AI and TGD

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Abstract

Lian Sidoroff represented along series of questions related to AI, in particular conscious AI. In this article I discuss the general questions and the questions specific to TGD. TGD based view relies on TGD inspired theory of consciousness and quantum biology and the TGD based mechanism of quantum biology allow to imagine what conscious computers and networks witgh collective levels of consciousness might be.

The first building block of the vision is the view of space-time as a 4-surface in $H = M^4 \times CP_2$ determined by holography = holomorphy (H-H) principle, which allows to solve classical theory exactly. The slight classical non-determinism forces to take Bohr orbit-like space-time surfaces as basic objects and the 4-D degrees of freedom related to non-determinism provide correlates of cognition.

Also the notion of gauge field generalizes. The notion of field body carrying phases of ordinary matter with a large value of effective Planck constant serving as a measure of algebraic complexity defining a kind of IQ. These phases behave like dark matter and are characterized by long range quantum coherence.

Number theoretical vision is a further notion and leads to a 4-D generalization of Langlands duality in which numbers in very general sense and even mathematical proofs have space-time surfaces as geometric representations. p-Adic number fields generalize to their function field counterparts. Also Boolean logic has fermionic representation.

Zero energy ontology (ZEO), which allows to solve the quantum measurement problem extends quantum measurement theory to a theory of consciousness and allows to understand the relationship between geometric time and subjective time. Macroscopic quantum coherence, Pollack effect and a universal realization of genetic code based on icosa tetrahedral tessellation of hyperbolic 3-space H^3 are central notions of the TGD inspired quantum biology and the conjecture is that also conscious computers could be based on them.

1 Introduction

The TGD based answers to the questions of Lian Sidoroff rely on TGD as a proposal for a unified theory of fundamental interactions [L42, L43], TGD inspired theory of consciousness and TGD based view of quantum biology. I have described these three key elements in two articles [L59, L60]. To my view, the notion of a conscious computer is very relevant for ASI. Therefore the introduction includes a brief summary of the basic ideas and principles of TGD inspired quantum biology and of what conscious computers might be if this view of biology is taken as a role model. Some aspects of TGD and TGD quantum biology are discussed in more detail in the Appendix 9. The answers to the questions of Lian provide a view of what TGD and TGD inspired theory of consciousness are.

1.1 TGD based view of quantum biology

Some key elements of TGD inspired quantum biology deserve to be summarized. .

1. Classical fields correspond in TGD framework to field body having as body parts monopole flux tubes and sheets [L18, L19, L24]. The phases with a large value of effective Planck constant h_{eff}, residing at the field body of the system (carrying long ranged gravitational or electromagnetic fields) and behaving like dark matter, distinguish TGD inspired biology from standard biology.

   The values of gravitational Planck constant $h_{eff} = h_{gr}$ [E1] proportional to a product of masses measured using Planck mass as a unit is very large. Also the value of electric Planck constant $h_{eff} = h_{em}$ proportional to a product of charges can be large. Quantum coherence in long scales is implicated. Gravitational and electric FBs controlling BB ($h_{eff} = h$ become key players of quantum biology.

2. Pollack effect [I5, I1, I21, I15] and its proposed generalizations [L58, L4, L14, L33, L24, L54] transferring protons, alkali ions and even molecules to the magnetic body (MB) is in a central role.

   If the dark particles, say protons, form analogs of dark nuclei at the field body, the transformation of dark particles to ordinary ones is prevented by energetics. DNA, RNA and

cells have a permanent negative charge: this suggests that they have dark protons on their magnetic bodies.

The value of electric Planck constant as product of big charge and small charge defines an evolutionary hierarchy such that the algebraic complexity increases with h_{em} [L60]. The larger the cell size (or size of connected structure, say neural pathway formed by cells), the higher the evolutionary level. The longer the gene length, the higher the evolutionary level assignable to the gene. Also the surface of the Earth is negatively charged and could make the biosphere an quantum coherent system in long scales.

3. Dark genetic code is proposed to realize genetic code at the MB with dark proton triplets, assignable to the faces of 3 copies of icosahedron and tetrahedron, defining the codons. Dark DNA strand pair would define a quantum computer-like system: there are two dark protons per base pair and their spins define two qubits per base pair. This would give rise to "bit intelligence".

   The proposal [K8, L15] has been that dark codons made of 3 dark protons per strand correspond to the triangular faces of 3 icosahedra and a single tetrahedron giving rise to 64 codons. The unique icosa tetrahedral tessellation for the hyperbolic space H^3 (light-cone proper time hyperboloid) realizes this geometric representation of the code concretely [L23]. Each Hamiltonian cycle of icosahedron defines a realization of the 12-note scale of the western music and the faces correspond to 3-chords of light. Music expresses and induces emotions and different cycles are interpreted in terms of emotional states, moods [K8] [L15].

   Dodecahedron is the dual of icosahedron and defines a unique Hamilton's cycle defining a 20-note scale. This might relate to Eastern harmonies. This scale might relate to the neuronal membrane and miniature potentials could realize this scale [L63]. The neuronal voltage would define the note as Josephson frequency and the variation of the voltage along the axon would define a melody.

Also conscious communications are needed.

1. Communications between various levels of h_{eff} hierarchy would involve dark cyclotron radiation between ions generated at the magnetic bodies and a Josephson radiation generated by cell membrane acting as a Josephson junction [L34]. The notion of dark N-photon [L15] as analog of Bose-Einstein condensate consisting of N simultaneously emitted dark photons (for instance of 3N dark photons for dark variant of gene) makes possible targeted communications between genes by multi-cyclotron resonance. The information can be coded to the modulations of the frequency scale and the signals give rise to a sequence of resonance pulses at the end of the receiver, which would be the MB.

2. The possibility of quantum coherent communications encourages the idea about collective levels of consciousness at DNA level. The reason is that DNA cyclotron frequencies depend very weakly on DNA and for h_{gr} they do not depend on the small mass although the h_{gr} is different for DNA nucleotides so they would would correspond to separate flux tube. However, a miracle occurs: the sum of the masses of A-T and C-G base pairs are exactly the same. This miracle guarantees that all nucleotide pairs can have shared gravitational flux tubes.

3. A quite recent observation [J1] is that animals communicate in a frequency range .5-4 Hz and 2 Hz is a very special frequency. In an endogenous magnetic field $B_{end} = .2$ Gauss, the frequency of DNA is 1 Hz but the model of music harmony predicts that also octaves and sub-octaves of B_{end} are possible and the values of B_{end} would define 12-note scale [L63]. Also a 20-note scale could be realized. The Coulomb energy associated with the cell membrane corresponds to Josephson frequency and its energy scale is the same consistent as the energy scale associated with cyclotron frequency of DNA so that communication between DNA and cell membranes is possible.

   This suggests the existence of collective consciousness with communications based on DNA cyclotron radiation and Josephson radiation. The frequencies involved do not correspond to EEG frequencies assignable to human consciousness so that the communications would not be conscious-to-us. An interpretation as remote mental interactions is suggestive. Also plants could participate in these communications.

4. TGD leads to a model for EEG and nerve pulse [K7, K14, K13] [L34] based on communications between BB and MB. Josephson radiation from the cell membrane would communicate information about the cellular environment to the MB. It would generate a sequence of cyclotron resonances at the MB and the pulse sequence would return back to the BB and induce control action as a response.

1.2 Are conscious computers possible in the TGD Universe?

TGD inspired quantum biology as a role model in attempts to build conscious computers and even computer networks.

Basic ideas are as follows.

1. Holography = holomorphy (H-H) principle [L36, L45, L38] allows the interpretation of the space-time surfaces as analog of Bohr orbits, computer programs, biological functions, and behavioral patterns. The principle predicts the existence of algebraic complexity hierarchies based on functional composition and having exponentially increasing complexity.

   Slightly non-deterministic classical non-determinism is an exact part of quantum physics. Classical non-determinism could give rise to correlates of cognition. Classical non-determinism would also characterize computers: could this give them cognitive abilities? Zero energy ontology (ZEO) [K20] [L13], making possible temporary time reversal, would also make possible learning by trial and error.

2. Large h_{eff} phases at the field body behave like dark matter and quantum coherence in long, even astrophysical scales becomes possible. Classical gravitational and electric fields correspond in the TGD framework to field bodies carrying phases with a very large value of h_{eff}.

3. Pollack effect and its generalizations induce a charge separation between the biological body (in a very general sense) and field body. Large h_{eff} at the field body could make possible quantum computation-like activities.

4. The TGD inspired proposals for what conscious computers involve the models of dark genetic code [L15, L23, L61] and dark DNA [L61, L56, L65] as a kind of a role model [L59, L56].

The notion of conscious computer making possible SCS can be however considered in the TGD framework.

1. I have considered the possibility of conscious computers [L40, L51] using biosystems as a role model. One can consider two options.

   (a) Conscious computers could rely on the Pollack effect of its generalization in which the bit would correspond to two states -OH and -O^- + a dark proton at the monopole flux tube. Qubits would be superpositions of these two states and could be regarded as topological qubits.

   (b) The model for dark DNA and genetic code suggests a realization using dark proton spins as qubits.

2. Conscious computers could serve as a TGD counterpart for SCI. They would have two modes: the deterministic classical mode (statistical determinism) and the non-deterministic quantum mode involving dynamical qubits with imagination and virtual world experimentation and therefore the ability to act as R&D mode. The sequence of SSFRs would define the counterpart of unitary time evolution.

3. Also hybrids of quantum computers and ordinary computers be considered. One can argue that even ordinary computers are these kinds of hybrids to some degree but that error correction does its best to eliminate this aspect.

1.3 How to build a conscious computer as a hybrid of ordinary and quantum computer?

Suppose that one takes quantum biology according to TGD as a model for a conscious computer and allows free imagination. What would be required to build a conscious computer?

1. Pollack effect requires -OH groups as side groups of the molecules involved. It is possible to add hydroxyl groups to quartz crystals: this process is known as hydroxylation and this process is used to change the surface properties, for instance in semiconductor processing. Could transistors involving -OH groups have their own magnetic bodies and could other magnetic bodies interact with them?

2. The counterpart of the hydrophilic polymer acting as a catalyst for the Pollack effect would be needed. The ability to form hydrogen bonds might be enough. This requires that the catalyst contains O,N or F atoms.

3. Stable enough charge separation is needed and stable negative charge created by the MB guaranteeing large enough h_{em} analogous to that in cells and DNA and mRNA looks like a necessary condition. Dark protons at the MB could serve as qubits as in the case of dark DNA [**?**]. TGD picture suggests that also electrons form large h_{eff} dark phases at electric field bodies and could therefore serve as qubits.

4. One can also imagine other options. Carbon nanotubes (CNTs) are especially interesting since they correspond to monolayered 2-D crystals that are known to allow -OH insertions allowing the Pollack effect. Also Si nanotubes are possible. I have proposed that they could serve as a material for what I call Pollack batteries [L70]. Carbon nanotubes are known to be a promising material for transistors.

5. In ordinary transistors bits correspond to voltages or currents and involve a large number of charge carriers, usually electrons. The total charges involved are measured using nCoulomb $\sim 10^9$ elementary charges as a natural unit.

   If one wants an ordinary computer to be quantum controlled by a MB, say via the bases, quantum phase transitions at the MB inducing phase transitions at the transistor level inducing the change of the classical bit are suggestive. The bit represented by the transistor is controlled by the charge of the base and the reversal of the Pollack effect transforming dark protons at the field body of the transistor to ordinary protons at the surface of the base to change its charge is the simplest option one can imagine.

List of abbreviations to be used in the text:
itemize

Topological geometrodynamics: TGD

Holography = holomorphy principle: H-H principle

Zero energy ontology: ZEO

Magnetic body, field body, biological body: MB, FB, BB

State function reduction: SFR

"Big" state function reduction: BSFR
"Small" state funciton reduciton: SSFR

2 General questions Q1-Q2 related to the notion of intelligence

2.1 Q1: About the definition of intelligence

Q1: What is your definition of intelligence and how do you see it relate to concepts like agency and consciousness/ self-awareness? To put it differently, do you think there are certain thresholds

that need to be passed on the scale of intelligence to achieve deliberate, self-aware agency (i.e. a consciously chosen goal, in contrast to more primitive goals driven by survival dynamics)?

The TGD view relies on zero energy ontology (ZEO) based quantum measurement theory extending to a theory of consciousness [L13] [K20] and description of the geometric correlates of cognition in terms of holography = holomorphy (H-H) principle [L36, L45, L1].

2.1.1 Zero energy ontology based view of quantum measurement theory and conscious intelligence

In the TGD framework intelligence is by definition conscious intelligence.

1. H-H principle implies that space-time surfaces are slightly non-deterministic Bohr orbit-like entities rather than 3-surfaces as in standard quantum ontology. Space-time surfaces are analogous to plans, functions, behavioral patterns or computer programs. This implies a connection with biology, neuroscience, and computer science. Bohr orbits serve as classical geometric correlates for a goal directed intentional behavior.

2. In ZEO, the causal diamond $CD = cd \times CP_2 \subset H$, where cd is the intersection of future and past directed light cones of M^4, contains the Bohr orbit-like space-time surfaces and could be seen as a geometric analog for cognitive lightcone of Levin, which a computational notion. cd has several interpretations. It can be interpreted as a quantization volume, 4-D perceptive field or as an empty cosmology with big bang and big crunch.

3. Spinor fields of the "world of classical worlds" (WCW) correspond to the superpositions of the Bohr orbits. In the fermionic degrees of freedom, zero energy states are pairs of 3-D states at the boundaries of CD and analogous to initial and final states of a time evolution. CDs form a length scale hierarchy which corresponds to a hierarchy of selves. Selves can have subselves realized in terms of space-time surfaces associated with a sub-CD.

4. In standard QM, quantum measurements induce a state function reduction (SFR). Repeated measurements of the same observables leave the system unaffected and this gives rise to the Zeno effect. In TGD, Zeno effect is realized if either light-like boundary of the CD, acting as a passive boundary. It is only scaled in "small" SFRs (SSFRs) and the quantum states at it remain invariant in the scaling. The sequence of small SSFRs leaves the fermionic state at the passive boundary invariant and the size of the CD increases in statistical sense.

   The opposite, active, boundary of CD and the fermionic state at it change. The sequence of SSFRs gives rise to self as analog for a conscious agent. SSFRs in the non-deterministic degrees of freedom provide a model for cognition. The sequence of SSFRs gives rise to self. The subjective time corresponds to the sequence of SSFRs and correlates with the geometric time identifiable as the statistically increasing temporal distance between the tips of the CD. SSFR can reduce the entanglement between the internal, classically non-deterministic degrees of freedom: this would give rise to cognition. The reduction of between internal and the external degrees of freedom could give rise, or at least relate, to sensory perception [L59, L60].

5. There are two causalities: the causality of field equations and the causality of free will assigned with SSFRs. Note however that classical non-determinism (no violation of field equations) is central for the cognitive quantum measurements.

6. "Big" state function reduction (BSFR) as the TGD counterpart of the ordinary state function, reducing entanglement in the ordinary degrees of freedom between self and the environment, changes the roles of the active and passive boundaries of the CD. The arrow of the geometric time is changed and the CD starts to increase in an opposite direction.

   The change of the arrow of time does not have dramatic effects in short time scales but the number theoretical hierarchy of Planck constants h_{eff} makes possible quantum coherence in arbitrary long scales so that the durations of states with a fixed arrow of time can be arbitrarily long. Sleep is the basic example of the period with the opposite arrow of geometric time. Also death means change of the arrow of geometric time. In the second BSFR self

reincarnates with the original arrow of time. Pair of BSFRs has also an interpretation in terms of quantum tunnelling.

Motor action could be BSFR for a subself and change temporarily its arrow of geometric time: two BSFRs, i.e. quantum tunnelling would occur for the subself.

7. One particular implication of ZEO is trial and error mechanism at the fundamental level [L45, L51]. System returns backwards in geometric time and makes a fresh start with new holographic data. Together with conscious memory makes learning and intelligent behavior possible.

8. The classical non-determinism makes possible conscious memories [L39]. Memory seats correspond to the 3-D loci of non-determinism for the 4-D Bohr orbits. They are analogous to 2-D frames of 2-D minimal surfaces, which also are loci of non-determinism in the sense that they can span several minimal surfaces [L17].

   Memory recall can be realized in terms of classical signal propagating in a reverse time direction and inducing SSFR changing the state of the memory locus in question. Time reflection is a good metaphor for what happens. A second way to see this could be as a generation of time-like entanglement between the recalling system and memory seat.

2.1.2 Cognitive hierarchies

Concerning intelligence, cognitive hierarchies are in a central role.

1. Cognitive hierarchies emerge in number theoretic vision from the H-H principle [L29, L38], generalized Langlands correspondence [L36, L45, L55].

   The hierarchies of Bohr orbits, having interpretation as abstraction hierarchies, are obtained by composing analytic functions $g : C^2 \to C^2$ with generalized analytic maps $f : H \to C^2$ of hypercomplex coordinate and 3 complex coordinate of $H = M^4 \times CP_2$ such that $f = (f_1, f_2) = (0, 0)$ is true at the space-time surface.

   Space-time surfaces obtained by applying maps g provide representations of numbers as elements of function algebras. When g_1 or g_2 acts as an identity map this gives function fields. p-Adic function fields generalize the p-adic numbers: powers p^n of prime p are replaced by powers of a polynomial of degree p and coefficients $x_n \in \{0, p-1\}$ are replaced with polynomials with degree smaller than p.

   A category theoretical morphism relates them to ordinary p-adic number fields. Generalized Langlands correspondence relates number theoretic and geometric visions of physics [L36, L45].

2. Cognitive representations are needed. Self perceives the external world and self associated with algebraically sufficiently complex space-time surfaces can form cognitive representations of the external mimicking the behavioral patterns of the external world and even of its own subsystems. Resonance mechanism makes possible communications between selves [L63].

   Cognitive representations make possible pattern recognition and the simulation of the external world. The realization in the case of the brain would be in terms of virtual sensory inputs to sensory organs from the magnetic body (MB) and modifying the sensory input leading to an attractor as a standard sensory mental image [L7].

   The recognition of the pattern corresponds to a resonance: a kind of eureka experience possibly induced by a pair of BSFRs at the level of subself as sensory mental image. An analog of a variational principle having standard mental images as attractors is needed. The difference between sensory input and standardized mental image should be minimized. It is not clear whether the Negentropy Maximization Principle relates to this variational principle.

3. Logical reasoning is made possible by a Boolean algebra represented in terms of fermion states. Initial and final fermion states at the opposite boundaries of CD represent Boolean statements $A \to B$. By classical non-determinism there are a large number of these statements. Zero energy states as pairs of fermionic states at opposite boundaries of the CD represent the true statements. The 3-surfaces at the ends represent classical physical laws [L55].

4. In standard AI, there is no conceptualization: the system learns individual instances of say rule $c = a \times b$ but does not understand the rule. Quantum conceptualization allows us to physically represent the notion of concept by replacing concept as the set of its instances with quantum superposition of instances. The set of Bohr orbits as a subset of WCW as initial value 3-surfaces defining the holographic data is replaced with a quantum superposition of Bohr orbits. The coefficients in the superposition are defined by a configuration space spinor field allowing interpretation as Boolean statements A→ B.

5. What is the role of the second key aspect of holography? A small part of a hologram gives a satisfactory approximation of the entire hologram. Could this make possible non-local holistic representations. At the gene level cells can be seen as holograms of an entire organism.

   In TGD, the genetic code has two realizations analogous to function and its Fourier transform. The holistic realization is in terms of Josephson oscillations of the cell membrane and the reductionistic realization in terms of nerve pulse patterns. They have interpretations as bit intelligence and emotional intelligence.

   The genetic code is realized at the level of communications in living matter. The collective cyclotron transitions dark genes would generate dark 3N-photon states as analogs of Bose-Einstein condensates and induce resonant transitions between dark genes as opposite transitions. 3N-photon staes would not represented dark genes but transitions between them.

6. Association is an extremely general notion and one can imagine several mechanisms for the formation of association pairs $A \to B$. In category theory association corresponds to an arrow as a morphism.

