Quantum self-organization by h_{eff} changing phase transitions

M. Pitkänen
Email: matpitka6@gmail.com.
http://tgdtheory.com/.

September 15, 2019

Abstract

The TGD based model for biological self-organization relies on the hierarchy $h_{eff} = nh_0$ of effective Planck constants labelling dark phases of ordinary particles residing at magnetic flux quanta. This model generalizes and suggests the replacement of non-equilibrium thermodynamics as basis of self-organization with its quantum variant based on dark matter hierarchy. The challenge is to formulate basic thermodynamical notions like work in terms TGD based quantum theory.

The basic mechanism would be a phase transition creating dark matter phase as a Bose-Einstein condensate like state with particles having identical conserved quantum numbers. Conservation laws would force the ordinary matter to have opposite total charges. For instance, in the case of work one has momentum or angular momentum as a conserved charge. In the case of charge separation and high Tc superconductivity it would be em charge. Even color charges can correspond to conserved charges in TGD framework allowing scaled variants of strong interaction physics.

Basic biological functions involving the notion of work and also the formation of sensory percepts would rely on this mechanism. Also the ZEO based theory of consciousness predicting the change the arrow of time in ordinary state function reduction plays a central role and a model of nerve pulse is discussed as an example.

1 Introduction

Hermann Haken [B3, B2] and Ilya Prigogine citebthePrigogine are two well-known pioneers of self-organization theories. The most important aspects of self-organization and non-equilibrium thermodynamics from TGD point of view are following.

1. The notion of thermodynamical non-equilibrium state is central. Temperature T is not anymore constant and varies in the system and also with time. Already Carnot cycle (see http://tinyurl.com/ntk9a3k) involving the system and environment at different temperatures can be regarded as a thermodynamical non-equilibrium state.

2. Thermal non-equilibrium states are generated in presence of energy feed. Otherwise the system would end up to a complete thermal equilibrium without any structure. These non-equilibrium states correspond to self-organization patterns.

3. The character of non-equilibrium states changes at critical points at critical values of parameters - say temperature, external magnetic field, or energy feed. Ordinary phase transitions could be seen as special cases of non-equilibrium phase transitions. If the flow of energy increases in transition, a more complex pattern with a longer coherence length is created. Long range fluctuations accompany the transitions.

4. Master-slave hierarchy is also a central notion. One can say that the master controls the dynamics of the slave in long time and length scales by providing a slowly varying background.

The TGD based model for biological self-organization relies on the hierarchy $h_{eff} = nh_0$ of effective Planck constants labelling dark phases of ordinary particles residing at magnetic flux

quanta [L12, L13, L16] [K10, K9]. This model generalizes and suggests the replacement of non-equilibrium thermodynamics as basis of self-organization with its quantum variant based on dark matter hierarchy. The challenge is to formulate basic thermodynamical notions like work in terms TGD based quantum theory relying on zero energy ontology (ZEO) [K8].

The basic mechanism would be a phase transition creating dark matter phase as a Bose-Einstein condensate like state with particles having identical conserved quantum numbers. Conservation laws would force the ordinary matter to have opposite total charges. For instance, in the case of work one has momentum or angular momentum as a conserved charge. In the case of charge separation and high Tc superconductivity it would be em charge. Even color charges can correspond to conserved charges in TGD framework allowing scaled variants of strong interaction physics.

Basic biological functions involving the notion of work and also the formation of sensory percepts would rely on this mechanism. Also the ZEO based theory of consciousness predicting the change the arrow of time in ordinary state function [L9] reduction plays a central role and a model of nerve pulse is discussed as an example.

2 TGD inspired quantum theory of self-organization

The basic observation is that in zero energy ontology (ZEO) [K8] TGD can be formally regarded as square root of thermodynamics. Whether this reduces thermodynamics to quantum theory in the sense that moduli squared for the state function - basically mode of classical spinor field in the "world of classical worlds" (WCW) gives thermodynamical partition function in some situations is not however clear.

