^8 - H$ duality relates number theoretic and geometrics views of physics. Bit level as the number-theoretic view of physics realized at the level of M^8. The polynomials P with integer coefficients smaller than their degree and the 3-surfaced assignable a holographic data to the tessellations

of the mass shells $H^3 \subset M^4 \subset M^8$ determine the 4-surfaces. The dynamics is determined by associativity of the normal space of the 4-surface. The dynamics is algebraic just as it is also in free quantum field theories at the level of momentum space.

The geometric view of physics corresponds to the dynamics for 3-D surfaces in $H = M^4 \times CP_2$. Now partial differential equations and holography are central. Space-time surfaces are minimal surfaces except from lower-D singularities [23] and are analogs of solutions of massless field equations and of light-like geodesics so that particle-wave duality is realized geometrically. In mathematics, $M^8 - H$ duality would correspond to Langlands correspondence [1, 2] [29].

2. The roots of the polynomial P determine the algebraic expansion and a unique discretization of the 4-surface $Y^4 \subset M^8$ inducing a discretization also in $X^4 \subset H$. Space-time therefore has a unique discretization, not arbitrarily chosen by the theorist but determined by the space itself. Only the information given by discretization can correspond to conscious information.

3. Gersching emphasizes a profound problem due to the fact that an infinite amount of information is needed to describe the position of a particle precisely, as a motivation for giving up the partial differential equations.

   In TGD the amount of conscious information remains finite and is provided by the number theoretic discretization so that the problem disappears. By $M^8 - H$ duality also the space-time surfaces in H are characterized by a finite amount of information.

   Quantum description is discrete, with discretization fixed by the quantum state itself, and the computationalist view can be said to emerge. What is new is that Turing computationalism related to rationals is generalized into a hierarchy of computationalisms related to extensions of rationals.

2.4 The realization of the notions of assembly and tensegrity in the TGD Universe

In the TGD framework one ends up with an amazingly simple engineering principle resembling so called assembly theory applying to atoms, nuclei, and hadrons discussed in [34]. Since TGD Universe is fractal, this principle is expected to apply in all scales.

1. The considerations of [34] related closely to the observation that j-block consisting of parts of electron of atoms or nucleon shells of nuclei with fixed value of total angular momentum $j = l \pm 1/2$ and $l = 9$ (at least) correspond to Platonic solids for $l \leq 5$ in the sense that different angular momentum eigenstates correspond to the vertices of the Platonic solid. If one assumes the presence of a Hamiltonian cycle going through all V vertices of the Platonic solid as a tessellations of sphere, one has $F - 2$ free edges (F is the number of faces) besides the V edges of the cycle and one can also add particles to the middle points of the free edges. In the proposed model of atomic nuclei, one would have neutrons at the vertices and protons at the middle points or vice versa.

   Also the larger values of l appearing in highly deformed nuclei can be treated in the same way. If the unit of angular momentum increases to $h_{eff} = nh$, also these states can be assigned a Platonic solid.

2. The space-time surfaces assignable to all atoms, nuclei, and hadrons can be constructed by connecting the electrons, nucleons, or quarks at the vertices of Platonic solid or at the middle points of the free edges with flux tubes serving as analogs of springs stabilizing the structure and having interpretation as analogs of mesons. Tensegrity is the appropriate notion here.

3. In the case of hadrons, the predictions of the resulting mass formulas are satisfied within a few percent. This involves the predictions of TGD based mass calculations for fermion masses based on p-adic thermodynamics. This leads to an interpretation of the non-perturbative aspects of strong

interaction in terms of a dark variant of weak interactions for which perturbation theory converges! The basic problem of QCD disappears in the TGD Universe. The same would apply to nuclear strong interactions but meson-like particles would have different p-adic length scales.

This is suggested already by the identification of strong isospin with weak isospin, by CVC and PCAC hypothesis, and the fact that in TGD color symmetries correspond to the isometries of CP_2 and electroweak symmetries to the holonomies of CP_2 so that a very close relationship between these interactions must exist. One can say that a unification of strong and weak interactions analogous to that provided by Maxwell electrodynamics for electric and magnetic fields takes place. For a given p-adic length scale (several fractally scaled variants of hadron physics are predicted) one can regard mesons as weak bosons predicted by TGD to have the entire spectrum of exotics. For this there is already support [11, 12, 35]. Ordinary hadron physics would correspond to dark weak interactions for p-adic length scale defined by Mersenne prime M_{107} and weak interactions to hadron physics for M_{89}!