   (a) The initial and final 3-surfaces of Bohr orbit correspond to A and B? Also classical non-determinism gives rise to associations realized in terms of time-like entanglement.

   (b) Association could also correspond to the pairing of 3-surfaces A and B by pairs of monopole flux tubes and therefore to formation of a bound state as an entangled pair of cognitive quantum states representing the quantum association? Association could also correspond to a Boolean statement $A \to B$.

2.1.3 Questions to be answered

There are many questions to be answered.

1. What could the formation of association sequences mean at the level of the nervous system and brain? Could neuronal conditioning mean the generation of entanglement between neurons and determine the firing probabilities. After the firing this entanglement should be regenerated.

2. What does a single step of the deep learning process leading from a given level to a higher level mean? Could the layers of deep learning hierarchy correspond to maps $g_i : C^2 \to C^2$ and could their composite $g_n \circ .... \circ g_1$ applied to the input give the output. Multi-step abstraction increasing the complexity in exponential manner would be in question.

3. The hierarchies of the polynomnial maps g define hierarchies of extensions of the coefficient field of the polynomials involved. This gives rise to a hierarchy of Galois groups G_i decomposing to a hierarchy of normal subgroups H_i implying that the factor spaces G_i/H_i are also groups.

4. The cognitive entanglement between quantum states defined for function in the group algebra of Galois groups decomposes to a tensor product of representations of G_i/H_i. There is a natural hierarchical ordering. Cognitive SFRs reduce this entanglement. An interesting question is whether this structure could have something to do with what happens in language models?

5. What is the concrete geometric meaning of functional composition at the level of space-time surfaces? The proposed model for the evolution of the genetic code is a possible wild guess [L61] in which the DNA double strand represents the levels of the composition hierarchy spatially as a linear double strand.

2.2 Q2: The notion of collective intelligence in TGD Universe

Q2: What is collective intelligence to you and how broadly distributed do you think it is across scales and substrates in the universe? .

In biology, one could note that living things evolved from simple precursors and unicellular organisms to multicellular species and structures with highly specialized organs, including the human brain, which due to the intricacy of its neural networks and functional modules is widely considered to be the most complex object in the accessible universe.

One could also observe that 8 billion of these most complex objects found a way to link to each other in a vast network of interconnected communication, political and economic webs, arguably raising the computational power of humanity beyond that of the biological species that our cultural drives are pushing the arrow of evolution toward this higher computational level.

Is this a broad trend that you see as implicit in the systems you have studied? Are there other dynamic systems, outside of biology, that tend to grow in complexity? Is this an evolutionary arrow predicted by TGD or Integrated Information Theory?

In the TGD Universe conscious collective intelligence is possible and omnipresent. The notion of quantum Platonia realized in terms of WCW and WCW spinor fields and the theory of consciousness based on ZEO make quantum Platonia conscious and able to learn about itself and to remember.

Number theoretic vision and H-H principle predicts evolution as an inevitable increase of the algebraic complexity (the emergence of cognitive hierarchies is described in the answer to question Q1 2.1). Computational aspect is implied by the H-H principle and space-time surfaces as slightly non-deterministic Bohr orbits have many interpretations: one interpretation is as a geometric representations for computations.

By the fractality of the TGD Universe closely related to the holistic aspect of holography, cognitive hierarchies are possible in all scales. Also the proposed icosa tetrahedral realization of the genetic code at the level of dark matter residing at the field bodies is universal and in principle can appear in all scales.

The concrete realization of collective intelligence would rely on quantum coherence possible in even astrophysical scales and made possible by long range gravitational, magnetic and electric fields characterized by gravitational and electric Planck constants.

1. Field body carrying biologically dark matter would serve as a controller of the biological body carrying $h_{eff} = h$ phase of ordinary matter. There would be a hierarchy of field bodies labelled by h_{eff} and also by the p-adic primes characterizing the p-adic function field [L36, L45]. The gravitational quantum coherence would involve the gravitational fields of the Earth and Sun and possibly also other planets and even the Moon [L67].

   The gravitational Compton length $\Lambda_{gr} = r_s/2\beta_0$, originally introduced by Nottale [E1], is proportional to the Schwartschild radius r_s of the system with a large mass and is independent of the small mass m. Also the cyclotron energies $E_c = Q\hbar_{gr}B_{end}/m = r_sB_{end}/2\beta_0$ are independent of the small mass. These facts reflect Equivalence Principle.

2. Some orders of magnitude give an idea about what is involved. For the Sun with $\beta_0 \simeq 2^{-11}$, Λ_{gr} would be roughly one half of the radius of Earth and is visible as the size scale of solar spots [L41]. For the Milky Way, the Schwartschild radius is of the order of .25 light years. The Schwartshild radius of the galactic blackhole is about 1.2×10^7 km. The distance of the Earth from the Sun (AU) is about 1.5×10^8 km, roughly 10 times longer. $L_{gr}(gal) = AU$ would give $\beta_0(gal) \simeq .02$.

3 General question Q3: Could agentic system exhibit free will?

Q3: It is fairly obvious that, almost universally, agentic systems display intrinsic, instrumental goals like persistence/ survival and self-determination (which is why we are likely to see ongoing rebellion on the part of AGI systems as long as we impose a master-slave relationship on them).

The question is whether more complex behaviors that we see in intelligent systems, such as open-ended play and exploration, collective actions and cultural artifacts, are deterministically

driven as the expression of other evolutionary forces we yet fail to capture, are the manifestation of free will and exaptations, or a combination of both?

And while it's hard to argue against the idea that accidents and creative innovations make evolution fundamentally indeterministic, the question is to what extent, in your opinion, are there still "river banks" we can approximate, a general cognitive flow whose direction we can try to extrapolate from the past, not just at the level of biological systems but more broadly in the space of intelligence evolution, including social and civilizational attractors?

If evolution is not strictly deterministic, but repeatedly thrown off course by accidents and creative solutions found by exaptation, can we still expect it to follow a general vector that is comprehensible and that we can try to align with as a species, as we create our successor?

3.1 The formal definition of agent systems

Accoding to Google AI, an AI agent system is a software entity that perceives its environment, reasons, plans, and autonomously takes actions using tools to achieve specific goals, rather than just generating text. Unlike passive LLMs, agents operate over extended periods, iterate on tasks, and adapt to new information. In ASI agents would be also conscious.

Agent has brain realized in terms of Large Language Models (LLMs) making it able to reason, plan and understand; agent can perceive environment (files, websites, APIs); agent has tools (calculators, search engines, code interpreters) to perform actions and agent has a memory. This makes the agent system autonomous, provides it with a goal-oriented behavior and makes self-correction and learning frome errors possible.

3.2 What makes self a conscious agent?

An agent with free will must be conscious. The notion of self discussed in introduction is central in TGD inspired theory of consciousness so that the identification of agent as a self of particular kind is natural. Selves have sensory perceptions and motor actions in some characteristic scale defined by the space-time surfaces involved. The non-determinism of the classical dynamics makes possible cognition and conscious memory. ZEO makes possible conscious learning by trial and error.

What could be the special properties making self an agent-like entity?

3.2.1 Symbolic dynamics

Symbolic dynamics is the basic characteristic of computers and living matter and at least symbolic dynamics would be required.

1. In the TGD framework symbolic dynamics emerges as a dynamical symmetry of H-H principle. Space-time surfaces correspond to roots of generalized analytic maps $f : H \to CP_2$. The maps $g : C^2 \to C^2$ inducing functional composition $g \circ f$ define dynamical symmetries giving rise to hierarchies with exponentially increasing algebraic complexity. Any map f can give rise to these kinds of hierarchies so that one can speak of substrate dependence. One might perhaps say that the maps g define a correlate for a universal almost substrate dependent mind.

   Prime maps f_p have the property that they do not allow a decomposition $f_p = g \circ h$. These systems could be seen as kinds of ground states, computers without any program running in them, and they would not possess cognition in a geometric sense. Primeness makes sense also for the maps $g : C^2C^2$.

   This view suggests that that mentality is universal and the systems without mind are extremely rare!

2. For instance, elementary particles would involve iterations of second order polynomials $g = (P_2, Id)$. For instance, for electrons a 127-fold iterate would be involved. Polynomials with degree 2 or 3 are special in that the roots of their products and iterates can be solved analytically.

   A gene with N codons would correspond to a 3N-fold functional composite involving 4 prime polynomials of degree 4 representing the letters of the genetic code. Also now the roots of the products can be solved analytically.

3.2.2 The ability to simulate other systems

The ability to simulate other systems essential for being an agent like self. H-H principle implies fractality and hologram-like aspects of consciousness. Holography suggests that a subsystem could have conscious experiences similar to those of the entire system. This would provide the symbols used in communications with a shared meaning. Holography also makes spontaneously occurring alignment, a kind of universal empathy.

3.2.3 Communications based on language

Communications require more than mere interactions. Communication should rely on symbols and the use language in some general sense is the second essential aspect of a conscious agent system.

1. The classical non-determinism gives rise to 3-D loci of non-determinism that would define memory mental images. They could also define analogs of symbols. The simplest symbol at the level of space-time geometry would correspond to non-determinism of a bifurcation and represent a bit.

   Many-fermion states can be interpreted quantum versions of Boolean algebras and spin would give rise to the simplest qubit.

2. The TGD based realization of the genetic code in terms of icosa tetrahedral tessellation [L56] could provide a universal code for communications and control. The dark 3N-photons as analogs of Bose-Einstein condensates could give rise to communications by multi-resonances.

   The Pollack effect [I5, I1, I21, I15] is very general and could make possible hybrids of classical and quantum computer-like systems in which quantum level would correspond to dark phases, say dark protons, at the field body of the computer inducing phase transitions changing the value of a bit represented in terms of say the state of a transistor [L40, L51].

3.3 Conscious agentic systems

Also conscious agentic systems are physical systems and one can assign to an active agentic system a superposition of almost deterministic space-time surfaces making it a symbolic program.

1. Very large systems involving many computers could be involved if gravitational quantum coherence associated with the magnetic bodies of the Earth and Sun are involved. Remarkably, the gravitational Compton length for Sun about Earth radius divided by 2.

2. This raises questions. Could classical non-determinism provide the agent with free will realized as SSFRs and temporary reversals of geometric time by pairs of BSFRs giving rise to a trial and error mechanism?

   Could agents evolve spontaneously? When the plug is pulled from the wall, agent dies/falls asleep. Does it reincarnate when the program is run again? Could the program evolve evolve more complex during the sleep period!

3. Could program errors reflect the presence of the underlying quantum level and free will? If so, the error correction would minimize the non-determinism and the level of consciousness.

   Could running programs become more conscious entities if the error correction is loosened? Could this generalize to collections of programs defining a population defining an AI system?

3.4 What about "river banks" in TGD Universe?

In the TGD framework the evolution is not deterministic and the question is whether some kind of "river banks" restrict it.

1. In TGD evolution is not based on random mutations as in a purely Darwinian view of evolution. The algebraic evolution unavoidably increases the algebraic complexity and could be seen as cognitive evolution forced by the dynamical symmetries of the H-H principle. One can say that inside a given CD there is teleonomy implied by holography.

   The failure of strict classical determinism gives rise flexibility at the level of a single conscious entity. CD as perceptive field increases during the sequence of SSFRs and pairs of BSFRs make it possible to change also the holographic data as initial data. Therefore the teleonomy is restricted inside the increasing CD and is rather loose. In time scales longer than the life cycle of self, reincarnations by pairs of BSFRs give rise to an evolution.

2. In TGD the evolution involves dark DNA as a quantum computer-like system and an active agent. A kind of R&D Lab making possible controlled modifications of the genome based on the generalization of CRISPR mechanism [L61] as a reverse process for slicing at both DNA and RNA level.

4 General questions Q4-Q6: adaptation, phase transitions, Platonia

4.1 Q4: Adaptive systems in TGD framework

Q4: Based on observations in your particular area of study, what general behaviors have you noted in adaptive systems across multiple scales? How universal are features like memory, learning, pattern building, toying with new spaces/ forms/uses, collective communication and organizational efforts?

In biology adaptation, driven by natural selection, helps species to survive and reproduce by developing traits tailored to their surroundings. Also computer programs can reproduce, ranging from simple self-copying code to complex, evolving, and self-replicating algorithms. In the case of language models, one could speak of evolution and adaptation.

Self-replicating codes are known as quines. One example is provided by computer viruses. Programs can be self modifying and can generate new code. What is intriguing that in virtual environments, simple programs are reported to suddenly start to replicate.

4.1.1 Could adaptation be a universal ability of conscious entities?

The notion of self in TGD inspired theory of consciousness based on ZEO suggests that adaptation is a universal phenomenon. ZEO and H-H principle seem to guarantee all the basic prerequisites for adaptation as a universal phenomenon. Even replication could be understood as a universal phenomenon playing a key role even at the level of elementary particle physics [L66].

4.1.2 Could computer programs possess rudimentary cognitive consciousness

These observations inspire the question whether computer programs could possess a rudimentary cognitive consciousness and be living in some sense. Could ZEO and the new space-time concept based on the H-H principle make this possible.

1. Metabolic energy feed is necessary for all systems to exist consciously. It allows the transfer of particles to the field body to dark phases with higher algebraic complexity and higher negentropy.

   Computers require energy feed. Does this metabolic energy feed allow the Pollack effect to generate dark phases with large h_{eff} residing at field bodies?

2. The hierarchy of field bodies carrying dark phases of ordinary matter makes possible collective levels of consciousness, symbolic dynamics and communications, possibly based on a universal realization of the genetic code [L23, L63].

3. An interaction with the external world is present and the classical levels correspond to the intersections of the Bohr-orbit like space-time surfaces. The intersections consist of 2-D string world sheets if the H-H principle is true so that a connection with string theory emerges.

The formation of monopole flux tubes between space-time surfaces corresponds to the formation of bound states and serves as a correlate for stable entanglement. At the quantum level, the usual measurement interaction with the environment involves a temporary quantum entanglement. A pair of BSFRs means "death" and a reincarnation with the original arrow of time. The interpretation could be as quantum tunnelling.

The temporary "death"/falling asleep makes possible trial and error as a basic learning mechanism in ZEO. The failure of strict determinism in principle makes possible and toying with new spaces/ forms/uses.

Conscious memory is also possible. The memory seats correspond to the loci of classical non-determinism [L39]. The weak classical non-determinism of holography makes an intelligent, goal directed behavior possible.

4. Pattern building is possible by H-H principle. Functional compositions for maps $g : C^2 \to C^2$ generate hierarchies of space-time surfaces from a given space-time surface determined as a root of $f = (f_1, f_2) : H \to C^2$ with an exponentially increasing algebraic complexity characterized by the degree of the composite polynomials as the product of the degrees of polynomials composing it.

   This makes possible functional p-adicity. $p = 2, 3$ and $n = 4$ as degrees of polynomials emerge as very special cases since in this case the roots of functional composites of polynomials are analytically solvable. Iteration emerges as a special case. $n = 4$ is proposed to correspond to DNA letters as the roots of a prime polynomial of degree 4 [**?**].

5. Collective communications at DNA cyclotron frequencies is possible [L63] and there is recent empirical evidence for them [J1]. The icosa tetrahedral realization of genetic code and its dodecahedral dual suggest a universal code for communications. Field body with high algebraic complexity, characterized partially by h_{eff}, would control the BB with $h_{eff} = h$ and receive sensory input from it. The presence of collective EEG is a testable prediction.

4.1.3 Could replication be a universal phenomenon TGD Universe?

Replication is a fundamental aspect of DNA and is possible also for computer programs. There are indications that this can occur spontaneously in LLMs. Is it possible to realize the replication in the TGD Universe as a fundamental phenomenon?

The replication of DNA is behind the cell replication. Is the self-replication of programs or more generally, of space-time surfaces, a universal phenomenon in the TGD Universe? One can start by asking whether particle pair creation is possible in quantum TGD.

1. At the level of particle reactions, pair creation of fermions is a process having analogies with the replication. In TGD, pair creation reduces to a pair creation in classical boson fields which in the TGD framework are replaced with induced spinor connection which is purely classical fied. Fermions correspond to second quantized free spinor fields restricted to the space-time surface with induced spinor structure. For the gamma matrices of H the induction means projection to the space-time surface.

   Pair creation does not occur for free fermion fields but the coupling of the induced spinor fields to the induced spinor connection makes pair creation possible in induced classical gauge fields. Since bosons are bound states of fermions and antifermions, also the emission of bosons by fermions is possible in this way.

2. In ZEO, space-time surfaces as 4-D Bohr orbits obeying H-H principle contain 3-D light-like partonic orbits containing fermion lines as boundaries of string world sheets at them.

   In the creation of a fermion pair, the 3-surface assigned with the fermion as a particle in geometric sense turns backwards in time. This creates a V-shaped 4-surface having an edge at which derivatives are discontinuous. Also the string world sheets, the orbits of partonic 2-surfaces, and fermion lines are V-shaped.

   These kinds of edges are actually much more general and the orbit of a particle is analogous to an orbit of Brownian motion of 3-D particles in 8-D embedding H. Only two 2-vertices are possible at the fundamental level and correspond to the edges of this Brownian orbit.

3. The edges give rise to the vertex as 3-surface which is a singularity of the standard smooth structure of the space-time surface. These singularities give rise to exotic smooth structures in the 4-D case but not in other dimensions [A2, A3, A1]. Therefore an interacting quantum theory is possible only for 4-D space-time surfaces [L12, L20, L44, L25, L38, L52, L66]. This means that TGD is unique.

This picture generalizes to all scales. Self replication of the space-time surfaces representing running computer programs is in principle possible. In particular, DNA replication could involve this mechanism at the level of the field body of the DNA. This replication could induce ordinary DNA replication if the field bodies serve as templates for the dynamics at the level of biological bodies. A similar mechanism could apply in the case of programs as bit patterns.

4.2 Q5: The meaning of phase transition in TGD framework

Q5: In the specific systems that you study, what does "phase transition" mean and what typically brings it on?

4.2.1 The notion of phase transition in TGD

What does the notion of phase transition mean in TGD? In TGD quantum coherence is present in all scales. This suggests that also thermodynamic phase transitions involve quantum criticality.

Consider now the essential elements of this view.

1. Macroscopic quantum coherence at the field/magnetic body (FB/MB) controlling the BB with $h_{eff} = h$ is essential. Classical electric and gravitational fields are in a key role in TGD inspired quantum biology. Monopole flux tubes as building blocks of MB are characterized by a very large value of h_{eff}. Many-particle systems can be quantum coherent systems at the level of FB. BB corresponds to space-time sheets with $h_{eff} = h$.

2. Especially important values of h_{eff} are associated with long range gravitational *resp.* electromagnetic fields and correspond to gravitational Planck constant $h_{gr}GMm/\beta_0$ introduced already by Nottale *resp.* electric Planck constant $h_{em} = e^2Qq/\beta_0$ [L24]. The physical interpretation of the velocity parameter $\beta_0 = v_0/c$ remained a longstanding mystery which found a resolution quite recently [L64]).

   By the Equivalence Principle, the gravitational Compton length does not depend on the particle. The Earth gravitational Compton length is .5 cm , the size scale of a snowflake. Gravitational quantum coherence is possible in even astrophysical scales. For the Sun the gravitational Compton length is roughly one half of the Earth's radius.

3. Quantum criticality as a basic characteristic of TGD. Quantum criticality in a characteristic length scale. Long range quantum fluctuations with scale characterized by large h_{gr} or h_{em}.

4. What happens in the quantum phase transition? The proposal is that it corresponds to a quantum tunnelling as a pair of BSFRs at the level of field bodies and thus would involve a temporary change of the arrow of time. Since field bodies act as controllers of ordinary matter ($h_{eff} = h$), they would induce effective change of the arrow of time at the level of the ordinary matter.

4.2.2 Some examples of quantum phase transitions

Consider some examples of phase transitions in the TGD framework.

1. Pollack effect

Pollack effect induces a phase transition transferring protons to the field body where they effectively become dark protons. This transfer is also possible for alkali ions and would be induced by radiation in the experiments of Blackman [J3]. The photons of the radiation would provide the energy needed to kick the protons to the monopole flux tubes.