1. The square root of thermodynamical partition function would be defined by complex square roots of Boltzmann weights identified as products $exp(-E/2T)U$ of square root of the ordinary Boltzmann exponential and phase factor U. Also the vacuum functional in WCW [K12] [L23] is analogous to square root of partition function.

2. In TGD field patterns are replaced by preferred extremals of action as analog of Bohr orbit connecting 3-surfaces at the boundaries of causal diamond (CD). This space-time surface exists only for preferred pairs of 3-surfaces. In quantum field theory (QFT) action exponential defined mere phase and is is formally analogous to Boltzmann weight: one has a formal analog of thermodynamics in the space of 4-D field patterns.

   Action exponent contains now also real part so that one has functional integral instead of path integral. In fact, one has discrete sum over preferred extemals for a finite cutoff defined by discrete cognitive representations required by adelic physics [L7, L8, L18, L19]. Integrability of TGD strongly suggests that this occurs effectively also for the continuum theory: sum would correspond now to sum over maxima of Kähler function with functional integral performed around its small deformations.

This picture suggests a generalization of non-equilibrium thermodynamics to quantum level based on the hierarchy of effective Planck constants $h_{eff} = nh_0$ [L15, L16] labelling the phases of dark matter in TGD sense.

1. The value of n is identified as the dimension of extension of rationals inducing in turn extensions of p-adic number fields and extension of adele. Reals and p-adic number fields form adele as a book like structure with pages labelled by reals and extensions of various p-adic number fields induced by the extension of rationals. The extension of rationals defines the back of the book as the intersection of its pages.

   At space-time level the back corresponds to the points of imbedding space with the values of preferred coordinates of imbedding space in the extension of rationals and thus common to reals and all p-adic number fields. Preferred coordinates are unique apart from time translation in M^8 picture and apart from isometries of H in $H = M^4 \times CP_2$ picture [L6, L21, L20].

2. The books corresponding to all extensions of rationals form an infinite library. In quantum jumps the dimension of the extension is bound to increase since the number of extensions

with dimension D smaller than given integer n is finite and the number of those with $D > n$ is infinite. Since the algebraic complexity of the extension increases with n, one can interpret this as evolution. In p-adic sectors one has cognitive evolution with n serving as "IQ". The increase of n means increase of quantum coherence lengths. The coherence of ordinary bio-matter would be forced by the quantum coherence dark matter with large value of n.

3. At the limit when the extension approaches algebraic numbers, the points of the cognitive representation form a dense subset of the space-time surface so that this corresponds to the optimal situation. I have conjectured that the roots fo Riemann zeta (see `http://tinyurl.com/nfbkrsx`) are algebraic numbers. A stronger conjecture would be that the roots of ζ span algebraic numbers. This would give to Riemann Zeta a completely unique role in mathematics. One can however argue that since the generalization of Riemann zeta as Dedekind zeta function exists for all extensions of rationals, this might not be true.

This suggests the following view about quantum self-organization.

1. Thermodynamical non-equilibrium states are replaced with zero energy states. Partition function is replaced with its square root having interpretation as a ground state wave function. This picture should be consistent with non-equilibrium thermodynamics.

   The density matrix characterizing ordinary space-like entanglement would be analogous to the ordinary density matrix. ZEO brings as a new element time like quantum entanglement between the quantum states associated with 3-surfaces at the two light-like 3-surfaces connected by preferred extremal. This entanglement is consistent with Lorentz invariance. By summing in the modulus squared of the amplitude (mode of WCW spinor field) over the states associated with 3-surfaces at second boundary of CD one obtains density matrix essential in p-adic thermodynamics involving superposition over massless states and states with non-vanishing mass squared.