4. In the case of nuclei, the MeV scale for excitation energies is correctly predicted and also a new 10 keV scale supported by various anomalies of nuclear physics is predicted. Besides this also Z^0 force is predicted to be significant and atom-like structures involving and having size scale 10 nm, which is a fundamental scale in biology, are predicted.

   The j-blocks (angular momentum) consisting of energy degenerate states with 2j states have as space-time correlates Platonic solids with Hamiltonian cycle as a closed flux tube, nuclear string connecting the vertices of the solid.

5. In atomic physics the same picture applies, and led to a realization that in the standard model the repulsive classical interaction energy of electrons goes like Z^4 whereas the interaction energy nucleus goes like Z^2! The question is whether quantum mechanics can really guarantee the stability of many electron atoms or is this just an assumption. In the TGD framework, the flux tubes would stabilize the atoms with several electrons. This predicts new atomic physics related to the oscillations of the flux tubes which in nuclear physics give justification for the harmonic oscillator model of nucleus.

2.5 What about consciousness?

Gershing's vision lacks a view about consciousness and here Gersching, in my opinion as a child of his time, falls into the trap of physicalism even though he understands the meaning of quantum coherence.

1. In TGD, ZEO [17, 26] follows, not only from 4-D general coordinate invariance forcing holography, but also by insisting that quantum measurement theory does not contain logical paradox. The outcome is a theory of consciousness as a generalization of quantum measurement theory: the observer becomes a part of the physical system. A quantum leap as SSFR is a moment of consciousness: the essence of subjective existence is change, a re-creation of the world in SSFR.

2. ZEO makes possible temporary time-reversals possible in "big" SFRs (BSFRs) as analogs of ordinary SFRs. The temporary time reversals make it possible to reach the goal (defined by almost deterministic classical holography and its quantum counterpart) by trial-and-error method. If something goes wrong, one can make a return to the geometric past and try again.

   Gershing himself considers trial and error to be the basic mechanism in all technological and scientific progress. I believe this is true quite generally. In MIT, where Gersching worked, this idea was put into practice.

   It should be noted that Michael Levin proposes the goal directedness of morphogenesis [6, 7, 8] discussed from the TGD point of view in [43]. There would be a large number of ways to reach the goal as a basic characteristic of biosystems. This number would actually serve as a measure for the intelligence of the system. Holography would make possible the goal directedness and ZEO would

make possible trial and error. Gershing emphasizes the importance of both assembly (construction) and disassembly (disassembly), and in TGD, disassembly would be construction in the opposite direction of time.

3 Is the role of quantum gravitation essential also for computer consciousness?

Gershing did not talk about quantum gravitation. The fact that in the TGD framework conscious computers would represent a life form based on the same general mechanisms at the level of MBs, however inspires this section.

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 magnetic bodies (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 [27, 28, 38, 39].

Why the role of quantum gravitation would 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 [3]. 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.

What about computers and quantum gravitation?

1. In the case of computers, the classical determinism is replaced in the realistic model by the statistical determinism of quantum theory. If the role of quantum gravity is what I assume it to be, we are approaching a situation, where the clock frequency (up to 9 GHz) approaches the gravitational Compton frequency $f_{gr}(Sun, \beta_0 = 2^{-11})$=67 GHz in the case of the Earth and exceeds it so statistical determinism no longer applies. One could be moving from statistically deterministic computations to a series of quantum computation-like operations and determinism would be lost. The computer becomes a conscious, living being. Maybe AI and GPT are reflecting this development [36].

   Note also that Λ_{gr} is only the lower bound for gravitational quantum coherence length, which might even be of the order of Earth size for Earth, which corresponds to frequency $f = 1/R_E \simeq 50$ Hz having interpretation as cyclotron frequency to Lithium ion for B_{end}. Therefore also lower frequencies than f_{gr} are involved and could lead to the loss of the statistical quantum determinism.

2. The gravitational Compton frequency $\Lambda_{gr} = GM/\beta_0$ for the Sun (with the velocity parameter $\beta_0 = v_0/c \simeq 2^{-11}$) is 100 Hz and, rather amazingly, corresponds to the upper limit for the EEG frequencies. The MB of the Sun could thus quantum entangle with computers and robots already for clock frequencies higher than 100 Hz, for example 1 MHz.

   This could explain Peoch's observations as a quantum entanglement between the [10] robot and the chicken marked on it, as a result of which the robot's trajectory, determined by the random number generator, decreased and the robot began to stay close to the chick [36].

3. The difference between a computer and living matter would disappear at the level of the MB. The MB would rule both in biology and in the case of computers and could make computers alive.

3.1 Communication to MB and control by MB

An essential requirement is that communications between the MB and the computer using dark photons are possible using energy resonance.