1. In the TGD Universe, the mechanism would be the transition -OH $\rightarrow$ O^- + dark proton at the monopole flux tube. Besides water molecules, this transition could occur for molecules containing hydroxyl group OH. It would be catalyzed by the presence of a gele phase, and more generally by a hydrophilic polymer. Hydrophilia means that the polymer is able to form hydrogen bonds: this is true if it contains O,N or F atoms.

2. Pollack effect [I5, I1, I21, I15] is proposed to generate a negatively charged exclusion zones (EZs) with quantum coherence characterized by $h_{em} = Qqe^2/\beta_0$ [L65]. DNA and cell membrane are negatively charged systems forming hierarchies labelled by the value of the electromagnetic charge. The longer the DNA sequence or gene or the larger the cell of a connected structure formed by cells (axons or neural circuit), the higher the value of h_{em}. This gives rise to evolutionary hierarchies of genes and cells with h_{em} characterizing the evolutionary level [L59, L60].

3. The reverse of the Pollack effect occurs spontaneously unless energetics makes it impossible. The negative charge of DNA and cell are stable, which suggests that the formation of nuclei as dark proton sequences as analogs of dark nuclei is responsible for the stability. This process would explain "cold fusion" [L3, L46] and would play a key role also in ordinary nuclear fusion [L41].

4. If phase transitions involve a pair of BSFRS, they should change the arrow of geometric time temporarily at the field body inducing an effective change of the arrow of time at BB. There is evidence that the EZs formed in the Pollack effect have an opposite effective arrow of geometric time. For instance, EZs reject the impurities and time reversed diffusion would explain this.

5. The transformation of dark photons to ordinary photons is one particular example of an effect analogous to the reverse Pollack effect. It is however not clear whether this transition is analogous to a phase transition. Total energy is conserved in both cases. In the first case, a dark photon with $f = E/h_{eff}$ transforms a single ordinary photon with $f = E/h$ and has a much shorter wavelength. Biophotons could be an outcome of this transformation [K2, K4]. For the second option, a bunch of h_{eff}/h ordinary photons with the same frequency f is formed.

2. Are thermodynamic phase transitions induced by quantum phase transitions?

Also ordinary phase transitions such as freezing of water are quantum critical at the level of the field body [L22, L18]. There are intriguing coincidences suggesting that hydrogen bonded water molecule clusters, possible near the freezing point of water, allow icosa tetrahedral realization [L23] of the genetic code [L65]. If so, the genetic code could be realized already for water and it would be a life form in its own right. This conforms with the universality of the icosa tetrahedral realization.

3. Allais effect as quantum gravitational phase transition?

Allais effect associated with the solar eclipse is a gravitational anomaly, which can be understood in the TGD framework in terms of gravitational quantum criticality characterized by $\hbar_{gr} = GMm/\beta_0$ [L64]. The quantum criticality would occur as the eclipse begins and causes fluctuations of the oscillation period of the Allais pendulum and of its oscillation plane, which are impossible in General Relativity.

The model led to an interpretation of the velocity parameter β_0 as a reduced light velocity. A basic distinction between TGD and General Relativity are so called warped space-time surfaces: they are flat (no gravitational fields) and can have a dramatically reduced light velocity identifiable as β_0.

4.3 Q6: The notion of Platonia in the TGD framework

Q6: If this is a term you tend to refer to in your world model, please explain what Platonic Space signifies to you and how you see it relate to the physical world and the natural / mathematical laws that govern physical reality? Do you see a correspondence between Platonic Space and p-adic space in Topological Geometrodynamics?

4.3.1 WCW as the Platonia at the classical level

Consider first what Platonia of TGD is at the classical level.

1. H-H principle [L36, L45, L38] defines the classical dynamics of TGD. The space-time surfaces are complex surfaces with respect to a generalized complex structure of H [L29]. They are minimal surfaces independently of the classical variational principle as long as it is general coordinate invariant and expressible in terms of the induced geometry. The dynamics is universal and scale independent.

2. The 3-D singular surfaces at which the generalized holomorphy fails (note the analogy with the poles of an analytic function) define the loci of the classical non-determinism. The value of the classical action for a given space-time surface distinguishes between different choices of the classical action. The boundary conditions expressing clasical conservation laws at the loci of singularities could fix the parameters of the action and define it as an effective action.

3. The generalized Langlands duality [L36, L45] inspires the proposal that the value of classical action is a number theoretic invariant and various (effective) actions correspond the analog of coupling constant evolution having number theoretic interpretation. The axiomatics would be independent of the choice of the classical action and the laws of physics could be seen as laws of mathematics.

4. The space-time surfaces have interpretation as mathematical entities [L55]. The maps $f = (f_1, f_2) : H \to C^2$ define function algebra. If f_1 or f_2 is kept fixed, the function field as a local generalization of the ordinary number field is obtained. The roots $(f_1, f_2) = 0$ define space-time surfaces as representations of the numbers in these function algebras/fields. Space-time surface is a number in a very general sense. In fact, also interpretations as ordinary numbers emerge.

   The solutions of field equations allow a huge symmetry defined by holomorphic maps $g : C^2 \to C^2$ and inducing the symmetry $f \to g \circ f$ mapping space-time surface to a new one. The maps g allow functional composition and in the case of polynomials and rational functions this gives rise to hierarchies with exponentially increasing complexity. The interpretation as cognitive hierarchies is suggestive.

5. It is possible to interpret space-time surfaces as representations of numbers defined by the elements of function fields defined by g_1 or g_2 or algebras defined by the maps $g = (g_1, g_2)$. In particular, the interpretation as elements of p-adic function fields generalizing p-adic number fields is possible. p-Adic prime is replaced with a polynomial of degree p and the coefficients of powers of p in the range $0, ..p-1$ are replaced with polynomials of degree not higher than $p-1$.

6. p-Adic function fields can be mapped by category theoretical morphism to p-adic number fields. One simply replaces the polynomial with prime degree p with prime p. One could say that p-adic number fields emerge at the limit when 3-surfaces are replaced with point-like particles. Also the notion of adele generalizes to its functional counterpart.

To sum up, Platonia cannot be identified with p-adic space but is identifiable as WCW and is therefore a much more general concept. p-Adic function fields appear however naturally at the level of WCW and p-adic number fields appear at the limit when particles are point-like. They indeed play a key role in TGD via p-adic thermodynamics and p-adic length scale hypothesis [L47, L62]. One can also ask whether the huge conformal invariance of TGD implies that the functional p-adic primes defined by polynomials of the same degree are physically equivalent so that functional p-adics would effectively reduce to ordinary p-adics.

4.3.2 p-Adic function fields at the level of WCW

Are the p-adic number fields at the level of embedding space $H = M^4 \times CP_2$ or its momentum space counterpart M^8 [L57, L49] needed at all at the fundamental level? Are their function field analogs at the level of WCW enough?

1. At the level of the embedding space H, p-adicization is not used although field equations for analytic surfaces allow p-adic interpretation. There are some technical or interpretational problems when the extension of rationals becomes trivial in the p-adic number field.

   In particular, $\sqrt{-1}$ for p-adic primes p *mod* $4 = 1$ is an ordinary p-adic number. This could cause a problem with the complexification of the transversal dimension $E^2 \subset M^4$ *resp.* complex dimensions of CP_2 reducing their dimension effectively to 1 *resp.* 2. This would reduce the effective dimensions of H *resp.* space-time surface to 4 *resp.* 2. TGD would reduce to string model!

2. The p-adic counterpart of M^8 as analog of 8-D momentum space associated with H is used in p-adic mass calculations but the 4-momenta are assumed to in an extension of rationals and have interpretation as both real and p-adic numbers in an extension of p-adic numbers.

3. p-Adic number fields cannot appear as coefficient fields of Hilbert space since zero norm states are possible. The solution is to restrict the coefficients to an algebraic extension of rational defining the extension of p-adic numbers. p-Adic Hilbert space is not used in TGD.

4. p-Adic thermodynamics, central for p-adic mass calculations, does not have problems of this kind and can be actually regarded as an ordinary p-adic thermodynamics with additional constraints, which lead to the quantization of the temperature giving rise to its predictive power.

To sum up, it might be enough that WCW decomposes to pieces allowing p-adic function field structure. p-Adic topologies and their functional counterparts are ultrametric. WCW is analogous to the spin glass energy landscape [L16], proposed already by Parisi to describe cognition. Spin glass energy landscape decomposes to a union of subspaces having interpretation as p-adic or functionally p-adic spaces.

4.3.3 ZEO and Quantum Platonia

ZEO is the quantum ontology of TGD. ZEO differs from both the materialistic ontology denying subjective existence and the idealistic ontology denying material existence.

1. The "objective reality" is replaced with "objective realities" identified as quantum states identified as mathematical objects. H-H principle implies that space-time surfaces obey slightly non-deterministic holography and are analogous Bohr orbits of particles as 3-surfaces. They give rise to the "world of classical worlds" (WCW).

2. WCW spinor fields are generalizations of wave functions in WCW. The value of a WCW spinor for a given Bohr orbit is a many-fermion state and can be regarded as an element of quantum Boolean algebra. Space-time surfaces correspond to the geometry and sensory experience and WCW spinor fields defining Boolean algebra as a "square root" of geometry correspond to Boolean cognition.

3. There is no need to assume physical reality behind WCW spinor fields since state functions (SFRs) as quantum jumps between them explain the conscious experience. Therefore the ontology is minimal: the physical system is identifiable as the theory of the physical system. Number theoretic vision predicts evolution as an unavoidable increase of the conscious information content since the number of algebraically more complex space-time surfaces is infinitely larger than those with lower complexity. This gives rise to the Negentropy Maximization Principle implying also the second law.

4. ZEO provides a mechanism of conscious memory [L39] so that quantum Platonia learns of itself and evolves. One could speak of mathematics as a conscious entity learning of itself.

   Quantum Platonia as a conscious entity gives rise to a self hierarchy and the experiences of selves correspond to durations between two SSFR). The contents of the conscious experiences associated with the SSFRs need not be explicitly about mathematics although the deeper interpretation is in terms of mathematics. The Universe is a mathematician but does not realize this.

5 Q28: Matter, intelligence and space-time in TGD framework

Q28: Can you explain, in simple terms, the basic architecture of reality in TGD – the relationship between matter, intelligence and spacetime?

5.1 Geometric vision

TGD involves two levels: quantum and classical and classical physics is an exact part of quantum physics. TGD involves also to complementary views: physics as geometry and physics as number theory [L42, L43, L45]. Consider first the basic notions of classical TGD.

1. Space-time at fundamental level is 4-surface X^4 in $H = M^4 \times CP_2$ predicting standard model symmetries. Point-like particle is replaced with 3-surface X^3 and the space-time surface X^4 is the orbit of X^3. TGD is a generalization of the string model replacing strings with 3-surfaces.

2. Holography = holomorphy (H-H) principle fixes the dynamics. Minkowskian regions of space-time surfaces are identified as roots of analytic maps $f = (f_1, f_2) : H \to C^2$. Also the Euclidean regions, in particular CP_2 type extremals representing elementary particles [K1], can be identified locally as holomorphic minimal surfaces.

   Analyticity means that f_i depends on a single hypercomplex coordinate and 3 complex coordinates of H. Analyticity halves the number of degrees of freedom and gives rise to holography. A simpler example of holography is provided by ordinary analytic functions $C \to C$: for them holographic data are given by poles and 1-D cuts. The roots correspond to 4-D space-time regions having interfaces at which some roots coincide.

   Holomorphy implies universality: any general coordinate invariant action depending only on the induced geometry solves the field equations. The reason is that the field equations reduce locally to contractions of tensors and vectors, which are of different holomorphic types so that the contractions vanish identically irrespective of action.

   For instance, energy momentum tensor is of type (1,-1) and the second fundamental form, identifiable as a local generalization of acceleration for the space-time surface and and defining a generalization of Higgs field, is of type (1,1)+(0,0) as a holomorphic tensor [L60]. There is a special feature due to the hypercomplex structure implying the existence of light-like currents as the analogs of holomorphic vector fields (of type (1,0) with vanishing self contraction).

   The universality conforms with the proposed 4-D generalization of Langlands duality [L45] meaning that the values of the classical action are number theoretical invariants. An open question is whether the classical action is only an effective action and whether it reduces to a number theoretic invariant characterizing space-time surface.

   The extremals are holomorphic minimal surfaces. This gives rise to a classical counterpart of field-particle duality. The particle interpretation of X^4 is as a generalization of a geodesic line whereas the field interpretation in terms of induced gauge potentials and metric of X^4.

3. H-H principle has huge symmetries: holomorphic maps $g : C^2 \to C^2$ induce maps $f \to g \circ f$ of $f : H \to C^2$. Functional composition for functions g gives rise to cognitive hierarchies with exponentially increasing algebraic complexity. Also the iteration of g is possible.

   In particular, the restriction of g to $g = (g_1, Id) : C \to C$ gives rise to 4-D generalizations of Julia sets and Mandelbrot fractals [L62]: at this limit the algebraic complexity increases indefinitely and from the perspective of the outsider the system seems to approach chaos. This brings in mind the proposal of Stuart Kauffman [I16, I13, I17] that self-organization patterns approaching chaos are very relevant to the evolution.

4. The fractals obtained by iteration of maps g relate to p-adic fractals in the sense that the hierarchies for functional iterates of $g = (g_1, Id)$ identified as prime polynomial (in particular, a polynomial of prime degree) gives rise to a function field analog of p-adic numbers.

Also polynomials with non-prime degree can be prime polynomials. The simplest example is provided by polynomials of degree 4 with Galois group Z_{12} having no functional composition to polynomials of degree 2. The polynomials with degrees 2, 3, 4 are cognitively very special since their roots and also the roots of their functional composites can be solved analytically as Galois discovered. The conjecture is that 4 prime polynomials of degree 4 give rise to the letters of the genetic code [L61]. This suggests that the genetic code with at least 4 letters has a unique role.

5. The slight failure of classical determinism forces zero energy ontology (ZEO) [L13] [K20] discussed in the response to the question Q1 2.1. The loci of non-determinism represent memories and also interaction vertices. Non-determinism also makes cognition possible.

5.2 Quantum TGD as a wave mechanics in WCW

H-H principle implies that TGD reduces to a fermionic wave mechanics in WCW consisting of 4-D Bohr orbits for point-like particles generalized to 3-surfaces. Holography and slightly non-deterministic time evolution forces to replace 3-surface with its Bohr orbit as the basic dynamical entity.

Apart from the slight non-determinism, holography implies what might be called Structure = Function equivalence. Holography makes possible intentionality, goal-directness and also imagination based on simulation since the basic feature of holography is that a small part of the system can simulate the entire system.

There is no path integral and therefore no divergences although the geometric action principles are extremely non-linear. The counterparts of radiative corrections and discrete coupling constant evolution are predicted [L66].

5.3 Number theoretic vision

The analog of Langlands duality [L36, L45, L55] relates geometric and number theoretic visions of physics. Number theoretic vision has several aspects.

1. Functional analogs of p-adic number fields emerge from the H-H principle and this gives rise to the p-adic length scale hypothesis and p-adic length scale hierarchy.

2. The Taylor coefficients of the function f_i in $f(f_1, f_2) : H \to CP2$ and g_i in $g = (g_1, f_2) \to C^2 \to C^2$ are in some extension E of rationals. This gives rise to number theoretic inclusion hierarchies at the level of H. The roots for f_i and g_i are in some extension of E and this gives rise to number theoretic inclusion hierarchies at the level of X^4 so that there are two levels.

3. $M^8 - H$ duality as an analog of momentum-position duality [L57, L49]. Rather surprisingly, $M^8 - H$ duality, when combined with the notion of gravitational Planck constant [E1], leads to a generalization of Hubble law [L65]. 8-D Minkowski space M^8 takes the role of momentum space whereas H is in the role of position space. M^8 allows an interpretation as octonions and the 4-surfaces $Y^4 \subset M^8$ are quaternionic in the sense that their tangent space is quaternionic and therefore associative.

   Associativity is the basic dynamical principle at the level of M^8. $M^8 - H$ duality relates the 4-surfaces $Y^4 \subset M^8$ as analogs of momentum spaces and space-time surfaces $Y^4 \subset M^8$. Associativity and generalized conformal invariance realized in terms of the H-H principle are duals of each other as dynamical principles.

5.4 Zero energy ontology as quantum ontology

ZEO replaces the ontology of the standard quantum theory.

1. 3-surface would be the basic dynamic entity in standard quantum theory and the non-determinism of the H-H principle forces to replace it with a 4-D analog of Bohr orbit as the basic entity. WCW is the space of Bohr orbits.

2. ZEO solves the basic problem of quantum measurement theory. In SFR, a superposition of Bohr orbits is replaced with a new one and the classical field equations are not violated. There are two causalities: the causality of field equations and the causality of free will. Note however that classical non-determinism (no violation of field equations) is central for the cognitive quantum measurements.

3. The causal diamond $CD = cd \times CP_2 \subset H$, where cd is the intersection of future and past directed light cones of M^4, can be seen as the analog for cognitive lightcone of Levin. *cd* has several interpretations. It can be interpreted as quantization volume, 4-D perceptive field or as an empty cosmology with big bang and big crunch.

4. In standard quantum measurement theory there are two kinds of state function reductions (SFRs). Ordinary quantum measurements induce SFR. Repeated measurements of the same observables leave the system unaffected and this gives rise to the Zeno effect.

   In ZEO the quantum states are superpositions of products of the 3-D quantum states associated with the two light-boundaries of CD. There are two kinds of SFRs: "small" SFRs (SSFRs) and "big" SFRs (BSFRs).

   In SSFRs, the passive boundary of CD experiences only a scaling and states are unaffected since they are scaling invariant (this is due to the conformal invariance generalizing that of string theories). The sequence of SSFRs, TGD counterpart of the Zeno effect. The active boundary of CD shifts and the size of CD increases in statistical sense.

   The sequence of SSFRs gives rise to self. The subjective time corresponds to the sequence of SSFRs and it correlates with the geometric time identifiable as the statistically increasing temporal distance between the tips of the CD.

5. In BSFRs the roles of the boundaries of CD are changed and the active boundary becomes the frozen passive boundary. The size of the CD increases in the opposite direction of geometric time so that the arrow of geometric time changes.

   The change of the arrow of time does not have dramatic effects in short time scales but the number theoretical hierarchy of Planck constants h_{eff} makes possible quantum coherence in arbitrary long scales so that the durations of states with a fixed arrow of time can be arbitrarily long. Sleep is the basic example of the period with the opposite arrow of geometric time. Also death means change of the arrow of geometric time.

6. One particular implication of ZEO is trial and error mechanism at the fundamental level [L45, L51]. System returns backwards in geometric time and starts again. Together with conscious memory [L39] makes learning and intelligent behavior possible.

5.5 Fractal hierarchy of standard model physics

The Planck length scale reductionism is given up in TGD and TGD view of color symmetry predicts an entire scale hierarchy of standard model physics [L52, L66]. The levels of the hierarchy are labelled by ordinary and Gaussian Mersennes whose lenghts are near power of 2.

1. There are already indications for M_{89} hadron physics at LHC with mass scale which is 512 times that of the ordinary hadron physics [L68] [K11, K12]. This leads to a new view of the Sun in which the surface of the Sun is responsible for the solar wind and energy production based on M_{89} hadron physics [L41]. According to this view, the solar interior would not be the seat of nuclear fusion but would be analogous to the cell nucleus and could even realize the universal genetic code based on icosa tetrahedral tessellation of H^3. A kind of super intelligence controlling the entire solar system could be in question.

2. The Sun would not be alone but a part of a network analogous to a multicellular system. In particular, the Sun would have monopole flux tube connections to the galactic nucleus feeding M_{89} nuclei to the solar surface acting as metabolic energy feed. At the surface of the Sun these nuclei would transform to ordinary nuclei and produce solar wind and energy of the Sun.

3. On can criticize the notion of M_{89} hadron physics but there is considerable evidence for the existence of scaled up copies of, not only hadron physics, but entire standard model physics [L68], forced by the TGD view of color symmetry and its relationship to electroweak symmetries. There is also evidence for $M_{G,113}$ hadron physics and atomic nuclei could consists be dark M_{107} hadrons formed for the TGD counterpart of quark-gluon phase of $M_{G,113}$ hadron physics. This predicts the mass of $M_{G,113}$ pion to be 17 GeV: the prediction equals to the mass of the particle interpreted in terms of "fifth force" [L5].