2. Master slave hierarchy is replaced with the dark matter hierarchy as a hierarchy of adelic physics labelled by extensions of rationals defining p-adic length scale hierarchy in terms of preferred p-adic primes identifiable as ramified primes of the extension [L3, L22]. Given level with extension having dimension $h_{eff}/h_0 = n$ serves as a master for the levels $m < n$ with m dividing n so that one has hierarchy consisting of extensions of extensions of.... Extension with dimension n would be extension of extension having dimension m. Quantum coherence of dark matter assumed to reside at magnetic flux tubes and sheets of the magnetic body (MB) would force the coherence of the ordinary matter.

   All self-organizing systems would reflect the presence of h_{eff} hierarchy, not only the living systems. Once one has coherence in macroscopic length scale, one knows that there must be quantum coherence of dark matter at MB having onion-like structure with layers labelled by p-adic length scales in corresponding and/or longer length scales.

   The additional hypothesis $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where $\hbar_{gr}$ is gravitational Planck constant introduced by Nottale [E1]. M is large mass -say the mass of Earth or Sun - and m small mass such as elementary particle mass, and $v_0 < c$ is velocity parameter makes possible macroscopic quantum coherence in long length scales.

   In accordance with Equivalence Principle gravitational Compton length $\Lambda = \hbar_{gr}/m = GM/v_0$ does not depend on m. Also cyclotron energies $\hbar_{gr}eB/m = GMeB/v_0$ are universal having no dependence on m. The proposal is that the dark photons have energy in visible and UV range (at least) and that they can transform in energy conserving manner to ordinary photons interpreted as bio-photons [K11]. Gravitation would be involved with large values of $h_{eff} = h_{gr}$ implying macroscopic quantum coherence. This is natural since gravitation is not only long range interaction but also non-screened. Needless to say, this changes dramatically the vision about quantum gravitation as something appearing in Planck length scale.

3. In non-equilibrium thermodynamics energy feed is necessary. This is the case also now [L12]. Quite generally, the energies of the dark quantum states increase with h_{eff}, when other parameters are kept constant. This requires energy feed to excite dark states and also to

preserve them since dark states decay spontaneously to states with lower value of h_{eff} having a lower energy. This energy feed would correspond to the metabolic energy feed in biosystems.

Even the self-organization involved with the emergence of increasingly complex convection patters in the heating of liquid could involve the hierarchy of Planck constants and the increase of the heating power would correspond to an evolution increasing the values of h_{eff} involved.

To sum up, dark matter would seen at the level of everyday physics and the idea about classical physics somehow emerging above some length scale would be completely wrong: quantum physics would be present in all scales.

3 Some challenges of quantum theory of self-organization

Quantum theory of self-organization as a square root of non-equilibrium thermodynamics must encounter several challenges.

1. One should understand quantum counterparts for various thermodynamical notions - mention only temperature and entropy. Modulus squared for ground state wave function would give thermodynamical partition function for the counterparts of thermodynamical states. The notions of temperature and entropy indeed emerge. p-Adic entanglement negentropies and their sum relating to cognition are also defined if the entanglement coefficients belong to an extension of rationals as indeed assumed in adelic physics [L7, L8].

2. Genuinely thermodynamical notions such as work and heat engines must be understood. Carnot's cycle is associated with the simplest heat engine and leads to an upper bound for the efficiency $\eta \leq \Delta T/T_{max}$ characterizing work - that is ordered energy - that can be extracted from thermal energy with breaking of second law of thermodynamics. Already in this case one has two different temperatures so that in strict sense one does not have thermodynamical equilibrium.

What could the quantum notion of work mean? The simplest example is a cylinder filled with gas. When heated it expands and does work. What happens at quantum level when work is done?

1. Work means generation of ordered energy so that the momenta for ordinary matter are parallel rather than random as for the feed of thermal energy. Dark matter should induce this coherence somehow. The simplest model is that a fraction of ordinary particles makes a phase transition to dark phase forming a Bose-Einstein condensate like state with parallel momenta with coherence length of the order of system size. Momentum conservation forces the ordinary matter to generate opposite total momentum and coherent motion is the outcome. The part of energy going to heating of ordinary matter corresponds to entropy and one should have $dE = TdS - pdV$.