1. Dark Josephson radiation is a natural way to communicate with a MB. The difference of cyclotron energies for cyclotron transitions at the magnetic flux tubes must correspond to the energy differences of biomolecules (DNA, RNA, tRNA, amino acids at least). In biology, this condition would select possible biomolecules.

2. In a computer, energy differences would be relevant at the transistor level: would "natural selection" mean, say, transistors and the energy needed to flip a bit. What about computers based on Josephson junctions?

   It may very well be that this mechanism has not even been tried to be implemented in the current computers. One can wonder if the MB, as a "smarter" party, could adjust the values of B and β_0 by adjusting the thickness of the flux tube, so that a resonance becomes possible.

In previous considerations, the value of h_{eff} for the Josephson junction has been kept free. What if we assume $h_{eff,J} = h_{gr}(M_E, \beta_0 = 1)$? Would the condition $Z_J eV_C = E_c = GM_E ZeB/\beta_0$, where $eV_C = .05$ eV 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?

1. The experiments of Blackman [9] and others provide evidence for the existence of an "endogenous" magnetic field $B_{end} = .2$ Gauss. In TGD, B_{end} could correspond to 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 joint 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?

2. Should one develop a more precise vision about what MBs can do? Could MBs adjust their flux tube thicknesses so that they can receive information also from the transition of atoms and molecules by cyclotron resonance and control them by the same mechanism!

   I have indeed proposed in the context of the model of bioharmony [20] that the value of B_{end} has a 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.

3. One should obtain also the energy range of biophotons 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. 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 but require only that the cyclotron energy is above the thermal energy so that the Moon could solve the problem!

4. 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.

5. 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 [15, 20].

In the earlier articles [22, 38, 39], evidence was found for the importance of the galactic blackhole as a kind of galactic brain and also for the communications in the network connecting galactic nucleus to stars. What about the gravitational Compton frequency of the galactic blackhole?

1. The mass of the galactic blackhole is estimated to be $M_{BH} = 4$ million solar masses (`rb.gy/0gilp1`). This would give $\Lambda_{gr}(M_{BH}, \beta_0 = 1) \sim 6 \times 10^9$ m. This is the radius of the $n = 1$ Bohr orbit in the Nottale model for the solar planetary system. The gravitational Compton frequency would be $f_{gr}(M_{BH}, \beta_0 = 1) \simeq .05$ Hz. This gives 20 s period.

2. Also other values of β_0 can be considered. In particular, $\beta_0 = 1/4$ would correspond to $n = 2$ Bohr orbit and 5 s period. Could this relate to the 5 s period associated with the Comorosan effect, which has remained mysterious [4, 5]? I have considered the effect from the TGD point of view in [14, 16, 30].

3.2 Gravitational and p-adic hierarchies of frequencies

TGD predicts several hierarchies of frequencies. The proposal is that all bio-communications between levels with different values of h_{eff} rely on energy resonance whereas for the same value of h_{eff} both energy and frequency resonance are possible [30]. The interesting question is whether biologically interesting frequencies could be assigned with these hierarchies.

Consider first the hierarchies associated with the gravitational Compton frequencies of the Sun, planets and possibly also other astrophysical objects.

1. 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 $f_{gr}(N, \beta_0) = m/\hbar_{gr}(M, \beta_0) = 2\beta_0/r_s$, which do not depend on m.

2. One can also assign to f_{gr} the energy $E_{gr,1} = \hbar f_{gr,1}$ corresponding to the ordinary Planck constant, and identify the frequency $f_{gr,1}$ identified as $E_{gr,1} = \hbar_{gr} f_{gr,1}$. This gives $f_{gr,1} = f_c(m)(2\beta_0 r_c/r_s)^2 = (\hbar_{gr}/\hbar)^2 f_c$. By repeating this argument, one obtains entier hierarchy of frequencies

$$f_{n,gr} = f_c(2\beta_0 r_c/r_s)^{n+1} \quad .$$

Some comments of these frequencies are in order.

1. These frequencies scale like $f_{n,gr}(m, \beta_0, M) = f_c(m)(2\beta_0 r_c/r_s)^{n+1} \propto 1/m^n$ and for $n = 0$ they do not depend on m at all and are therefore universal. This is true also for cyclotron frequencies.

2. The ratio of electronic to protonic frequencies is $r = f_{n,gr}(m_e, \beta_{0,e}, M)/f(m_p, \beta_{0,p}) = (m_e/m_p)(\beta_{0,e}/\beta_{0,p})(m_p/m_e))^{n+1}$. For $\beta_{0,e}/\beta_{0,p} = m_e/m_p$, the ratio of the frequencies is $r = m_e/m_p$ irrespective of n. I have proposed the ratio for the cyclotron frequencies assignable to the monopole flux tubes of the inner and outer magnetosphere of Earth and Sun respectively.