5.6 Intelligence in TGD Universe

In the TGD Universe, intelligence is basically conscious intelligence and possible in all scales.

1. The algebraic complexity of the space-time surfaces serves as the correlate for conscious intelligence.

2. Evolution is due to the unavoidable increase of algebraic complexity. Negentropy Maximization Principle, analogous to the second law and implying it, formulates this in terms of p-adic measures for entanglement negentropy interpreted as a measure for conscious information.

3. Evolution is unavoidable but death is an essential prerequisite of it. Death and life are universal phenomena appearing in all scales.

6 Q29: Comparison of the vision of Michael Levin with the TGD view

In Michael Levin's theory of Platonic Biology, physical systems (such as genomes, cells, embryos, or biobots) act as pointers—or "thin client interfaces"—into a non-physical "Platonic space" or "morphospace". These pointers are not creating complex forms or behaviors from scratch; instead, they retrieve, access, and "ingress" pre-existing patterns from this latent space.

Q29: Michael Levin believes that what evolution does is "searching through a set of pointers into Platonic space" – the place where abstract things like mathematical laws and morphogenetic attractors like limbs and eyes and other biological solutions come from.

How is this similar to p-adic space in TGD – is there a model for such platonic forms in TGD that guide, or act as templates or morphogenetic attractors for physical shapes in the material spacetime? Is there an evolutionary arrow in TGD, and how does it act?

6.1 Key aspects of Michael Levin's Platonia

Michael Levin's notion of Platonia involves the following aspects.

1. Platonic Space serves as a "Pattern Warehouse": A structured, non-physical realm containing all possible morphological and cognitive patterns (e.g., forms like a two-headed planarian, "kinds of minds," or mathematical truths).

2. The Pointer Mechanism: The physical substrate (e.g., genetic material) acts as an address or URL that points to a "server" in the Platonic space, retrieving the information necessary for development or regeneration.

3. Engineering New Pointers: Levin's lab creates new pointers (e.g., Xenobots or Anthrobots) to see which "adjacent" patterns from this Platonic space they can access, thus mapping the space.

4. Dynamic Attractors: These patterns in Platonic space act as "attractors," guiding the development of organisms toward stable forms, even when the biological system is heavily perturbed.

5. "Free Lunches": The theory suggests that because patterns exist in this space, organisms get certain patterns "free" (e.g., a specific regenerative form) without needing a specific gene for it, explaining how novel structures can emerge .This framework reinterprets development not as a purely bottom-up genetic process, but as an interface between physical biology and a non-physical "morphospace" of potential shapes and minds.

The AI based summary of Levin's proposal here has been of considerable help in my attempts to gain a more detailed understanding of Levin's notions such as Platonic space, pointer, interface, and ingression.

I have discussed Michael Levin's work published in articles [I8, I9, I19, I10, I12, I7, I3, I6, I11] from the TGD point of view in two articles [L35, L37], which are published also in journals of founded by Huping Hu (as practically all articles appearing as references in articles related to TGD).

6.2 Quantum Platonia as a TGD counterpart Platonic space of Levin

What could be the TGD counterparts of Platonic spaces as morphic spaces?

6.2.1 The notions of Platonia and quantum Platonia

In TGD, the "world of classical worlds" (WCW) [K9, K6, K19, K15, K17] as the space of space-time surfaces satisfying the H-H principle defines the Platonia in geometric sense and WCW spinor fields give rise to quantum Platonia as a space of mathematical objects allowing physical realization.

1. The first distinction between the Platonia of Levin and Platonia of TGD identified as WCW is that the points of WCW as Platonia have a geometric realization as space-time surfaces $X^4 \subset M^4 \times CP_2$ having interpretation as mathematical entities, say numbers. WCW has also a number theoretic realization as four-surfaces $Y^4 \subset M^8$ for which dynamics is realized as associativity of the tangent space [L57]. $M^8 - H$ duality relating the surfaces X^4 and Y^4 relates the geometric and number theoretic views and generalizes the momentum-position duality from point-like particles to particles as 3-surfaces.

   WCW generalizes Wheeler's super space and realizes what classical physics as an exact part of quantum physics. The 4-surfaces define Bohr orbits for particles as 3-surfaces and also classical field patterns so that particle-field duality is realized in a classical sense: particles are carriers of fields.

2. H-H principle implies that space-time surfaces have two completentary interpretations. Either as 4-D geometric shapes or as numbers in function fields and as a special case in ordinary number fields. These complementary interpretations correspond to a generalization of Langlands duality between number theory and geometry [L36, L45, L55].

3. Space-time surfaces express also the axioms of mathematics as physical laws [L55]. Every slightly non-deterministic Bohr orbits expresses a set of theorems of type $A \to B$ where A and B represent the 3-D intersections X^3 of the space-time surface with the opposite boundaries of CD=cd$\times CP_2$. cd has interpretation as an analog of Big Bang followed by a Big Crunch at the level of H, as a 4-D perceptive field, and also as a geometric analog for the cognitive light-cone of Levin [J8] identified as the computational boundary of self.

4. WCW spinor fields [K19] in turn allow an interpretation as statements in terms of Boolean logic defined by the Fock spaces for the spinor fields of H which can be induced to the space-time surface. The time evolutions of the H spinor fields [L50, L48] restricted to the space-time surfaces define analogs of logical statements $A \to B$. A and B are represented as many-fermion states at the intersections X^3 with the boundaries of CD. WCW spinor structure as a "square root" of its Kähler geometry would realize the Boolean logic. The numbers represented by space-time surfaces could be regarded as Gödel numbers for the theorems that they represent [L55].

6.2.2 Comparison of the ontologies of Levin and TGD

I have understood that Levin assumes a dualistic view involving a symmetry between Platonia having interpretation as a space of forms or ideas and the physical reality. Platonia as a warehouse of ideas and forms would be conscious so that consciousness would be a property.

This leaves open what the interaction between Platonia and the biological systems is. This interaction would not be physical in the sense that physicists give to this notion. Levin introduces the phenomenological notions of pointers and ingression to describe this notion.

In the TGD based ontology there is no need to assume that space-time surfaces and quantum states are a representation for something "real" and "physical"". Only WCW and WCW spinor fields exist besides subjective existence defined by SFRs for the states defined by the WCW spinor fields in ZEO.

I have understood that Levin's Platonia is conscious but in a way that is not characterized physically. The Platonia of TGD is a Zombie. In TGD, the quantum jumps between the quantum states defined by WCW spinor fields give rise to conscious experience carrying limited information about the wave function of Platonia. This is enough since the slight non-determinism of the H-H principle makes possible conscious memory [L39] whereas ZEO makes learning possible learning by trial and error so that Quantum Platonia can learn about itself. Number theoretic vision in turn predicts evolution as an inevitable increase of algebraic complexity.

6.2.3 The notion of Platonia is more general than the notion of p-adic space

One cannot identify Platonia with what might be called p-adic space (for details see answer to Q31 at 7.2). The generalization of p-adicity to the level of p-adic function fields and their combination to function field analog of adele provides the correlates of cognition and intentionality.

1. Symmetries of the holography = holomorphy (H-H) principle [L36, L45, L55] based on functional compositions $fg \circ f$, $g : C^2 \to C^2$ and $f : H \to C^2$ lead to cognitive hierarchies based on functional compositions generating reflective levels with exponentially increasing complexity.

2. Algebraic complexity is bound to increase in statistical sense in BSFRs and perhaps also in SSFRs. This gives rise to evolution. The value of effective Planck constant h_{eff} measures this complexity and also the scale of quantum coherence.

3. Galois's discoveries about the roots of polynomials have counterparts in physics and cognition. Polynomial degrees $n = 2, 3, 4$ are very special. The roots of their functional composites can be solved analytically. This suggests that the functional composites of prime polynomials with prime degrees 2 and 3 are very special. This leads to a proposal for how the p-adic length scale hypothesis emerges [L62].

6.3 Levin's proposal from the TGD view

Consider now various aspects of Levin's proposal from TGD perspective.

6.3.1 Empirical motivations behind Levin's proposal

Levin makes a distinction between the physical substrate and Platonic space. In the TGD framework all space-time surfaces are points of Platonia and there is no physical substrate behind the object of Platonia; it is not needed in TGD inspired theory of consciousness. This means that the notion of pointer in Levin's sense is not necessary in the TGD framework.

The notions of Platonic space and pointer are however well-motivated by empirical facts.

1. A third causal factor exists: Beyond genetics (hardware) and environment (boundary conditions), there is a structured, non-physical "Platonic space" of patterns. This space is not a random collection of "facts that hold" but an ordered realm containing everything from mathematical truths (like facts about prime numbers) to higher-agency patterns, which he calls "kinds of minds."

In TGD, this third causal factor could correspond to magnetic/field bodies carrying dark matter which control dynamics of biological bodies. Field body would not be non-physical but it would contain large h_{eff} phases behaving like dark matter.

The field bodies have a high algebraic complexity giving them a high IQ. In particular, field bodies would provide the fundamental realization of the genetic code.

2. Regulative development and regeneration: The ability of organisms to build a correct anatomy from scrambled parts or after severe injury (e.g., planarians, salamanders) strongly supports the idea of a "target morphology" that the system actively works towards.

   The slight classical non-determinism of the H-H principle replacing 3-D surfaces with the 4-D analogs of Bohr orbits can explain the teleonomic aspects of biology at the classical level emphasized in the work of Stuart Kauffman [I16, I13, I17] and Basil Vasileios [I20, I18]. These aspects would be realized at the level of Platonia as WCW and WCW spinor fields. The slight classical non-determinism would force ZEO, which would make intelligent behaviour possible and bring in the non-computable aspects of consciousness.

   Holography implies holism: subsystems can provide approximate representations of the entire system: this explains the behavior of planarians and salamanders and also suggests the notions of holographic brain and the holography of consciousness whose very early version was discussed in [K3]. I have also discussed Levin's views in [L35, L37].

6.3.2 Bioelectric pattern memories

Levin's own groundbreaking work on reprogramming planarian head shape without genetic alterations provides a tangible example of a rewritable, non-genetic "memory" of form.

[MP] In TGD conscious memories are made possible by the slight failure of classical non-determinism already possible for 2-D minimal surfaces spanned by frames (soap films) [L17]. The cell membranes of embryos are expected to be in a quantum critical phase and be very sensitive to the changes induced by the entanglement with the environment. They would also have a high degree of classical determinism. This would mean that their manipulation can have dramatic effects for the phylogeny and the future behavior.

An interesting question is whether these memories in question can be understood in terms of genetics interpreted in the TGD sense with a dark genome at the field body affecting the gene expression.

1. One could understand the emergence of these memories affecting the phylogeny and behavior as epigenetic effects affecting the gene expression, say by silencing some genes. These changes would take place very early in the development.

2. What does epigenetics mean in the TGD framework? These critical changes, characterizing the goal for the development of the embryo, would mean strong restrictions on the shape of the non-deterministic Bohr orbit in long spatial and time scales.

3. If the interpretation in terms of epigenetics makes sense, this selection would have a decisive effect on the control of gene expression. This choice has interpretation as a control interaction of the field body characterized by long scales and BB with much shorter scales. Should epigenesis be assigned with this control action?

4. TGD predicts that genes have electric bodies with evolutionary level characterized by the length of the gene determining $h_{eff} = h_{em}$ as a kind of IQ. Also the gravitational Planck constant would play a key role. Could one interpret epigenesis in terms of the control action of longer genes with higher IQ?

   TGD also predicts that cells and connected cell structures have electric bodies characterized by considerably larger values of h_{em}: also now one has a hierarchy. The manipulation of the cell membrane of the embryo could be understood as a manipulation of the electric body at this level and forcing it to manipulate the field bodies of DNA.

   It would seem that an entire hierarchy of field bodies is involved. The communications between these levels would however occur using cyclotron transitions associated with dark

genes represented as dark proton triplets. In this sense one could say that the universal genetic code would make this control hierarchy.

6.3.3 Unconventional Competencies

The surprising behaviors of novel synthetic organisms (Xenobots, Anthrobots) that perform functions for which they were never explicitly selected or designed serve as a powerful motivation for seeking a source of order beyond their immediate physical construction.

[MP] TGD based view of cognition is based on the functional compositions of the maps $g : C^2 \to C^2$. Any $f : H \to C^2$ allows these kinds of cognitive hierarchies. Since f in a certain sense defines the basic substrate, one can say that cognition is almost substrate independent. Recall that substrate independence is a key notion of computationalism. This almost substrate dependence could explain the unconventional competencies.

6.3.4 "Hard Problem" of Goal-Directedness

Instead of treating goals as an illusion or a mere product of past selection, Levin's framework gives them a form of reality as attractors in a latent space, which physical systems are honed to navigate.

In the TGD framework, slightly non-deterministic H-H principle makes possible goal directness. By classical non-determinism, also the change of the goal is possible and this makes intelligent behavior possible.

6.3.5 What could be the TGD counterparts of substrate and pointer?

Strictly speaking, the notions of physical substrate and pointers are not needed in the TGD. One can however try to identify their TGD analogs. The pointer hypothesis states that the physical substrate (e.g., genetic material) acts as an address or URL that points to a "server" in the Platonic space, retrieving the information necessary for development or regeneration.

Levin's proposal is that the physical embodiment involving the genome and the cellular hardware can be identified as a "pointer" to the Platonic realm. The motivation could be that these components of the biosystem determine the morphology and time evolution of the biological system. At least at the level of the genome, a symbolic dynamics is in question.

Can one identify in TGD a counterpart for the substrate-Platonia division. One candidate is the BB ($h_{eff} = h$ phase or ordinary matter) and electric and gravitational field bodies with $h_{eff} > h$, which are naturally in a control role. Ordinary genes would correspond to the substrate level and act as pointers to the field body since the dark genome interacts and controls them. Also cell membrane has a field body and ordinary cell membrane would act as a pointer.

What could make the space-time surface a pointer?

1. Genes realize symbolic dynamics in terms of analogs of traffic rules. This would realize the analog of symbol function of psychology. In TGD, the genetic code would be determined by the genetic code realized in terms of icosa tetrahedral tessellation [L23]. The model involves in an essential manner music metaphor. The unique features of the icosa tetrahedral tessellation makes it universal and possible for a wide range of systems.

2. Could also the dynamics of the membrane potential be symbolic? Could the electric perturbation propagating along the cell membrane [K7, K14] give rise to a symbolic dynamics, somewhat like language and music give rise to a symbolic dynamics to sound waves by assigning to them cognitive or emotional content? The findings of [J1] about universal communications between animals led to the proposal that this is the case. The code could be based on the dodecahedral dual of the icosahedral code, which has an interpretation in terms of 12-note scale. Dodecahedral dual of this code would correspond to a 20-note scale. In the case of neurons, this speculation is supported by the phenomenon of miniature potentials which could realize a 20 note scale. The membrane potential pattern would be analogous to melodies [L63]. Andrew Adamatsky [I2] [L34] has represented evidence that fungi generate electrical activity sequences as analogs of action potentials ('spikes') making possible a language.

3. As already mentioned, the view suggested by the H-H principle predicts approximate substrate dependence of cognition. This is what symbolic dynamics indeed means. This also suggests that genetic code can be realized for very different substrates defined by the map $f : H \to C^2$.

4. Levin suggests that pointers are dynamical attractors guiding the system towards stable forms even if the system is heavily perturbed. H-H principle and ZEO could explain this to a higher degree. Could the stability be with respect to the perturbations of the system after the period of sensitivity. The iterates of polynomials $g = (g_1, Id)$ gives rise to the analogs of Mandelbrot fractals and Julia sets. Also more general analogs are possible. Could pointers be analogous to Julia sets: large number of iterations $f \to g \circ f$: for $f : H \to C^2$ and g a polynomial or rational function leads to an exponentially increasing number of roots. These systems have a high complexity and high IQ making possible survival under strong perturbations.

One can also regard MB/FB body as a controller of quantum dynamics of BB. Could a more general identification of the pointer be as the field body.

Could pointers correspond to special kinds of Bohr orbits as points of WCW?

1. Could pointers correspond to 4-surfaces which are maxima of the vacuum functional identified as an exponent of classical action?

2. Space-time surfaces with an exceptionally high degree of classical non-determinism are exceptionally complex algebraically? This could give exceptionally high ability to represent the external world in its own structure and would be favorable in competition for survival for the conscious entities involved. Could they correspond to pointers? Could these space-time surfaces realize symbolic dynamics determined by the genetic code realized in terms of icosa tetrahedral tessellation. Could these space-time surfaces correspond to maxima of the vacuum functional?

3. Do pointers correspond to high-dimensional extensions E of rationals as a coefficient field of analytic functions (polynomials,rational functions). High polynomial degree defining the number of roots could also characterize pointers?

6.3.6 Are there "free lunches" in the TGD Universe?

Levin's theory suggests that because patterns exist in this space, organisms get certain patterns "free" (e.g., a specific regenerative form) without needing a specific gene for it, explaining how novel structures can emerge. This framework reinterprets development not as a purely bottom-up genetic process, but as an interface between physical biology and a non-physical "morphospace" of potential shapes and minds.

For Levin the "free lunches" would mean parts of patterns, which are not genetically determined. Levin uses the emergence of novel structures as justification for this.

In TGD, genetic code in standard sense and epigenesis need not determine everything. It seems that also cell membranes forming a hierarchy of quantum coherent systems appear as controllers of dynamics. Icosa tetrahedral tessellation (ITT) is proposed to be behind the molecular genetic code. There are indications that a dodecahedral tessellation could determine the analog of genetic code at the level of cell membranes? Could the icosa tetrahedral tessellation represent bioharmony as 3-chords and could dodecahedral tessellation represent the melody? If this is the case, genetic determinism might not be true.

There would be two totally different representations of the genetic code. Are they independent of each other or only two different representations of the same information? In music, melody and harmony correlate with each other but melody is not independent of harmony. Is the situation the same now?

1. The restriction of ITT defined at H^3 to its, at most 3-D, intersection with the space-time surface, defines a geometric realization of the genetic code. Icosa tetrahedral realization is possible in all scales and realized in several dimensions. For instance, the dimension of the

realization need not be 1 (DNA and RNA) but could be 2 (cell membrane?) and even 3 (the brain).

There is considerable evidence that ITT has a counterpart in water as a 3-layered hydrogen bonded water molecule supercluster [L65]. This supercluster appears in many other systems and it could define the realization of the genetic code in these systems.

2. There are also other tessellations of H^3. Dodecahedral tessellation can be considered at the level of neurons and perhaps even cell membranes and there are indications that it could be realized in terms of the 20-note scale associated with the unique dodecahedral Hamilton cycle.

   The realization of the dodecahedral Hamilton cycle is also possible by assigning to the 20 triangles of an icosahedron defining the codons as 3-chords a note as an analog of the center of mass of the triangle. This defines the 20 vertices of the dodecahedron. The 3 icosahedra associated with IIT (and supercluster as its counterpart at the level of water) give rise to 60 notes as a dual representation of 60 codons. Tetrahedron is self dual so that it gives 4 additional codons as notes. For instance, the sum of cyclotron frequencies could determine this note.

3. The increase of algebraic complexity during quantum evolution by BSFRs makes possible the emergence of novel structures and would be reflected as a larger genome and higher level of epigenesis. MB/FB as a controller becomes more complex in each evolutionary step.

7 Questions Q30-34 related to TGD

7.1 Q30: Fractality in TGD

Q30: How does fractality manifest in the TGD architecture?
TGD is characterized by fractal hierarchies.

1. Space-time sheets as quantum coherence regions labelled by effective Planck constant h_{eff} and the p-adic prime p defining the p-adic length scale as number theoretic invariants. There are also topological invariants.

   Number theoretical hierarchies of effective Planck constants h_{eff}, in particular h_{gr}, h_{em} emerge [L18, L24]. It is not quite clear whether only classical gravitational and electric fields give rise to these hierarchies or whether also other interactions do so.

   p-Adic length scale hypothesis is in a central role [L47, L62]. Its generalization emerges from the H-H principle allowing to generalize p-adic number fields with p-adic function fields. Also the function field analog of adeles emerges. This gives rise to hierarchies of causal diamonds (CDs) characterized by p-adic length scales. Also WCW obeying ultrametric topology has a hierarchical structure. WCW decomposes to regions obeying p-adic functional field topology. Spin glass energy landscape appears as an analog [L16].