2. This picture applies also to the work generating coherent rotation in macroscopic scales. In this case dark quantum coherent states with parallel spin or angular momenta would be formed and by angular momentum conservation force the formation of coherent rotation of ordinary matter.

3. Quite generally, energy and momentum as conserved quantum numbers can be replaced with energy and some other conserved quantum quantities such as angular momentum or charge. Quantum coherent states with dark particles having identical quantum numbers are generated and ordinary matter has opposite total quantum numbers by basic conservation laws.

   One can understand the phase transitions generating coherence in longer scales as an emergence of dark Bose-Einstein like states carrying total quantum quantum numbers with conservation forcing opposite total quantum numbers for the ordinary matter. Work can be seen as a process analogous to spontaneous magnetization with spin replaced with momentum or angular momentum. Even freezing, melting, spontaneous magnetization, etc.... might allow this description.

4. An interesting question is whether conservation law for some quantum number is always involved. For instance, water is known to involve at least two phases and TGD proposal is that the other phase(s) correspond to dark phases in which magnetic flux tubes carrying dark proton sequences identifiable as dark nuclei are involved: this could be due to Pollack effect [L1] [L1]. Charge separation would occur and the conserved charge would be electromagnetic charge.

Quite generally, the formation of a quantum coherent dark matter structure with large h_{eff} would be always behind the formation of coherent structure of ordinary matter: one would have forced coherence. Also energy feed would be essential.

Consider some examples.

1. Magnetization is a standard example about a phase transition and still far from well-understood. Magnetization would be due to the generation of dark matter at magnetic flux tubes inducing the magnetization. Conservation of spin and more generally angular momentum would be essential. Dark matter at the magnetic body (MB) of system would have spontaneous magnetization and parallel spins and angular momenta.

   Remark: No currents are needed to generate the magnetic field if the flux tubes carry monopole flux. TGD allows this since CP_2 is homologically non-trivial containing non-contractible 2-surface.

   Hysteresis curve representing magnetization of a ferromagnet as function of external magnetic field represents an interesting challenge for the model. The fraction of the dark phase varies along hysteresis curve and the magnetization process is not reversible.

   The description of antiferromagnetism is a challenge for this picture since in this case the total spin vanishes. Magnetic body as a network of flux tubes suggests that given flux tube behaves like dark ferromagnet inducing ferromagnetic subsystem by conservation of spin: the dark and ordinary spins would have nearly the same M^4 projection.

2. This picture applies also to the strange effects associated with rotating magnetic systems discovered by Godin and Roschin [H1] [K13]. The observed cylindrical flux sheets carrying rotating dark particles with non-vanishing total angular momentum would be spontaneously generated and ordinary matter - the rotating magnetic system - would generate opposite angular momentum.

   The source of the energy feed is not obvious: one possibility is that the energy comes from the magnetic energy of the rotating system or from the electrostatic fields involved. Also external source can be considered. Interestingly, the rotation accelerates as the rotation frequency of the motor approaches 10 Hz, which defines a fundamental bio-rhythm. Could it be that the energy feed comes from outside as dark photons with 10 Hz frequency but large energy?

3. Super-conductivity presents a second example. Cooper pairs are charged so that charge separation would be involved. If Cooper pairs correspond to ordinary particles, the model requires their transformation to dark Cooper pairs. In high Tc superconductivity Cooper pairs are formed at higher critical temperature T_{c_1} and supra currents become possible at lower critical temperature T_c [K4, K5]. Ordinary Cooper pairs could not have any coherent momentum in macroscopic scales above Tc. Dark Cooper pairs having parallel momenta would emerge at T_c and the ordinary Cooper pairs would receive an opposite momentum.

4. Tornado involves center at low pressure and temperature and there is heat flow from environment generating the rotation of the vortex which has lower velocity towards center so that the center is at rest. This would mean increased pressure by $p + \rho v^2/2 = constant$.