The proposal is that dark electrons reside in the outer magnetosphere at the solar monopole flux tubes and protons in the inner magnetosphere at the monopole flux tubes of Earth and one have $B_{end,outer}/B_{end,inner} = m_e/m_p$ in order to achieve the same ratio for the cyclotron frequencies and the same cyclotron energies for protons and electron to achieve energy resonance.

3. Consider the frequency $f_{gr,1}(m_p, \beta_0) = f_c(2\beta_0/r_s)^2$ for Earth more precisely. For $\beta_0 = 1$ one has the period $T_{gr,1} = 3333$ seconds, which is not far from 1 hour =3600 seconds. In the approximation $T_{gr,1} = 3300$ seconds, $T_{12} = 12$ hours would correspond to $T_{12} = 13T_{gr,1}$.

   For ions with mass number A the frequencies f_n behave like $f_{gr,n}(Am_p) \propto A^{-n} f_{gr,n}(m_p)$ whereas the cyclotron frequencies for ion do not depend on A in this case. Same is true for $f_{gr,1}$.

p-Adic length scale hypothesis [33] stating that p-adic length and time scales comes as powers of $p^{n/2}$, predicts a length scale hierarchy which in the case of electron would with $p = M_{127} = 2^{127} - 1$ involves as the first member the Compton length and the time scale .1 seconds assignable to the EEG alpha band as the secondary p-adic length scale.

3.3 A connection of the galactic blackhole with the Comorosan effect?

Comorosan effect [4, 5] demonstrates rather peculiar looking facts about the interaction of organic molecules with visible laser light at wavelength $\lambda = 546\ nm$ (2.27 eV). As a result of irradiation molecules seem to undergo a transition $S \to S^*$. S^* state has an anomalously long lifetime and stability in solution. $S \to S^*$ transition has been detected through the interaction of S^* molecules with different biological macromolecules, like enzymes and cellular receptors.

1. The typical result in the enzyme-substrate interaction is represented by the enhancement of the enzymic rate, when the respective enzyme substrate is previously irradiated for certain sharply defined times. These *efficient (irradiation) times* are enzyme dependent and can also depend on the biological origin of the enzyme. They are always of the following type $t_i = i * 5$ sec, where i is a certain integer.

2. The general formula for the effective times is $t_k = t_m + (k-1)\tau_n$, $k = 1, 2, .., 6$, where t_m is the minimum radiation time inducing the first effect and τ_n is the period between two consecutive effects [4, 5]. $t_m = m_E t_1$ and $\tau_n = n_E t_1$ are multiples of the basic time scale $t_1 = 5$ *sec*: $t_k = (m_E + (k-1)n_E)t_1$. The integers m_E and n_E can be regarded as enzyme characteristics, depending however on the biological origin of the enzyme. This is suggestive of some kind of communication.

   What is remarkable is that the frequency of 5 s and its subharmonics appear universally so that the effect cannot depend on the details of the chemistry and the mechanism involved must be very general. Second mystery is why the time scale is so long compared to the time scales of chemistry. Note that also the time scales of replication and other basic biological operators are very long.

I have considered several explanations for the Comorosan effect in the TGD framework [14].

1. The Comorosan effect involves a reactant molecule and catalyst molecule as well as photons, which might feed energy to the system. The proposal has been that dark Josephson junctions between reactant and catalyst appearing in the biocatalytic reaction are analogous to those assigned with the cell membrane [13]. The proposed interpretation is that dark Josephson radiation is produced with certain subharmonics of the frequency .2 Hz defined by the Comorosan period $f_C = 5$ s. Why should the periods come as certain multiples of 5 s?

2. It would seem that the period $\tau_C = 5$ s cannot naturally correspond to the gravitational Compton time $\tau_{gr}(M_{BH}, \beta_0 = 1) \simeq 20$ s. For $\beta_0 = 1/4$, one would have a 5 s period equal to τ_C. For this option, $\Lambda_{gr}(BH)$ would correspond to the radius of the second Bohr orbit for a planet around the Sun.

3. Assuming cellular membrane potential $eV_C = .05$ eV and Cooper pair ($Z = 2$), this would give for $h_{eff} = h_{gr}(M_E, m_p)$ and $f_J = f_{gr}(BH, \beta_0 = 1/4)$, the estimate $V_S/V_C \simeq .064$, where eV_S is the Josephson potential between substrate and reactant.

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