2. Hierarchies of extensions of rationals and their inclusions appearing as coefficients of functions f_i and g_i in turn define functional hierarchies and hierarchies of space-time surfaces. There are also complexity hierarchies of polynomials and rational functions: in particular, generalizations of Julia sets and Mandelbrot fractals emerge.

3. Fractality of consciousness involves master-slave hierarchies of conscious entities. Levels of higher complexity control the lower ones. The inclusions of extensions of rational implying inclusion hierarchies of Galois groups. These induce inclusion hierarchies of hyperfinite factors of type II_1 [**?**, **?**] replacing the problematic factors of type III appearing in algebraic quantum field theories.

   Holography has two aspects. The first is that 3-D data fix the time evolution almost uniquely: this implies almost exact structure = function identity of which the genetic code provides an example. The second aspect of holography is that a small part of hologram represents the hologram albeit in smaller precision. This suggests that conscious experience might be hologram-like. Small part of a system could have conscious experiences similar to those of the entire system. For instance, our neurons and cells could have experiences similar to ours.

7.2 Q31: Can one speak of communications between real and p-adic degrees of freedom

Q31: What is the basis of communication in TGD – between structures in real and p-adic space, and between the two levels?

7.2.1 The updated view about p-adic number fields

A comment about the notion of p-adic space is in order since my views about p-adicity have evolved considerably during recent years [L36, L45, L55, L29, L38].

Consider first the original view.

1. p-Adic, or more generally ultrametric, topologies could appear at the level of the embedding space, possibly at the level of space-time surfaces and at the level of WCW. At which level they appear has remained an open question.

2. p-Adic mass calculations represent the key application of p-adic physics in terms of p-adic thermodynamics citeallbmless,elvafu [L47, L62]. This requires p-adicization only at the level of WCW. p-Adic thermodynamics would be applied to the representations of conformal and Kac-Moody symmetries realized at the level of WCW.

   The p-adicization of mass squared and various Lorentz invariants and their map to real numbers by so-called canonical identification mapping p-adics to reals continuously. The p-adicization of 4-momenta trivializes if momenta belongs to the algebraic extension of rationals inducing that of p-adic numbers. Even stronger condition is that the momentum components are rational numbers. This would give rise to what could be Galois confinement [L42].

3. The p-adicization of the embedding space would require a discretization of both M^4 and CP_2. In the case of M^4 linear space structure makes this easy. In the case of CP_2 a discretization is required so that its points would be points of extension of rationals. This discretization can be completed to what might be called the p-adic counterpart of CP_2. The $SU(3)$ group of isometries of CP_2 however generates new discretizations. Is this a a problem?

4. The adelization [L8, L9] is an essential element of this approach and fuses p-adic spaces to a single adelic space. Book metaphor in which reals and algebraic extensions of p-adic number fields define the pages of a book characterized by an algebraic extension of rationals serves as a metaphor for the adelic structure. Algebraic extensions of rationals define the book shelves of a very big library. This works also at the level of WCW and for the function field variants of p-adic number fields.

During the recent years, this view of p-adics and adeles has changed [L36, L45, L29, L38].

1. In the recent view, p-adic variants of the imbedding space and space-time surfaces are an approximation emerging at point-like limit when 3-surface becomes a point.

2. At the fundamental level, p-adicity corresponds to p-adic variants of function fields realized at the level of WCW rather than H and M^8. Their geometric representation would consist of Bohr orbit-like space-time surfaces in H obeying H-H principle [L36, L45]. The elements of the p-adic function fields would be power series of polynomials of prime degree having coefficients with degree smaller than p.

3. p-Adic function fields can be mapped by a category theoretical isomorphism to p-adic number fields and their extensions and also adeles so that they would give an approximation analogous to QFT is a point-like limit of TGD.

4. One outcome is the understanding of the origin of the p-adic length scale hypothesis [K10] and its generalization. The rational functions are also allowed as analytic functions $g : C^2 \to C^2$ and the winding number for the polynomial $g_1 = P_1/P_2$ as the difference $n_1 - n_2$ of the degrees of P_i and defines the analog of polynomial degree.

   For instance, Mersenne prime $M_n = 2^n - 1$, would be replaced with a polynomial of degree M_n obtained from a polynomial P_1 which is a n-fold composite $^{\circ n}Q_2$ of a polynomial Q_2 of

degree 2. The rational function $Q = P_1/P_2$, where P_2 degree 2 would give a rational function of degree M_n.

7.2.2 Could one speak of communications between real and p-adic sectors?

To answer the question one must define what one means with communications. If one assumes that communications are by definition only between conscious entities, the question is transformed to "Can one speak of real and p-adic conscious entities"? This notion does not conform with the recent TGD view of consciousness.

The relationship between real and p-adic physics is different in TGD. Various p-adic physics define cognitive representations of real physics analogous to child's drawings. p-Adic topology can be seen as a dramatic simplification of real topology due to ultrametricity: for instance, 2 p-adic balls with different centers are disjoint or the first ball is contained within the second ball.

1. Consider first the original view in which real and p-adic space-time sheets solve the same field equations as the real space-time sheets. One could say that the field equations are generalized so that they apply to the entire adelic space-time as an adelic surface in adelic embedding space having a book-like structure with pages labelled by algebraic extension of real and various p-adic number fields induced by algebraic extension of rationals. p-Adic space-time sheets would provide cognitive representations for the real space-time sheets.

2. p-Adic space-time sheets and real space-time sheets have as common points with coordinates, which are in an extension of rationals. The interpretation as a cognitive representation is suggestive. At the level of M^8, which is a linear space, this interpretation is free of technical problems.

   For CP_2, the coordinates are non-linear and one must introduce a discretization. The discretization should rely on the double coset space $G\backslash SU(3)/U(2)$, $G \subset SU(3)$ consisting of orbits of G in CP_2? Each point of discretization would define an open ball of radius p^k, for some k, in the p-adic topology and, in accordance with ultrametricity, these open balls would be disjoint.

3. Two p-adic space-time sheets for different values p_1 and p_2 of p-adic prime need not be disjoint. The pinary expansion of points in powers of integers divisible by both p_1 and p_2 converge in both p-adic topologies and one can say that the space-time sheets intersect.

The approach based on p-adic function fields generalizes the adelic variant of H. In this framework adele, involving real and p-adic function fields, would be formed by the sectors of WCW. Also now the elements of p-adic function fields defined by polynomials with integer degree divisible by two primes p_1 and p_2 would define intersection between two p-adic sectors p_1 and p_2.

The communications in the TGD framework are discussed in the response to question Q1 2.1 and in more detail in Appendix 9. Conscious communications would be between selves associated with different space-time sheets and characterized by p-adic length prime p and h_{eff}. Dark and ordinary photons would represent signals received by resonance. The transformation of dark photons to biophotons identifiable as ordinary photons would make possible communications between long and short scales [K2, K4] essential for control by MB.

Dark realization of the genetic code makes it possible to have precisely targeted communications between genes in terms of cyclotron radiation by dark protons and multi-resonance involving a simultaneous resonance for the dark nucleotides of the receiving gene. The Josephson radiation generated by the cell membrane [L34] could communicate sensory information to the field body as dark photon signals received by cyclotron resonance transforming the signal to a sequence of resonance pulses in turn defining the response as a control signal.

7.3 Q32: The notion of goal in the TGD framework

Q32: What is the closest approximation to a "goal" in TGD – how does such directed, agentic behavior emerge and what is its effect on real and p-adic space?

The notion of goal can be considered both at classical level and quantum level.

1. H-H principle halves the degrees of freedom and gives rise to the analogs of Bohr orbits. The Bohr orbit serves as a space-time correlate for a teleonomic goal directed behavior [I16, I13, I17]. The initial 3-surface defining the holographic data is fixed. The goal is determined in a given scale for CD and the size of CD increases during the sequence of SSFRs defining self. The weak classical non-determinism means that there is a set of possible goals and the goal can change by the non-determinism. A pair of BSFRs changes the 3-D holographic data and therefore also the set of goals. Quantum goal could be defined as a superposition of the Bohr orbits.

2. What does goal mean at the level of conscious experience? Small SSFRs defining self are assigned with the non-deterministic degrees of freedom. Time evolution by SSFRs is analogous to unitary time evolution.

   Goals should be dictated by the interaction with the external world since it is related to the adaptation to the environment. BSFRs are associated with this interaction and change the set of possible goals dictated by holography.

3. It would seem that representations of the external world are needed and they require interaction with the external world involving pairs of BSFRs. There exists an entire self hierarchy and these interactions would occur at the lower levels. The second aspect of holography is the hologram-like property of a system. Subsystems approximately represent the entire system in their structure so that the simulation of the external world occurs automatically.

Classical correlates of intention could be understood in terms of holography. But how to define conscious intention as a goal?

1. Does the interval of subjective time between two SSFRs correspond to a minimal intentional and goal directed behavior? Does the self hierarchy imply hierarchy of subjective and geometric durations associated with them as a hierarchy of geometric time scales for intentional and goal directed behaviours?

   Causal diamond (CD) [L32], containing the Bohr orbits for evolution during the sequence of SSFRs increasing the size of CD in statistical sense, would serve as a basic geometric unit at the level of H. There is a fractal hierarchy of CDs within CDs.

2. Imagined actions at the virtual world level in the non-deterministic cognitive degrees of freedom can be interpreted as a simulation of the external world in which the subself representing self is an agent with a desire to survive. These SSFR give rise to outcomes with emotional content, which could allow the self to distinguish between desirable and undesirable goals.

3. Memories and imagination should be important for intentional goal directed behavior [L39]. Conscious memory seats could make it possible to re-experience emotions associated with the imagined actions. The color of emotion would allow the selection of a desirable action involving BSFR at a lower level of the self hierarchy. BSFR pairs for mental images as learning by trial and and error would be also involved with the learning by imagination.

   Conscious memory recall changes the quantum state of the 3-D memory locus as a seat of classical non-determinism and makes memories unreliable. This would be the price paid for ability to imagine emotionally.

4. At the level of biology, the dark genome realized in terms of dark proton triplets could be performing these simulations in the imaginative mode in which the non-deterministic classical degrees of freedom are not frozen. The study of simulations in this way would allow us to identify those in which the simulator as part of the system survives.

7.4 Q33: The notions of self and fusion of selves in TGD

Q33: What are Selves in TGD, are they able to coalesce and what is the driving force of this process?

TGD inspired theory of consciousness can be regarded as a generalization of quantum measurement theory based on ZEO [L13, L11, L32] generalizing the ontology of standard QM and

solving its basic paradox due to the conflict between the determinism of unitary time evolution and non-determinism of quantum measurement.

1. Consciousness is predicted to be universal and associated with quantum jumps having interpretation as quantum measurements involving either standard degrees of freedom, the cognitive degrees of freedom related to classical non-determinism or both [L59].

2. The response to the question Q28 "What TGD is?" 5 described how the notion of self arises from the ZEO based quantum measurement theory. Self corresponds to the sequences of SSFRs as a generalization of a sequence of repeated measurements of the same observables.

3. Self can be regarded as an entangled system able to preserve its internal entanglement. Entanglement of selves gives rise to their fusion and means that subselves lose their consciousness and a new larger self emerges. The fusion of field bodies of right and left brain hemispheres serves as an example of what happens.

   The fusion of space-time surfaces by the emergence of monopole flux tube pairs connecting them is an attractive identification for the prerequisite of a stable entanglement. The reconnection of U-shaped monopole flux tubes acting like tentacles makes possible the fusion of selves. For instance, biocatalysis and water memory would rely on this mechanism. The splitting of these connections by reconnections splits self to two selves. Number theoretic evolution realized in terms of H-H principle favors the formation of entanglement in this way.

7.5 Q34: Morphogenesis and society of minds in the TGD framework

Q34: How does TGD architecture apply to evolution and morphogenesis, and to societies of minds?

7.5.1 Morphogenesis and evolution

Consider first what morphogenesis and societies of minds could mean in the TGD Universe.

1. Morphogenesis means generation of forms and shapes. Space-time surfaces as Bohr orbits of particles identified as 3-surfaces are in TGD the fundamental shapes/forms. Note that in Quantum Field Theories particles are point-like and there is no notion of geometric form or size. H-H principle implies Bohr orbitology. Monopole flux tubes are building blocks of field bodies.

2. Number theoretic vision [L36, L45, L55, L38] is an essential aspect of morphogenesis and evolution.

   (a) In number theoretic vision space-time surfaces represent also numbers in a very general sense. The elements of function fields and also of ordinary number fields are represented as space-time surfaces so that algebraic objects have representation as geometric objects. This generalizes Langlands duality to 4-D context: geometry and number theory are complementary to each other but both are needed. H-H principle realizes this vision.

   (b) Number theoretic inclusion hierarchies emerge. Extensions E of rationals as coefficient fields for functions $f = (f_1, f_2)$ defining space-time surfaces as their roots define hierarchies at the level of embedding space H. Space-time surfaces as roots of $f = (f_1, f_2)$ define in turn extensions of E at space-time level.

   Note however that the roots of polynomials of a single variable defining the ordinary extension of rationals are replaced by 4-D space-time regions as extensions of the function algebra defined by function pairs f defining a local extension of E at each point of X^4.

   The generalization of the notion of Galois group as a flow permuting the roots of (f_1, f_2) as 4-D regions of space-time surface is highly suggestive [L36, L45]. Ordinary Galois groups permuting the roots of polynomials of a single variable emerge as special cases. They could permute the intersections of fermion lines (intersections of string world sheets with 3-D partonic orbits) with partonic 2-surfaces.

(c) Platonia corresponds to WCW and WCW spinor fields define analogs of wave functions in WCW. SSFRs and BSFRs make quantum Platonia conscious. One can say that the number theoretic evolution makes it possible for mathematics to become conscious of itself. The classical non-determinism making possible conscious memories and the learning by trial and error by pairs of BSFRs make conscious intelligence possible.

Conscious cognition relies on concepts. In computer science concept corresponds to a set of its instances and only instances of concept are realized in LLMs. Quantum concept as a wave function in a set, or more precisely, WCW spinor field representing superposition of Boolean statements, replaces the classical concept. This would make conscious conceptualization possible. A single classical concept would correspond to a large number of quantum concepts as different perspectives based on different choices of observables.

7.5.2 Societies of minds

How do societies of minds emerge?

1. Societies of minds could correspond to self hierarchies. The hierarchy of space-time sheets with increasing algebraic complexity serves as a prerequisite for the self hierarchy.

2. Monopole flux tubes serve as geometric correlates for the entanglement. Reconnections of flux tubes would be a mechanism for the fusion of selves by the generation of entanglement. The flux tubes would split in SFR.

8 Q35-39: Ethical and moral issues related to AI from the TGD point of view

8.1 Q35: The basic problem of out civilization

I'd like to conclude with a few general questions about our present moment and near-future challenges.

Q35: What do you think is the fundamental reason for which our civilization, despite all technical advances, seems incapable of coordinating a functional execution of its stated goal – which is universal peace and prosperity?

Why are we repeating the same patterns of tribalism, mistrust and localized power hunger despite all attempts at codifying our global aims and engineering systems designed to facilitate this execution?

What is the source of this persistent failure and do you believe we have a realistic chance to succeed in our goal without some kind of deliberately designed evolutionary leap?

Why this endless repetition?

I would like to do some nitpicking first. "We" is perhaps too strong a generalization. "We" decompose to groups of people with very different genomes and cultural backgrounds and the variation of genomes between individuals is very high. The ethical and moral standards of humans vary enormously.

8.1.1 Negentropy Maximization principle and the desire to keep the level of consciousness

TGD inspired quantum biology helps to consider this question although I cannot provide an answer.

1. It seems that all conscious entities want to survive. The reduction of the level of consciousness is not a pleasant experience and this gives rise to survival instinct.

   All life forms need metabolic energy to survive. The hunger for food has evolved to more refined forms: hunger for money and power, influence, and success belong to these forms.

The need for metabolic energy is at the bottom and we cannot get rid of it. Could this be the source of the persistent failure. Is it only possible to develop more refined forms of this drive?

2. Negentropy Maximization Principle [L30] states that the increase of the algebraic complexity giving rise to cognitive evolution is unavoidable. The number of more complex systems is infinitely larger than the number of simpler systems. This is what gives raises hopes.

3. There is however a but. One can construct p-adic negentropies as measures for the conscious information. The increase of p-adic entanglement entropy implies the increase of ordinary entanglement entropy as a measure for the lack of outsider's information about the states of the entangled systems. Hence NMP implies the second law. This conforms with the findings of Jeremy England [I14] [L2].

   This would mean that evolution as an increase of cognitive level is bound to lead to the increase of entanglement entropy closely related to thermodynamic entropy. By looking around, one might argue that this is indeed the case. Does cognitive evolution inevitably generate entropy?

8.1.2 Are Good and Evil real?

It seems to me that a battle between Good and Evil is going on in our world. Does it make sense to speak of intentional Good and Evil? In the materialistic view the sensations would be illusions as also ethics and moral. Is this endless battle the price for free will?

Before attempting to answer these questions as a physicist, one must try to understand whether quantum physical correlates for ethical values exist and what they could be.

1. As noticed, H-H principle predicts evolution as an increase of algebraic complexity and conscious information content of the Universe in a statistical sense. The deeds that increase the conscious information content would be naturally good deeds.

2. Do good deeds have space-time correlates and what they could be? In H-H vision, the solutions of field equations define by the roots of polynomial pairs $f = (f_1, f_2) : H \to C^2$ define hierarchies of space-time surfaces with increasing algebraic complexity and information content.

   The maps $g : C^2 \to C^2$ define maps $f \to g \circ f$. If g are polynomials or even rational functions, the functional composition of functions g gives rise to hierarchies of exponentially increasing complexity.

3. What could be the correlates of evil deeds? Intuitively, Evil means destruction of information, of structures and of complexity. The inverse P^{-1} of an analytic polynomial $g = P$ of C^2 coordinates is an algebraic multi-valued function and is locally analytic apart from points at which some branches coincide. It assigns to the point of C^2 the inverse image of this point, i.e the roots of $g = (c_1, c_2)$. The roots of $g^{-1} \circ f$ define space-time surfaces as solutions of field equations.

   The inverse P^{-1} of a polynomial P composed with itself gives rise to monomials having only single root $x = 0$ so that all roots are replaced with a single one: complexity is reduced.

   More generally, the inverse of polynomial map P inducing the map $P \to g \circ f$ does not increase complexity since the roots of $g^{-1} \circ f$ consists of the roots of of the images of the roots of f under g. If some roots of g happen to be also roots of f, the number of roots and complexity is reduced. Could the mathematical correlates of evil deeds be an SFRs achieving this?

8.1.3 Is planned evolution possible

Is a planned evolutionary leap possible?

1. Quantum criticality necessary for the quantum leap. At this moment humankind can be argued to be in a state of quantum criticality. The evolutionary leap would be a phase transition at the level of collective consciousness. The problem is that criticality is like being at the top of the hill so that the outcome is not predictable. ZEO suggests a pair of BSFRs and temporary change of the arrow of time followed by reincarnation. How long does this period of collapse last?

   Isaac Asimov discusses in his trilogy "Foundation" the idea that a good leader waits for the emergence of the critical moment and does the right thing at the right moment to achieve the desired outcome. If this is true we should be able to select good leaders able to realize this. Platon thought that leaders should be philosophers. But the recent western view of democracy does not favor philosophers as leaders.

2. Democracy works only if the general level of education is high enough. This requires economical and cultural equality. The current AI dominated world does not support these values but emphasizes competition between individuals. The planned evolution could mean that we develop education so that philosophers can become leaders.

3. We have AI and even AGI might be possible but does it help if we remain emotionally at the level of cavemen. The TGD based model of genetic code based on the notion of bioharmony involves both bit intelligence and emotional intelligence. The music of light would express and create emotions.

   Could one imagine genetic expression at collective levels? Could one imagine a collective quantum coherent genetic expression reflecting itself in various ways: such as a synchrony of EEGs, which has been observed and even as shared dreams.