   The presence of magnetic fields in the vortex however generates magnetic pressure and energy so that one has $E_B + p + \rho v^2/2 = constant$. Hence p could be lower at the center and explains the effects of tornado. Temperature is also lower and also this is due to the magnetic energy. The magnetic field need not be electromagnetic. Long ranged Z^0 fields are indeed possible in TGD for large values of h_{eff} and one of the oldest proposals concerning hydrodynamics is that hydrodynamical vortices could correspond to Z^0 magnetic flux tubes. Only dark Z^0 magnetic flux tubes would be needed. In sunspots this indeed happens, which leads to ask

whether magnetic spots could correspond to tornadoes. Also in Jupiter there is a red spot representing a permanent tornado.

One can regard tornado as a quantum analog of Carnot's engine. Temperature difference between the exterior and the center corresponds to that in Carnot's engine and could be generated spontaneously by the generation of magnetic flux tubes: the quantum coherent rotation of dark particles at flux tubes forces the coherent motion of ordinary particles by angular momentum conservation.

5. In the case of ordinary hydrodynamical vortex there is no external energy feed and vortex created in some manner decays to smaller vortices. The interpretation would be as a cascade resulting as the value of h_{eff} decreases making the quantum coherence length smaller. Also now dark magnetic - or rather, Z^0 magnetic [K2] - flux tubes carrying dark particles could be present. The question whether Z^0 fields are present in long length scales is still open: chiral selection in living matter could be interpreted in terms of the presence of Z^0 fields in cellular length scales. Z^0 magnetic fields could be important also in super-fluidity and the conserved and quantized vorticity could correspond to Z^0 magnetic flux.

6. Ball lightning could be also seen as a simple self-organizing system. The energy of particles could come from the acceleration of charged dark particles at the magnetic flux tube involving very small dissipation explaining also the charged particles and gamma rays with anomalously high energies found to accompany lightnings. Also a charge separation giving rise to an analog of cell membrane like structure involving also charge separation would be involved.

4 Applications to TGD inspired quantum biology and consciousness theory

Living matter moves in various ways. The generation of dark matter condensates could explain how work is done in living matter. Living matter also perceives and dark matter condensates could also lead to the generation sensory qualia. In TGD framework sensory perception and motor action can be actually regarded as time reversals of each other [L14]. Libet's findings [J1] showing that volitional motor action such as raising index finger is preceded by neural activity supports the view that motor action generates time reversed state at some levels of the hierarchy of space-time sheets [L17].

4.1 Quantum engines in biology

Quantum engines building themselves by self-organization in presence of metabolic energy feed would be the key notion.

1. Muscle represents a basic example about a living system doing work. A toy model is as a structure consisting of n parallel vertical filaments of length L - such as flux tubes - forming a horizontal pile in vertical plane such that they can glide with respect to each other in vertical direction but cannot get loosen from each other. The minimum length of the configuration is L and maximal length is nL. The stretching of the muscle would be caused by a push of say right-most filament upwards and this motion would force other filaments to follow when the shift of this filament exceeds L. h_{eff} increasing ordinary-to-dark phase transition for the associated flux tubes would generate Bose-Einstein condensate with particle in the same direction. By momentum conservation the filament receives an opposite momentum.

2. ATP machinery (see `http://tinyurl.com/ovhk94j`) involves ATP synthase, which can be regarded as a molecular motor with a rotating shaft. Each turn of this motor creates ATP from ADP. This requires energy feed obtained as protons accelerate through the membrane potential gradient and give their energy to the rotation of the shaft and to the chemical energy of ADP. The energy of protons comes from electron transport chain and is provided by metabolite. The angular momentum of the shaft would be generated by the conservation

of angular momentum in the formation of dark Bose-Einstein condensates with bosons carrying parallel angular momenta. The H^+ motors driving flagella would work in very similar manner.

An interesting question concerns the nature of the Bose-Einstein condensates involved in the process.

3. In cell membrane ions are pumped against gradient of electric field. This requires energy and work must be done. The proposed general quantum mechanism for work explains how the work could done at quantum level.