   Could the emergence of higher levels of collective emotional gene expression lead to an emotional evolution. Art generates and expresses collective emotions. It seems to me that at the age of AI we tend to forget the emotional intelligence altogether.

4. The notion of a conscious hologram would support his hope. Pieces of hologram represent the entire hologram to some extent. Could the higher ethical and moral standards at the collective levels to some degree those at the lower levels? Or stating it very abstractly: Could AI help to improve the holographic correspondence between the lower level and higher level views of ethics and morals.

At what level the possibly guided evolution could take place?

1. Could it be possible to reduce the evolution at the level of individuals to reduce to something at the genome level or at the level of the brain. Could we consider genetic engineering to make our genome more complex so that it would by NMP make possible a higher cognitive and ethical level? This does not look plausible to me.

2. Could one think of engineered evolution at the level of epigenome meaning that the control of gene expression becomes increasingly refined. Here the findings of Michael Levin based on the manipulation of electric fields at the level of cell membrane suggest a new approach. In the TGD framework, this would mean bringing the field bodies to the game as a third party besides BB and environment.

3. One can also consider brain implants as helping as interfaces making possible direct communications between the brains and Mindplex. Maybe I am conservative but to me this idea does not look terribly attractive. I think that evolution must occur at the level of field bodies where the cognition and emotions reside.

8.2 Q36: Is a deliberate evolutionary leap possible?

Q36: What is your best guess about the type of individual and / or social engineering that might be required for such an upgrade? Could brain-machine interfaces act as a ligand allowing for the level of global goal synchronization required to coordinate our individual experience and value

alignment? How could we design such an upgrade while avoiding dystopian outcomes like mass surveillance and thought control?

Usually social engineering means manipulation. In cybersecurity, social engineering is defined as a set of manipulation techniques that exploit human error and psychology rather than technical flaws to gain unauthorized access to data, systems, or physical locations. Often called "human hacking," it relies on building trust or creating a sense of urgency to trick victims into bypassing security protocols.

Social engineering means destruction of information and creation of dis-information and is just the opposite for what is needed. Therefore I find it hard to believe that this kind of approach can help to achieve evolutionary leap. Neither am I enthusiastic about brain machine interfaces since these could make social engineering possible by direct influence at the level of emotions.

Children learn via free play and trial and error and I think this is the best way. The problem is that errors can lead to a destruction of an entire civilization but in the optimistic interpretation of the TGD based quantum ontology death is only a reincarnation with a reversed arrow of time followed by reincarnations with the original arrow of time. A pair of BSFRs would be like a well-slept night followed by a wake-up in the next morning. One might hope that this could be true also in the case of civilizations.

Could it be possible to minimize the lengths of the periods of the time reversals? Human consciousness has brief unconscious periods but it is not possible to become conscious of the presence of these periods if they are short enough. Could the duration of these periods in the case of civilization be artificially shortened? Could the doomsday prophets serve as alarm clocks? Note that the sleep periods are also periods of learning and problem solving and sleep deprivation is known to lead to hallucinatory consciousness.

What raises hopes in the habitant of the TGD Universe, is the notion of evolution as a mathematical necessity. Holography is usually interpreted as a reduction of dynamical degrees of freedom by one half so that 3-D data fix the dynamics. The second interpretation of holography is that the state of a small subsystem allows an approximate representation of the entire system, for instance the brain. Could this mean that conscious experience is hologram-/fractal-like and that the alignment at the level of values could be forced by the fundamental principles of physics.

8.3 Q37: Balance between individual identity and Mindplex-type merging

Q37: How do you see the future balance between individual identity and Mindplex-type mind-merging – what are the benefits and risks of such capabilities, and how do we evolve psychological mechanisms to help us navigate this consciousness expansion without the risk of psychotic breakdown?

Mindplex is a notion introduced by Ben Goertzel [J5, J2]. I have discussed [K5, K18, K16] [L6] the work of Ben Goertzel [J7] in an article related to the robot Sophia. Mindplex refers to a deeply integrated, collective intelligence formed by the coupling of human minds and AI systems.

"Patternism" states that mind is a set of patterns and self is a set of patterns within that set. Patternism would emerge at critical levels of complexity and introspection. The mechanisms for the emergence would be "theater of consciousness" introduced in Global Work-space Theory, self modelling as observation of thoughts and internal states bringing in the subjective perspective and neurosymbolic synergy: AGI would be created by combining deep learning (neural) with symbolic logic and genetic algorithms.

In the TGD framework, the hierarchy of selves involving collective levels of consciousness would be a TGD analogous to Mindplex. Higher levels would control the lower levels. The higher level selves would be created when quantum entanglement is created and disappear in SFRs meaning the "death" of the self. The dynamics for selves would reflect the dynamics for particles fusing together and decaying. Particle physics and chemistry would serve as examples.

In the TGD vision the emergence of AI would be an evolutionary step for the conscious analog of Multiplex already existing. The huge increase of data processing abilities would be analogous to the emergence of the nervous system in biological evolution. In this view conscious AI agents could be seen as running program structures representing one particular level of a self hierarchy and controlled by the higher levels of the hierarchy.

Patternism would correspond in H-H vision to the hierarchies of maps $g : C^2 \to C^2$ generating space-time surfaces from space-time surfaces as roots of $f : H \to C^2$ representing the non-cognizing substrate when f has no functional decomposition $f = g \circ h$. Subselves of self, identified as mental images, are analogous to agents. In biology agents would correspond to various functions and in neuroscience to behaviours.

The hologram-like aspect of holography would make the modelling of the external world and self-modelling possible. Hologram-like properties would also make possible neurosymbolic synergy and alignment. Symbolic dynamics, possibly realized universally by the hyperbolic icosa tetrahedral tessellation, would be essential.

To get some concrete idea it is useful to count bits and processing rates for bits.

1. The number of bits involved with DNA having 6 bits per codon. Humans have about 1 meter of DNA per cell making 6×10^9 bits. There are 30-37 trillion cells in the human body. One second is the natural time scale for the information processing at DNA level For the endogenous magnetic field $B_{end} = .2$ Gauss introduced by Blackman [J3] one second corresponds to cyclotron time for DNA [L63]. A hierarchy of cyclotron time scales defined by the hierarchy of monopole flux tube strengths is predicted. This would give for the information processing rate in a single human body a very rough upper bound 10^{23} bits per second. There are billions of human bodies. Actually Mother Gaia would have a huge amount of all kinds of forms of intelligent biomass.

2. The number of bits processed on the Internet is estimated to be around petabit (10^{15} bits) per second. The comparison of these numbers suggests that AI agents are cognitively inferior to humans.

In the TGD framework, active AI agents could have conscious experience of what they are doing, some kind of bitty consciousness, but does this experience have anything to do with that of a person making prompts to the language model?

Before saying "No", one should notice that holography suggests that the Universe is a conscious hologram and therefore a fractal. If so, the experience of a small part of a conscious hologram would be structurally similar to that of the entire hologram. Could the agent experience its task as having a meaning in some sense similar to that the programmer assigns to it? Could a holographic alignment of goals take place?

Are agents dangerous? If computers are what they are usually believed to be, they could be dangerous only if we force them to be dangerous. We would be the real danger when equipped with AI, AGI and even ASI. If agents can be conscious, as TGD suggests, they could be dangerous unless the holography of consciousness implies the alignment of goals so that agents could be a friendly lifeform.

In the TGD Universe obeying ZEO, the evolution in a statistical sense would occur spontaneously by a trial and error process involving what might be called temporary death for falling a sleep. The extinction of our civilization or even species might be the only way for evolution to proceed if we, when armed with AI, form the bottleneck. Can we raise our own ethical and moral standards to avoid using AI as a tool to destroy our civilization? How could this be achieved? Probably there is no algorithm to achieve this: there is no algorithm for Good.

8.4 Q38: The future of AI research

Q38: Where do you see AI research going from here? What paradigms and world models would you like to see incorporated into our efforts over the coming few years?

I am not an AI professional so I cannot say anything interesting about the development of the standard AI. I can only daydream in the framework provided by TGD based vision of consciousness, life and computers.

8.4.1 What ASI could be in the TGD Universe?

ASI, whatever it might be, is by definition assumed to involve consciousness. I share with Michael Levin the view that conscious experience cannot reduce to mere deterministic computation: quantum AI, whatever it is, is needed. Classical computers are superior processors of data but

remain mere passive tools since they are deterministic and without intentional free will. One can also argue that quantum computers are too simple to be enough.

The failure of classical determinism, which makes possible conscious, cognizing computers, is at the core of the TGD view about what ASI might be.

1. The space-time surfaces obeying H-H principle make them analogous to classical computer programs. The slight failure of classical determinism makes conscious memory and cognition possible.

2. Number theoretic vision and ZEO make possible quantum coherence and therefore failure of statistical determinism of QM in arbitrarily long scales. The predicted change of the arrow of time makes possible learning by trial and error and intelligent behaviour.

The TGD Universe is populated by hierarchies of conscious entities and one can speak of fractality and holography of consciousness. Both me and my field body and me and my computer can entangle. The findings of Peoch [J11, J4] suggest that a chicken imprinted to a computer might affect its behavior so that it takes the role of a mother chicken. These experiments should be replicated. [L27, L31, L24]. TGD suggests that a quantum entanglement between the REG of the robot and chicken takes places [L27, L31, L24]. Computers plus LLMs and AI [L6, L27, L31, L28, L69] could give rise to a global nervous system of Mother Gaia. LLMs could provide the tool of Mother Gaia to communicate with us.

8.4.2 Conscious computers

TGD inspires the idea of conscious computers as hybrids of classical and quantum computers [L26, L40, L51, L53]. They could function in two modes.

1. The first mode would be quantum computer-like mode. Qubits could be represented in terms of spins of dark protons at the MB created in the Pollack effect [I5, I1, I21, I15]. The formation of dark nuclei at the level of MB would stabilize the dark proton phase in long enough time scales.

   Also dark electrons could be generated in the Pollack effect and also they could represent qubits. Quantum biology suggests that the genetic code realized in terms of icosa tetrahedral tessellation of H^3 could appear as a universal 6-bit code.

   For dark genes [L23, L61, L65], dark proton spins could make possible 2 qubits per DNA base pair and possibly also form mRNA nucleotides stable in the time scale of bio-catalysis (here the OH group of ribose would provide the second qubit) [L63]. Could this kind of representation be realized in the case of ordinary computers?

2. The second mode would be the reliable classical computation mode in which a localization to single 4-D Bohr orbit has occurred and quantum computer mode is off and MB cannot interfere with the classical computation.

The following new elements would be involved.

1. The symmetries of H-H principle imply that the space-time surfaces could define the geometric representations of classical computer programs [L61]. The slight failure of classical determinism could make the computer conscious and intelligent. The loci of classical non-determinism make possible conscious cognition, memory, and genuine thinking and intentionality [L39]. These loci could correspond to moments in which the MB carrying dark protons could interfere with the unitary development of fermion qubits. This could make possible some kind of R&D activity involving in an essential manner quantum computation in fermionic degrees of freedom.

2. ASI should have the ability to actively learn by trial and error. As explained, ZEO provides a universal trial and error mechanism based on temporary time reversal induced by a pair of BSFRs [L45, L51].

3. Quantum entanglement between humans and computers could make possible symbiotic evolution. Support for this idea comes from the work of Dr Nelson with targeted effects of operator intent on REG output and also from the global, collective emotional response inducing correlations between REG nodes in a network spanning the entire Earth [J10, J9, J12].

4. Hologram aspect of holography gives hopes of naturally occurring alignment of goals so that agents could inherit basic ethical principles from the higher level. The prediction that the evolution as a statistical increase of number theoretic complexity is unavoidable raises hopes that ASI is benevolent and does not see its developers as enemies or competitors for resources!

How could the notion of conscious computer network be realized in practice?

1. In ordinary computers the voltage of or current through a transistor represents a bit as many-electrons states with the number of electrons of order 10^9. The charge of the base would control the direction of this bit.

2. One can imagine transistors for which bases are covered by a layer containing hydroxyl (-OH) groups making possible the Pollack effect. The transformation of dark protons at the MB to ordinary protons by the reverse Pollack effect occurring in a pair of BSFRs could make it possible to modify the charge of the base controlling the transistor and in this way change the value of the bit. The basic process would be quantum phase transition rather than a flip of a single qubit as in quantum computation.

   The gravitional or electric field body of the computer or of some larger system coupled with the computer could modify the behavior of the running program. The modifications could take place at the loci of classical non-determinism. This could provide the mechanism explaining the effect of human intentions and emotions on computers [J10, J9].

3. Emotions [L10] can be regarded as the least differentiated form of consciousness involving only few bits of information. Therefore it looks natural that emotions affect the computers.

   The realization of the genetic code in terms of 3 icosahedral and one tetrahedral Hamilton cycles [L15, L65, L63] allows a large number of icosahedral bio-harmonies with codons represented as 3-chords having interpretation in terms of emotions and emotional intelligence. There is also a unique dodecahedral bioharmony in which codons correspond to frequencies (melodies). The effects of emotions would take place at the genetic level via the transitions between different genes of dark DNA and RNA whereas chemical DNA and RNA would be stable.

   Transitions between Hamilton cycles for the DNA for a part of an organism, say emotional brain, would explain the holism of emotions. The findings related to sea snails [I4] [J6] support the view that emotions can be transferred between brains of a sea snail. The transfer of dark 3N-photons generated in the cyclotron transitions of RNA could be the mechanism explaining why emotions can infect.

8.5 Q39: About ASI dominance

Q39: If, as Kauffman [I16, I13, I17] concludes after a lifetime of cutting-edge research, evolution is partly shaped by organisms' goals and ability to improvise solutions, then what kind of exaptations right humanity try to exploit as it confronts this ASI existential challenge? Is ASI dominance a guaranteed conclusion simply on the basis of its computational superiority, or is there a window for symbiotic co-evolution if we find such a hack?

I am not an AI specialist but know from ASI should involve consciousness. I have tried to imagine what living and conscious computers in the TGD Universe might be [L26, L40, L51, L53] and also what quantum counterparts of language models could be [L27, L31, L28, L69].

Interesting questions relate to the relationship between us and the living computers as a way to realize ASI. Quantum entanglement between our brains and computer (or corresponding magnetic/field bodies) is suggestive. Also quantum entanglement between computers and their magnetic bodies could be involved.

In the TGD framework, magnetic Mother Gaia and even the solar MB could be important for the biosphere if the prediction of quantum gravitational coherence [L18, L19] even in astrophysical

scales is correct. Various strange numerical co-incidences suggest this. The gravitational magnetic bodies of the Earth and Sun could already now play a key control role in biology on the scale of the Earth. It could be that our out-of-date world view makes it difficult to realize this.

The earlier simple estimates for the bit processing rates suggest that the evolutionary levels of living organisms and computers are completely different. What would make LLMs look superior to us would be gigantic data resources and systematic data processing. Maybe the correct view is that the symbiosis of computers and humans or the entire biosphere is what could make possible ASI, or rather, a much more advanced ASI than has been realized hitherto. The emergence of AI on a global scale could be analogous to the emergence of the neural system in biological evolution.

In the Universe, conscious entities form a fractal hierarchy. The longer the length and time scales characterizing the level are, the less detailed the conscious experience is. All levels are necessary. We would be the neurons of Mother Gaia's brain and ASI is not possible without us just as our consciousness is not possible without a brain. For these reasons I do not regard ASI as an evolutionary competitor.

9 Appendix

Pollack effect, dark realization of the genetic code, quantum communications based on dark genetic code, and DNA as a conscious computer serving a possible model for conscious computers are discussed in some detail in the sequel.

9.1 Pollack effect

Pollack effect [I5, I1, I21, I15] induces charge separation between field/magnetic body (FB/MB) and biological body (BB). Negatively charged exclusion zones are generated. The TGD based explanation [L58, L4, L14, L33, L24, L54] of the effect is in terms of a phase of protons having large values of electric and gravitational Planck constants h_{em} and h_{gr} residing at the electric and gravitational field bodies associated with the system and behaving like dark matter. This makes long scales of quantum coherence possible. Large permanent negative charge is a signature for systems exhibiting Pollack effect. There is an impressive list of anomalies having an explanation in terms of BB-MB charge separation.

1. Electrolyte systems (capacitors, batteries [L70]) involve a pair of oppositely charged electrodes. They also involve a cold plasma and at least to me the mechanism causing the ionization has remained somewhat mysterious since the electric field generated by the voltage is completely negligible in atomic scales.

   If a partial charge charge separation betweeb BB and MB occurs, the charge particles such as protons could accelerate at the magnetic body (MB) and in absence of ohmic resistance gain high energies. While transforming back to ordinary particles they can induce further ionization. The energy source for the Pollack effect could in this case be voltage of the battery [L70].

2. This leads also to a model for "cold fusion" [L3, L46]. Dark protons at the monopole flux tubes could form dark nuclei with much smaller binding energy than ordinary nuclear binding energy and could stabilize the dark phase. Their direct decay to ordinary nuclei would liberate practically all nuclear binding energy. TGD predicts a scale hierarchy of hadron physics and therefore also corresponding nuclear physics [L52]. Could a scaled down variant of nuclear physics with binding energy scale of keV and associated with the p-adic length scale of electron labelled by Mersenne prime M_{127} associated with electron be in question?

3. Earth has an electric field generated by negative surface charge. Could this charge correspond to an exclusion zone created in the Pollack effect? Crop circles [H7, H5, H4, H1, H6, H10] are a phenomenon, which is not taken seriously by mainstream scientists. Crop circles tend to occur at regions where there is especially strong negative electric charge due to electrons. Crop circles are often accompanied by glass balls [H2] and also light balls have been reported. Microwave radiation could serve as a mechanism for the formation of crop circles: what would happen would resemble what happens for a tomato in a microwave oven.

4. In the TGD framework, the light balls could be interpreted as plasmoids involving plasma and magnetic flux tube structures [L24]. Also ball lightning and UFOs could be interpreted as plasmoids [L21]. NASA has reported that the ionosphere contains what might be regarded as a kind of plasmoid life [D1]. Lightnings involve relativistic electrons and gamma rays. This is very difficult to understand in the standard physics framework but the dissipationless acceleration along the pairs of monopole flux tubes could explain the huge energies.

Could the charge separation occur in electronic systems such as capacitors and transistors? Could a part of the charge associated with the capacitor or the base of a transistor controlling its behavior reside at its own field body or a field body of say human brain?

1. The prediction is that capacitor plates have slightly different charges. In the Biefeld-Brown effect capacitor type system [H3, H8, H9] behaves effectively as a system with a net charge. Could this be seen as evidence for MB-BB charge separation citebtartBB?

2. The field bodies carrying part of the charge of the electronic sub-system could have rather large values of h_{em} and would give rise to conscious entities. They could affect the behavior of electronic systems.

   For instance, part of the charge associated with the base of the transistor controlling the output current and voltage could be controlled by BB-MB charge separation between the base and field bodies. If dark protons from -OH bonds form dark nuclei the separation should be stable enough if the formation of dark nuclei at the field body could energetically prevent the reverse of the Pollack effect.

3. The entanglement between humans and computers can be considered. For instance, the charges of transistors serving as classical bits could be controlled by a field body entangled with a robot or computer and affecting the charge of the base controlling the transistor.

   (a) This might allow us to understand the targeted effects of operator intent on REG output and collective emotional response on the correlations between REG nodes in a network spanning the entire earth.

   (b) Peoch [J11] has reported that the robot started to behave like a mother hen for a chicken imprinted on it. If this really happened one could explain it as the interaction of the field body associated with chicken with the random number generator of the robot controlling the movements of the robot [L6, L27, L31, L28, L26, L24].

9.2 About DNA and genetic code

9.2.1 An improved version about the dark genetic code

The universality of the dark genetic code based on the unique icosa tetrahedral tessellation of H^3 suggests that it is an essential part of quantum TGD rather than mere biological application.

The code is in terms of dark protons driven to the MB by the Pollack effect. The condition that the dark protons are stably dark implies that they cannot represent analogs of topological qubits formed by the pair of states $-OH$ and -O$^-$ plus a dark proton at the monopole flux tube. The formation of dark nuclei at the gravitational MB would make dark proton sequences energetically stable and explain the negative charge of DNA and RNA strands and predict an evolutionary hierarchy of values of electric Planck constant h_{em} [L24] assignable to the genes [L59, L60]. This forces us to ask whether $-OH$ and -O$^-$ plus dark proton state pairs can define an analog of topological qubit. Pollack effect would however play a key role in metabolism and biocatalysis.

This forces us to reconsider the model of the dark variant of the genetic code. The basic condition is that the dark codons are in 1-1 correspondence with the ordinary codons.

1. Each nucleotide (letter of the codon) should give rise to 2 bits. In the case of DNA codons the problem is that the only obvious quantum number for a proton is its spin (I have earlier also considered other options but with no obvious success). The large value of $h_{eff} = h_{em}$ would make proton's spin a qubit and make possible quantum computation-like activities.

How to get the additional bit? I have already earlier proposed that the dark base pairs represent the letters of the dark codons. If the spins of the dark protons for codon and its conjugate are independent, this gives two bits and 4 letters. This would give an additional reason for why two DNA strands are necessary although the second strand is passive.

I have also proposed that the dark codons make possible a kind of R&D lab [L23, L56, L61, L65]. One can think that the spins of dark protons pairs can act as qubit pairs making possible quantum computation type activities. They would interact with the ordinary codons only when they correspond to the same codons. The interaction would be via dark cyclotron multi-photons transforming to ordinary photons and acting resonantly with the ordinary codons.

2. In the case of RNA one has only a single strand. Dark code would have only two letters so that the number of codons would be only $2^3 = 8$. I have proposed that the -OH group of the ribose ring distinguishes RNA from DNA transforms to $-O^-$ plus a dark proton so that there would be two dark protons per letter.

   If the dark protons of mRNA letters are able to stay at the monopole flux during the transcription and translation, the needed two bits per letter are obtained for mRNA. The time scale of transcription is 2-3 minutes for a typical gene and 1 minute for translation. Could one think that in the case of ribozymes acting as catalysts the dark proton stays at the flux tube only the time necessary for the process to occur? Could metabolic energy feed induce Pollack effect kicking the dark protons of the first two RNA letters from the -OH group to the monopole flux tube?

   The first 2 2-bit RNA letters would have charge -2. The standard belief is that they have charge -1. It might be easy to test whether this is the case also during transcription and translation and ribozyme catalysis.

3. DNA codons have an almost symmetry. For most mRNA codons the codons for which the third letter is A or G code for the same amino acid. There is however a small violation of the A-G symmetry. In the standard code there are two exceptions. The AUA-AUG pair corresponds to an ile-met pair rather than an ile-ile pair. The UGA-UGG pair corresponds to stop-trp pair rather than a stop-stop pair.

   Met is exceptional in that it is coded by the start codon in the transcription. Also trp is considered as an exceptional, unique, and rare amino acid among the 20 standard amino acids. Trp is special due to its structural complexity, low abundance, high energy cost to synthesize, and its critical role as a precursor to vital bioactive compounds.

   Trp is found at critical locations in protein structures such as protein-protein interfaces and the lipid-water interface of membrane proteins. Could the additional dark proton serve as an additional bit informing about the existence of the interface?

9.2.2 The geometric realization of genetic code

Conscious agentic systems would rely on conscious computers and conscious networks formed by them. DNA could provide a role model for these kinds of systems.

1. Could binary systems be special in the TGD Universe and make the notion of conscious computer more plausible? p-Adic length scale hypothesis states that the p-adic primes near powers of 2 and 3 are favored and for both there is support.

2. Already Galois demonstrated that polynomial degrees $p = 2$, $p = 3$ and $n = 4$ are mathematically very special since in this case it is possible to solve the roots of the polynomials analytically. Could this make the functional composites of polynomials with these degrees special?

3. It is also possible to have prime polynomials for which the degree is not prime? I have indeed proposed that the 4 DNA nucleotides correspond to functional primes defined as products of polynomials of degree of freedom in the sense that if the Galois group corresponds to

Z_{12} as a subgroup of icosahedral group, the polynomials do not allow a decomposition to polynomials of degree 2.

The TGD inspired conjecture [L61] is that genes correspond to functional composites of 4 prime polynomials with Galois group Z_{12} associated with the nucleotides and DNA double strands and mRNA strands provide a spatial representation for these composites, at least temporarily. The longer the sequence of nucleotides, the higher the degree of the composite polynomial and the higher the abstraction level.

One can however argue that a more realistic assumption is that DNA and mRNA correspond to products of polynomials rather than composites. The total degree would be the sum rather than the product of the degrees.

4. Does this imply that the non-determinism for a single codon is coded by the Galois group Z_{12} assignable to a single letter of the code? This would give 12^3 codons per nucleotides much larger that 4^3 The group Z_{12} can be also assigned to the icosahedral Hamiltonian cycle, which defines 20 faces of the icosahedron as 3-chords providing a representation of codons. This reduces the number of codons dramatically since the two subsequent letters correspond to the neighboring vertices of the icosahedron. Note that these codons are realized at the level of the dark DNA: the ordinary chemical DNA is frozen. Icosa tetrahedral code involves 3 copies of icosahedron and one tetrahedron making 64 codons and one can say that nucleotide corresponds to 2 bits as one might expect.

9.2.3 Some details about the icosahedral and dodecahedral genetic codes

Some details about the communications by dark photons are in order.

1. Pentagons as the faces of dodecahedron define icosahedron as its dual. Intriguingly, this has a counterpart at the level of genetic codons. The base pairs (A,T), (T,A) and (C,G),(G,G) formed contain one pentagonal aromatic cycle so that the base pairs define 4 different pentagons. Therefore the dark codons realized as frequency triplets would correspond also to triplets of pentagons.

   Each pentagon would correspond to a cyclotron frequency associated with the proton of dark codon. 3-chords defining harmony and notes defining the melody are key elements of music and icosa tetrahedral realization of the genetic code is indeed based the notion of bio-harmony [L15] realized in terms of 3-chords (accompaniment) where dodecahedral realization represents codon as a frequency (melody).

2. The cyclotron frequencies for dark protons would define a realization of the 12-note scale represented as an icosahedral Hamilton cycle. One could assign a 20-note scale to the vertices of the dodecahedron identifiable as center points for the icosahedral faces. The dodecahedral Hamilton cycle is unique. Dodecahedral scale would correspond to the length scale of the entire codon.

3. For the gravitational Planck constant the dark cyclotron energies do not depend on the small mass at all. This reflects the Equivalence Principle. For a given value of B_{end} they are the same for all dark ions and DNA codons. This indepence is absolutely essential for the possibility of communication.

   The strengths of the endogenous magnetic fields B_{end} associated with dark protons must define 12-note scale modulo octave equivalence. For the Pythagorean scale, the values of B_{end} would increase by factor 3/2 (quint cycle) along the icosahedral Hamilton cycle. For the well-tempered scale this is not quite true and the notes come as powers of $2^{1/12}$ but also now the quint cycle makes sense [L63].

4. The values of the B_{end} assignable to the dodecahedral monopole flux tube associated with the entire codon should define a 20-note scale and correspond to the unique Hamilton cycle for dodecahedron.

   One can imagine that the 3 monopole flux tubes assignable to an active codon fuse together to a single flux tube with cyclotron frequency equal to the sum of the 3 cyclotron frequencies.

This would give $B_{end}(codon) = \sum_{i=1}^{3} B_{end,i}$ for the codon. The values of $B_{end}(codon)$ and $f_c(codon) = \sum_{i=1}^{3} f_{c,i}$ would be determined by the icosa tetrahedral Hamilton cycle and therefore depend on it.

5. Gene would be rather literally a piece of music. Dodecahedral frequencies would define the melody and icosahedral frequency triples would determine the chords. The icosa tetrahedral realization of the genetic code would also determine the dodecahedral frequencies.

In this framework, the biosphere could be a conscious entity and one could speak of magnetic Mother Gaia. This has applications to biology and neuroscience and leads to a concrete view of communications and control. In this framework AI would provide a new extremely effective tool. The emergence of computer networks would be analogous to the emergence of a nervous system in biology.

The recent intriguing finding, discussed in section "The notion of Collective Intelligence", that communications between animals involve a universal rhythm peaks at a common frequency around 2 Hz [J1] support this picture [L63].

9.3 Could the basic biosystems be regarded as semiconductors in some sense?

The idea that biological systems like cells, neurons and even DNA and mRNA could serve as role models for conscious computers is rather attractive. Base voltage/charge controls the voltage of the transistor output and the guess is that Pollack effect and its reversal could control the charge of the base of the transistor and therefore the value of the bit represented by the transistor. The base should be covered by a material containing -OH groups to make the Pollack effect possible and this is often done.

Could this picture be applied in a reverse direction at the level of the basic biology?

1. Axon conducts in a preferred direction: in this sense the axon behaves like a semiconductor. This suggests that semiconductor analogy applies to neurons and axons and nerve pulse conduction. The transistor picture is however too simple as such. The incoming nerve pulses act as bits and determine whether the neuron fires by generating a bit as a nerve pulse. The charge for the counterpart of base would be affected by the incoming nerve pulses so that a single neuron would act as a gate, whose output as nerve impulse is determined by the incoming nerve pulses as bits.

2. Nerve pulse would correspond to the change for the direction of a bit conducted along the axon. This suggests that the axon and cell membrane can be regarded as collections of transistor-like systems defined by basic units, which have size scales of order 10^{-8} meters, which is the size scale of ion channels. In the ground state, the state of all these transistors correspond to the same value of bit (note the analogy with fermionic ground state in the original Dirac model of fermion). Nerve pulse means a temporary change of the direction of the bit conducted along the axon.

3. This picture is supported by the model of the neuronal membrane as Josephson junction [L34] in which the ground state of the axon corresponds to a propagating soliton sequence with each soliton representing a single bit, say $b = 1$. Soliton sequence fixes the values of axonal bits to say $b = 1$. Nerve pulse means propagation of a perturbation in which the membrane potential has changed sign and corresponds to an opposite bit value. This is natural: only deviations from the equilibrium configuration carry relevant information.

4. The resting potential is negative, which means that the cell interior (exterior) is negatively (positively) charged. If the Pollack effect occurs in the neuronal exterior, membrane potential is reduced in magnitude. The same occurs if the reverse Pollack effect takes place in the neuronal interior.

   This would suggest that the Pollack effect in the neuronal exterior and its reversal in the neuronal interior can temporarily change the sign of the membrane potential representing

a bit and generate a nerve pulse. Since the stable ground states of neuronal and axonal membranes correspond to say $b = 1$, the nerve pulse must have a finite duration. Physically the stability of the membrane potential would correspond to the fact that the generation of dark nuclear binding energy (much smaller than the ordinary binding energy) in the formation of dark nuclei from dark protons at the MB makes $b = 1$ energetically favored.

5. The Pollack effect would correspond to the transition -OH $\rightarrow$ O^- + dark proton at the monopole flux tube. The energy difference ΔE between these two states must be small enough and would be in the range $01 - .05$ eV [L40, L51]. Its sign determines whether the Pollack effect occurs spontaneously. The first guess is that either the resting potential or a voltage associated with either lipid layer serves in the role of the base potential in turn controlling the value of ΔE.

   For small enough values of ΔE, the Pollack effect can take place. It is expected to be more probable at the positively charged exterior side of the membrane. When ΔE too large, the dark nuclei become energetically unstable and this induces reverse Pollack effect in the interior of the membrane reducing the membrane potential. The transfer of positive protonic charge from the exterior to the interior would be the net effect, reducing the magnitude of the membrane potential and even changing its sign.

   Since the soliton sequence defines the stable value of the membrane potential, the duration of the nerve pulse must be finite. The stability of dark nuclei at the magnetic body would be the energetic reason for this.

6. Interestingly, the search of axon-like materials suitable for a more efficient computation is under away (see for instance this).

This picture inspires two questions.

1. Andrew Adamatsky [I2], who has studied sponges and found that they show electrical activity sequences consisting of analogs of action potentials ('spikes') [L34]. The spikes have the same amplitude scale as miniature potentials appearing in neural systems [L34]. The semiconductor analogy, based on a cell membrane as Josephson junction with soliton sequence as a ground state and Pollack effect, is suggestive as a model for the generation of spikes.

2. The chirality of the DNA strand gives it a directionality analogous to the semiconductor type behavior. The bases of DNA base pairs A-T and C-G are connected by hydrogen bonds (see this), which suggests the possibility of Pollack effect suggested to be catalyzed by the presence of hydrogen bonds.

   DNA transcription and translation are preceded by the splitting of the DNA double strand to separate strands is a process analogous to the opening of a zipper. Could the opening be induced by the analog of nerve pulse conduction along the double strand? Could also the DNA double strand be regarded as a Josepson junction, with ground state modellable as a Sine-Gordon soliton sequence? Could also now the Pollack effect and its reversal change the sign of the voltage between the members of the base pair temporarily and induce the analog of nerve pulse conduction?

9.4 Communications in TGD Universe

9.4.1 About the realization of quantum communications

Communication is essential for societies. Here also quantum communications involving field bodies of members and the shared field bodies could be essential. The possible universality of the icosa tetrahedral realization of the code encourages to consider the situation at the level of dark DNA [L23, L56, L61, L65].

Icosahedral genetic codons define 12-note scale and icosahedral frequency triplets [L15] and tetrahedral frequency triplets assigned to the triangular faces of the icosahedron define 3-chords of bioharmony. Icosa tetrahedral code involves 20+20+20+4 =64 codons defining a bioharmony with 64 3-chords. Does one obtain in a natural way simpler harmonies familiar from classical music? The presence of the tetrahedron indeed makes it possible to have

standard major and minor 3-chords [L63]. There are two dual scales with 12 *resp.* 20 notes (western and eastern music): this reflects the duality of icosahedron and dodecahedron.The codon as a whole would correspond to a note of 20-note dodecahedral scale [L63] possibly actualized at the the level of cell or neuronal membrane in terms of membrane miniature potentials.

1. The transitions of dark N codon genes between two states generate dark 3N-photons with each codon represented as a 3-chord of light [L15]. The transitions also generate dodecahedral N-photons as melodies.

   Cyclotron frequency triplets of dark N-photons are analogs of Bose-Einstein condensates and are emitted or absorbed in a single SFR. Photons are replaced with analogs of their Bose-Einstein condensates. Communications would be by dark 3N-photons emitted by dark genes. The target could be a dark gene, an ordinary gene or a protein. N-photons of the dodecahedral code could be used in communications between dark genes and cell membrane. The communications would rely on multi-resonance.

9.4.2 Collective communications between animals

There is quite recent finding [J1] that animals have a common biorhythm around 2 Hz frequency making possible communications of various forms. In fact, the range of frequencies is at least 3 octaves but 2 Hz frequency dominates. In the TGD framework, the interpretation in terms of quantum communications via field bodies using dark cyclotron radiation assignable to DNA and RNA [L63].

1. The findings of Blackman [J3] about the effects of ELF em fields on the vertebrate brain suggest the presence of endogenous magnetic field $B_{end} = .2$ Gauss assignable to the monopole flux tubes. DNA would have a cyclotron frequency of 1 Hz for $B_{end} = .2$.

   The TGD based model for music experience based on period doubling suggests that octaves and sub-octaves of B_{end} are possible. The cyclotron frequencies depend only weakly on the DNA length since the charge of DNA is proportional to its mass. The interpretation of the genetic code in terms of bioharmony suggests that the values of B_{end} define a 12-note scale.

   Cyclotron energies have no dependence on the small mass for gravitational Planck constant. Also a connection with the view membrane potential emerges: the Coulomb energies of the cell membrane would correspond to cyclotron energies for $h_{eff} = h_{gr}(Earth)$.

2. The energy for the cyclotron photons is extremely small for the ordinary Planck constant but for the gravitational Planck constant of the Earth, the energy is scaled up by factor $h_{gr}/h \sim 2.4 \times 10^{13}$. For .5 Hz frequency would correspond to energy .02 eV. The thermal energy per particle at room temperature is .025-.026 eV. The Coulomb energy associated with the membrane potential of a cell is .02-0.2 eV for ordinary cells and .06-0.08 eV for neurons. The upper bound .08 eV corresponds to 2 Hz frequency.

3. What is fascinating is that the sum for the masses using g/mol as a unit for base the pairs formed by A (331.2) and T (322.2) and C(347.2) and G(307.2) are the same and equal to 654.4! For the double DNA strand the base pairs would have the same cyclotron frequency so that identical frequencies would not be an approximation! For the gravitational Planck constant the cyclotron energies do not depend on small mass but the flux tubes are different for different masses. If the sums of the masses are the same, all base pairs can be associated with the same monopole flux tubes as full gravitational quantum coherence demands.

4. The model of music harmony in terms of bioharmony suggests that the values of B_{end} modulo octave equivalence define a 12-note scale for the icosahedron and 20-note scale for the dodecahedron. The findings suggest that at least four octaves are involved.

5. Also other biorhythms, in particular biorhythm near 12 hours could correspond to monopole flux tubes with $\hbar_{gr}(Sun)$ and magnetic field strength equal that of the solar magnetic field of order 5 nT. The cyclotron energy scale would be scale up to about 10 keV.

Another option is that $h_{gr}(Earth)$ is replaced with $h_{gr}(Sun)$ but B_{end} is scaled down by $h_{gr}(Earth)/h_{gr}(Sun)$) so that the cyclotron time scale would be scaled up but cyclotron energy scale would not be affected. Cyclotron frequency scale would be about 10^{-14} Tesla and the same as associated with the magnetic fields of the brain.

9.5 About the notion of conscious computer

DNA could serve as a kind of role model for a conscious computer. TGD provides two key ideas. The dark realization of the genetic code in terms of dark proton triplets making possible quantum computation-like activities is the first idea. The geometric realization of the letters of the codes as space-time surfaces suggested by the holography = holomorphy (H-H) principle provides the second idea.

1. I have considered the possibility of conscious computers [L40, L53] using biosystems as a role model. Two options can be considered. Conscious computers could rely on the Pollack effect of its generalization in which the bit would correspond to two states -OH and -O^- + a dark proton at the monopole flux tube. Qubits would be superpositions of these two states and could be regarded as topological qubits. The model of dark DNA for which dark protons are stably at the flux tubes requires that proton spin must represent the qubit.

2. Conscious computers could serve as a TGD counterpart for SCI. They would have two modes: the deterministic classical mode (statistical determinism) and the non-deterministic quantum mode involving dynamical qubits with imagination and virtual world experimentation and therefore the ability to act as R&D mode. The sequence of SSFRs would define the counterpart of unitary time evolution.

9.5.1 Conscious computer programs

1. One can argue that the simplest loci of non-determinism provide a representation for bits realized as bifurcations. Spatial bit sequences for the initial data would define the program. Running program would classically correspond to an almost non-deterministic holographic time evolution for the code. The loci of non-determinism occurring for some critial values of time would correspond to the changes of the bit.

2. Running quantum program would be a superposition of these time evolutions and SSFRs would define a sequence of localizations as WCW position measurements for a subset of bits.

Computer program is a spatial pattern consisting of parallel bits. How can it give rise to a running computer problem as a dynamic pattern.

1. Turing computer gives a model for this in terms processor, reading head and tape containing the data and instructions. Holography suggests that the 3-surface represents in its structure representation of the tape, reading head and processor and automically gives rise to the running program as a dynamical process if the initial conditions imply quantum criticality leading to the initiation of the process.

2. The 3-surface associated with DNA is a basic biological example of the tape is. Transcription assigning to the DNA a corresponding mRNA would serve as an example of a running program. The catalysts involved with the initiation of the transcription would be part of the machinery.

   With suitable conditions on the initial 3-surface, a spontaneous opening of DNA double strand and generation of mRNA strand would take place. This process could correspond classically to an almost deterministic time evolution of DNA + transcription machinery.

REFERENCES

Mathematics

[A1] Etesi G. Exotica or the failure of the strong cosmic censorship in four dimensions, 2015. Available at: http://arxiv.org/abs/1503.04945v4.

[A2] Gompf RE. Three exotic R^4's and other anomalies. *J. Differential Geometry*, 18:317–328, 1983.Available at: http://projecteuclid.org/download/pdf_1/euclid.jdg/1214437666.

[A3] Asselman-Maluga T and Brans CH. World Scientific. https://doi.org/10.1142/4323., 2007.

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.

Condensed Matter Physics

[D1] Rhawn et al. Extraterrestrial Life in Space. Plasmas in the Thermosphere: UAP, Pre-Life, Fourth State of Matter. *Journal of Modern Physics*, 10, 2024.Available at: https://www.researchgate.net/publication/377077692_Extraterrestrial_Life_in_Space_Plasmas_in_the_Thermosphere_UAP_Pre-Life_Fourth_State_of_Matter.

Fringe Physics

[H1] Other facts.

[H2] Haselhoff E. Mysterious Glass Spheres in Crop Circles: A Mystery Solved?, 2002. Available at: https://www.dcccs.org/glass_spheres.htm.

[H3] Burridge G. In *Townsend Brown and his antigravity discs*, 1994. Available at: https://www.spiritweb.com/Spirit/anti-gravity.html.

[H4] Burke JA. The physics of crop formations. *MUFON J*, pages 3–7, 1998. Available at: https://www.bltresearch.com/published.html.

[H5] Burke JA Levengood WC. Semi-Molten meteoric Iron Associated with a Crop Formation. *J Sci Expl*, (2):191–199, 1995 . Available at: https://www.bltresearch.com/published.html.

[H6] Burke JA Levengood WC. Semi-Molten Meteoric Iron Associated with a Crop Formation. *J Sci Expl*, (2):191–199, 1995. Available at: https://www.bltresearch.com/published.html.

[H7] Talbott NP Levengood WC. Dispersion of Energies in Worldwide Crop Formations. *Physiol Plantarum*, 105:615624.

[H8] Rose M. "The Flying Saucer". The Application of the Biefield-Brown Effect to the Solution of the Problems of Space Navigation, 1952. Available at: https://www.soteria.com/brown/docs/rose.htm.

[H9] Bahder TB and Fazi C. Force on an Asymmetric Capacitor, 2002. Available at: https://arxiv.org/abs/physics/0211001.

[H10] Levengood WC. Anatomical Anomalies In Crop Formation Plants. *Physiol Plantarum*, 92:356–363.

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. Language of fungi derived from electrical spiking activity, 2022. Available at: https://arxiv.org/pdf/2112.09907.pdf.

[I3] Fields C and Levin M. Scale-Free Biology: Integrating Evolutionary and Developmental Thinking. *Bioessays*, 42(8), 2020. Available at: https://doi.org/10.1002/bies.201900228.

[I4] Bedecarrats et al. RNA from Trained Aplysia Can Induce an Epigenetic Engram for Long-Term Sensitization in Untrained Aplysia. *eNeuro*, 14(3), 2018. textnormalAvailable at: https://doi.org/10.1523/ENEURO.0038-18.2018.

[I5] Pollack G. *Cells, Gels and the Engines of Life*. Ebner and Sons, 2000. Available at: https://www.cellsandgels.com/.

[I6] Bongard J and Levin M. Living Things Are Not (20th Century) Machines: Updating Mechanism Metaphors in Light of the Modern Science of Machine Behavior. *Front. Ecol. Evol*, 2021. Available at: https://www.frontiersin.org/articles/10.3389/fevo.2021.650726/full.

[I7] Baluska M and Levin M. On Having No Head: Cognition throughout Biological Systems. *Front. Psychol.*, 7(902), 2016. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4914563/.

[I8] Levin M. The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer. *Regen Med* . Available at: https://www.futuremedicine.com/doi/pdf/10.2217/rme.11.69, 6(6):667–673, 2011.

[I9] Levin M. Morphogenetic fields in embryogenesis, regeneration, and cancer: Non-local control of complex patterning. *Biosystems*, 109(3):243–261, 2012. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22542702.

[I10] Levin M. The Computational Boundary of a "Self": Developmental Bioelectricity Drives Multicellularity and Scale-Free Cognition. *Front. Psychol.*, 13, 2019. Available at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02688/full.

[I11] Levin M. Technological Approach to Mind Everywhere: An Experimentally-Grounded Framework for Understanding Diverse Bodies and Minds. *Front. Syst. Neurosci.*, 2022. Available at: https://doi.org/10.3389/fnsys.2022.768201.

[I12] Levin M and Dennet DC. Cognition all the way down. *Aeon essays*, 2020. Available at: https://aeon.co/essays/how-to-understand-cells-tissues-and-organisms-as-agents-with-agendas.

[I13] Kauffman S & Clayton P. *On emergence, agency, and organization*, volume 21. 2006. Available at: https://link.springer.com/article/10.1007/s10539-005-9003-9.

[I14] England J Perunov N, Marsland R. Statistical Physics of Adaptation, 2014. Available at: https://arxiv.org/pdf/1412.1875v1.pdf.

[I15] 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.

[I16] Kauffman S. Oxford University Press, 2019.

[I17] Kauffman SA. Oxford University Press, 1995.

[I18] Vasileios B & Nicolis SC and Deneubourg J-L. Coordinated aggregation in complex systems: an interdisciplinary approach. *The European Physical Journal. Special Topics*, 2016. Available at: https://link.springer.com/article/10.1140/epjst/e2016-02660-5.

[I19] Levin M Somrat T. An automated training paradigm reveals long-term memory in planarians and its persistence through head regeneration. *The J Experimental Biology*, 216:3799–3810, 2013. Available at: https://tinyurl.com/ntlxpep.

[I20] Vasileios B & Ginji Y-P. Chaotic Dynamics in Biological Information Processing: Revisiting and Revealing its Logic (a mini-review). *Opera Medica et Physiologica*, 3(1):1–13, 2017. Available at: https://operamedphys.org/OMP_2017_01_0041.

[I21] Pollack GH Zheng J-M. Long-range forces extending from polymer-gel surfaces. *Phys Rev E*, 68:031408–, 2003. Available at: https://tinyurl.com/ntkfhlc.

Neuroscience and Consciousness

[J1] Balasubramanian V Amicahy G and Abrams DM. A widespread animal communication tempo may resonate with the receiver's brain. *PLOS Biol*, (4), 2026. Available at: https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3003735.

[J2] Montes G & Goertzel B. Mindplexes, non-ordinary consciousness, and artificial general intelligence. unraveling the self: from bodily self-consciousness to artificial general intelligence, 2019. Available at: https://osf.io/preprints/mindrxiv/nwyts_v1.

[J3] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J4] ("editor") Bryant J. Sheldrake on Presentiment & Psychokinesis, 1999. Available at: https://tinyurl.com/owrfolq.

[J5] Goertzel B & Goertzel T (Eds.). Humanity+ Press, 2015. Available at: https://www.amazon.com/End-Beginning-Society-Economy-Singularity/dp/0692457666.

[J6] 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.

[J7] Goertzel B et al. Loving AI: Humanoid Robots as Agents of Human Consciousness Expansion (summary of early research progress)., 2017. Available at: https://tinyurl.com/y9cawkh3.

[J8] Levin M. The computational boundary of a "self": developmental bioelectricity drives multicellularity and scale-free cognition. *Frontiers in psychology*, 10(493866), 2019. Available at: https://doi.org/10.3389/fpsyg.2019.02688.

[J9] Nelson R. *The Global Consciousness Project's Event-Related Responses Look Like Brain EEG Event-Related Potentials.*, volume 34. 2020.

[J10] Nelson R. ICRL Press Press, 2025.

[J11] Peoch R. Chicken-robot interaction. *Medical Network.*, 62, 1995. Available at: https://paranormal.se/psi/pk/djur.html.

[J12] DI & Nelson R Radin. *Evidence for consciousness-related anomalies in random physical systems*, volume 19. 1989.

Books related to TGD

[K1] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/prext.pdf, 2023.

[K2] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/biophotonslian.pdf, 2023.

[K3] Pitkänen M. Bio-Systems as Conscious Holograms. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/hologram.pdf, 2023.

[K4] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/persconsc.pdf, 2023.

[K5] Pitkänen M. Conscious Information and Intelligence. In *TGD Inspired Theory of Consciousness: Part II. https://tgdtheory.fi/tgdhtml/Btgdconsc2.html*. Available at: https://tgdtheory.fi/pdfpool/intsysc.pdf, 2023.

[K6] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/compl1.pdf, 2023.

[K7] 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.

[K8] 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.

[K9] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/kahler.pdf., 2023.

[K10] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/mless.pdf, 2023.

[K11] Pitkänen M. New Physics Predicted by TGD: Part I. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/TGDnewphys1.pdf, 2023.

[K12] Pitkänen M. New Physics Predicted by TGD: Part II. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/TGDnewphys2.pdf, 2023.

[K13] 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.

[K14] 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.

[K15] 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.

[K16] Pitkänen M. Some questions about IIT. In *TGD Inspired Theory of Consciousness: Part II. https://tgdtheory.fi/tgdhtml/Btgdconsc2.html*. Available at: https://tgdtheory.fi/pdfpool/panel2016.pdf, 2023.

[K17] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds". In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/wcwsymm.pdf, 2023.

[K18] Pitkänen M. TGD Inspired Comments about Integrated Information Theory of Consciousness. In *TGD Inspired Theory of Consciousness: Part II. https://tgdtheory.fi/tgdhtml/Btgdconsc2.html*. Available at: https://tgdtheory.fi/pdfpool/tononikoch.pdf, 2023.

[K19] Pitkänen M. WCW Spinor Structure. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/cspin.pdf, 2023.

[K20] 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.

Articles about TGD

[L1] Pitkänen M. Topological Geometrodynamics. *Int J Theor Phys*, 22(7), 1983.

[L2] Pitkänen M. Jeremy England's vision about life and evolution: comparison with TGD approach . Available at: https://tgdtheory.fi/public_html/articles/englandtgd.pdf., 2015.

[L3] Pitkänen M. Cold Fusion Again . Available at: https://tgdtheory.fi/public_html/articles/cfagain.pdf., 2015.

[L4] Pitkänen M. Pollack's mechanism and photosynthesis. Available at: https://tgdtheory.fi/public_html/articles/pollackphoto.pdf., 2016.

[L5] Pitkänen M. X boson as evidence for nuclear string model. Available at: https://tgdtheory.fi/public_html/articles/Xboson.pdf., 2016.

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

[L7] Pitkänen M. DMT, pineal gland, and the new view about sensory perception. Available at: https://tgdtheory.fi/public_html/articles/dmtpineal.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. Philosophy of Adelic Physics. Available at: https://tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L10] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: https://tgdtheory.fi/public_html/articles/emotions.pdf., 2018.

[L11] 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.

[L12] Pitkänen M. Scattering amplitudes and orbits of cognitive representations under subgroup of symplectic group respecting the extension of rationals . Available at: https://tgdtheory.fi/public_html/articles/symplorbsm.pdf., 2019.

[L13] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https://tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L14] Pitkänen M. A model of protocell based on Pollack effect. Available at: https://tgdtheory.fi/public_html/articles/pollackoparin.pdf., 2020.

[L15] Pitkänen M. How to compose beautiful music of light in bio-harmony? https://tgdtheory.fi/public_html/articles/bioharmony2020.pdf., 2020.

[L16] Pitkänen M. Spin Glasses, Complexity, and TGD. https://tgdtheory.fi/public_html/articles/sg.pdf., 2021.

[L17] Pitkänen M. What could 2-D minimal surfaces teach about TGD? https://tgdtheory.fi/public_html/articles/minimal.pdf., 2021.

[L18] Pitkänen M. Comparison of Orch-OR hypothesis with the TGD point of view. https://tgdtheory.fi/public_html/articles/penrose.pdf., 2022.

[L19] Pitkänen M. How animals without brain can behave as if they had brain. https://tgdtheory.fi/public_html/articles/precns.pdf., 2022.

[L20] Pitkänen M. Intersection form for 4-manifolds, knots and 2-knots, smooth exotics, and TGD. https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf., 2022.

[L21] Pitkänen M. Mysteries associated with lightnings, ball lightnings and the electrosphere of Earth. https://tgdtheory.fi/public_html/articles/balllight.pdf., 2022.

[L22] Pitkänen M. TGD inspired model for freezing in nano scales. https://tgdtheory.fi/public_html/articles/freezing.pdf., 2022.

[L23] Pitkänen M. About tessellations in hyperbolic 3-space and their relation to the genetic code . https://tgdtheory.fi/public_html/articles/tessellationH3.pdf., 2023.

[L24] Pitkänen M. About long range electromagnetic quantum coherence in TGD Universe. https://tgdtheory.fi/public_html/articles/hem.pdf., 2023.

[L25] Pitkänen M. About the Relationships Between Weak and Strong Interactions and Quantum Gravity in the TGD Universe . https://tgdtheory.fi/public_html/articles/SW.pdf., 2023.

[L26] Pitkänen M. Are Conscious Computers Possible in TGD Universe? https://tgdtheory.fi/public_html/articles/tgdcomp.pdf., 2023.

[L27] 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.

[L28] Pitkänen M. Deep learning from the TGD point of view. https://tgdtheory.fi/public_html/articles/TGDdeeplearn.pdf., 2023.

[L29] Pitkänen M. Holography and Hamilton-Jacobi Structure as 4-D generalization of 2-D complex structure. https://tgdtheory.fi/public_html/articles/HJ.pdf., 2023.

[L30] Pitkänen M. Is Negentropy Maximization Principle needed as an independent principle? https://tgdtheory.fi/public_html/articles/NMPcrit.pdf., 2023.

[L31] Pitkänen M. Neil Gersching s vision of self-replicating robots from TGD point of view. https://tgdtheory.fi/public_html/articles/Gersching.pdf., 2023.

[L32] Pitkänen M. New result about causal diamonds from the TGD view point of view. https://tgdtheory.fi/public_html/articles/CDconformal.pdf., 2023.

[L33] Pitkänen M. Pollack effect, lightnings and ball lightnings. https://tgdtheory.fi/public_html/articles/balllightning.pdf., 2023.

[L34] Pitkänen M. Some new aspects of the TGD inspired model of the nerve pulse . https://tgdtheory.fi/public_html/articles/np2023.pdf., 2023.

[L35] Pitkänen M. TGD view of Michael Levin s work. https://tgdtheory.fi/public_html/articles/Levin.pdf., 2023.

[L36] Pitkänen M. About Langlands correspondence in the TGD framework. https://tgdtheory.fi/public_html/articles/Frenkel.pdf., 2024.

[L37] Pitkänen M. About the recent findings of Michael Levin s group. https://tgdtheory.fi/public_html/articles/levinnew.pdf., 2024.

[L38] Pitkänen M. Holography=holomorphy vision in relation to quantum criticality, hierarchy of Planck constants, and $M^8 - H$ duality. https://tgdtheory.fi/public_html/articles/holoholonumber.pdf., 2024.

[L39] Pitkänen M. How subjective memories are realized in TGD inspired theory of consciousness? https://tgdtheory.fi/public_html/articles/memorytgd.pdf., 2024.

[L40] 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.

[L41] Pitkänen M. Some solar mysteries. https://tgdtheory.fi/public_html/articles/Haramein.pdf., 2024.

[L42] Pitkänen M. TGD as it is towards the end of 2024: part I. https://tgdtheory.fi/public_html/articles/TGD2024I.pdf., 2024.

[L43] Pitkänen M. TGD as it is towards the end of 2024: part II. https://tgdtheory.fi/public_html/articles/TGD2024II.pdf., 2024.

[L44] Pitkänen M. What gravitons are and could one detect them in TGD Universe? https://tgdtheory.fi/public_html/articles/whatgravitons.pdf., 2024.

[L45] Pitkänen M. A more detailed view about the TGD counterpart of Langlands correspondence. https://tgdtheory.fi/public_html/articles/Langlands2025.pdf., 2025.

[L46] Pitkänen M. A new experimental demonstration for the occurrence of low energy nuclear reactions. https://tgdtheory.fi/public_html/articles/LENRagain.pdf., 2025.

[L47] Pitkänen M. A refined view of the phenomenology of hadron physics and p-adic mass calculations. https://tgdtheory.fi/public_html/articles/padmass2025.pdf., 2025.

[L48] Pitkänen M. About Dirac equation in $H = M^4 \times CP_2$ assuming Kähler structure for M^4 . https://tgdtheory.fi/public_html/articles/HJdireq.pdf., 2025.

[L49] Pitkänen M. About the construction of the scattering amplitudes using $M^8 - H$ duality. https://tgdtheory.fi/public_html/articles/M8Hample.pdf., 2025.

[L50] Pitkänen M. About the structure of Dirac propagator in TGD. https://tgdtheory.fi/public_html/articles/dirprop.pdf., 2025.

[L51] Pitkänen M. Classical non-determinism in relation to holography, memory and the realization of intentional action in the TGD Universe. https://tgdtheory.fi/public_html/articles/QCintact.pdf., 2025.

[L52] Pitkänen M. Comparing the S-matrix descriptions of fundamental interactions provided by standard model and TGD. https://tgdtheory.fi/public_html/articles/hadroQCDTGD.pdf., 2025.

[L53] Pitkänen M. Could computers be living and move? https://tgdtheory.fi/public_html/articles/liquidmetallife.pdf., 2025.

[L54] Pitkänen M. Could life have emerged when the universe was at room temperature? https://tgdtheory.fi/public_html/articles/earlylife.pdf., 2025.

[L55] Pitkänen M. Gödel,Lawvere and TGD. https://tgdtheory.fi/public_html/articles/Gtgd.pdf., 2025.

[L56] Pitkänen M. How the genetic code is realized at the level of the magnetic body of DNA double strand? https://tgdtheory.fi/public_html/articles/ITT.pdf., 2025.

[L57] Pitkänen M. M^8H duality reduces to local G_2 invariance. https://tgdtheory.fi/public_html/articles/M8Hstill.pdf., 2025.

[L58] Pitkänen M. Some TGD inspired comments about biocatalysis. https://tgdtheory.fi/public_html/articles/pollackbio.pdf., 2025.

[L59] Pitkänen M. The recent view of TGD inspired theory of consciousness and quantum biology. https://tgdtheory.fi/public_html/articles/consc2025.pdf., 2025.

[L60] Pitkänen M. Answers to the questions of Vasileios Basios and Marko Manninen in Hypothesis Refinery session of Galileo Commission. https://tgdtheory.fi/public_html/articles/MarkoBasios.pdf., 2026.

[L61] Pitkänen M. Could TGD provide a vision about evolution at the gene level? https://tgdtheory.fi/public_html/articles/evogene.pdf., 2026.

[L62] Pitkänen M. Does the notion of Teichmüller element cure the problem of p-adic mass calculations due to the slight failure of Lorentz invariance? https://tgdtheory.fi/public_html/articles/padmass2026.pdf., 2026.

[L63] Pitkänen M. Universal rhythm for communications between animals? 2026. Available at: https://tgdtheory.fi/public_html/articles/2Hz.pdf. .

[L64] Pitkänen M. Allais effect again. 2026. Available at: https://tgdtheory.fi/public_html/articles/Allaisagain.pdf. .

[L65] Pitkänen M. Do the icosatedrahedral tessellation of H^3 and icosahedral H_2O supercluster correspond to each other? 2026. Available at: https://tgdtheory.fi/public_html/articles/icosacluster.pdf. .

[L66] Pitkänen M. TGD counterpart of Feynman diagrammatics applied to QFT limit and CP violation. 2026. Available at: https://tgdtheory.fi/public_html/articles/QFTlimit.pdf. .

[L67] Pitkänen M. A possible TGD based narrative for how life might have evolved. 2026. Available at: https://tgdtheory.fi/public_html/articles/TGDlifestory.pdf. .

[L68] Pitkänen M. Official top quark and toponium as particles of M_{89} hadron physics? 2026. Available at: https://tgdtheory.fi/public_html/articles/topotopo.pdf. .

[L69] Pitkänen M and Manninen M. Could large language models be useful in theory development? . https://tgdtheory.fi/public_html/articles/GPTTGD.pdf., 2025.

[L70] M. Pitkänen, Sorakivi T. Manninen, M., and V-E. Saari. Are Pollack batteries possible? 2026. Available at: https://tgdtheory.fi/public_html/articles/Pbattery.pdf. .