4. One can consider also charge separation as similar quantum phenomenon with conserved momentum replaced with conserved em charge. Pollack effect occurs in presence of energy feed - such as IR photons - and generates negatively charged regions - exclusion zones (EZs) in water bounded by organic matter. The TGD based model [L1] assumes that protons are transferred to magnetic flux tubes, where they form dark protons sequences having interpretation as dark nuclei [L2, L5]. This would be both fundamental mechanism of pre-stellar evolution and biology. For instance, negatively charged DNA (each nucleotide is charged) would be accompanied by dark DNA consisting of sequences of dark protons with 3-proton units providing a realization DNA, RNA, tRNA and amino-acid states and also vertebrate genetic code [L4, L10].

   The formation of cell membranes involving charge separation with negative charge in cell interior could also involve Pollack effect making possible pumping of protons and also other charge particle to generate membrane potential in the presence of metabolic energy feed realized as ordinary photons. Also spontaneous formation of lipid layers - also of soap films - could be this kind of process.

4.2 Quantum model for nerve pulse

In TGD based model of nerve pulse axonal membrane is generalized cylindrical Josephson junction defined by axonal membrane consisting of smaller Josephson junctions defined by membrane proteins.

1. A sequence of mathematical penduli along axon in rotation in the same direction is the mechanical analog. Oscillation frequency Ω transforming to a rotation frequency above critical value is proportional to the resting potential V. When V is overcritical, the pendulum starts to rotate instead of oscillating. The system should be near quantum criticality for the transformation of rotation to oscillation or vice versa.

2. During nerve pulse membrane potential and therefore also rotation frequency is reduced and changes sign and then returns back to the original value. The first guess is that at criticality there is a kick reducing the rotation frequency Ω and continuing to change its sign and then return it to original.

The basic condition is that resting state becomes critical at critical hyper-polarization. There are two options for the resting state.

1. According to the original model [K7], resting state can be regarded as a soliton sequence associated with the phase difference over the membrane. More concretely, the mathematical penduli rotate in same direction with phase difference between determining the propagation velocity of solitons. The rotation frequency is slightly above that for oscillation. There is a preferred direction along axon. This conforms with the reduction and change of sign of potential and thus of Ω.

   Problem: Hypo- rather than hyper-polarization should cause the nerve pulse as a transformation of rotation to oscillation. Something goes wrong.

2. Alternatively, the penduli almost rotate being near criticality for the rotation: the penduli almost reaches the vertical position at each oscillation as required by criticality. That hyper-polarization would cause the nerve pulse as propagating soliton conforms with this idea.

Problem: Ω and thus V should increase rather than reduce and even change sign temporarily.

Neither option seems to work as such but the first option is more plausible as a starting point of an improved model.

The membrane potential changes sign suggesting quantum jump. Could zero energy ontology (ZEO) based view about quantum jump as "big" (ordinary) state function reduction (BSFR) help? Could nerve pulse correspond to BSFR?

1. Could BSFR occur changing temporarily the arrow of time in ZEO and induce nerve pulse. Could opposite BSFR take place after this in millisecond scale and establish the original arrow of time. Using the language of TGD inspired theory of consciousness [L9], a conscious entity, sub-self or mental image, would die and reincarnate with an opposite arrow of time, live for the duration of nerve pulse and then die and reincarnate with the original arrow of time. Nerve pulse would be a propagation of a temporary neuron death along the axon and would occur as neuron becomes hyper-polarized.

2. In the article [L17] about the recent findings of Minev et al [L17] related to quantum jump in atomic physics are discussed. ZEO predicting that the arrow of time is changed in BSFR. This would create the illusion that discontinuous quantum jumps correspond to a classical time evolution leading smoothly and deterministically to the final state.

   This because BSFR leads to a state with reversed arrow of time, which corresponds to a superposition of classical time evolutions leading from the final state to the geometric past and it this, which is observed. This would also explain why the removal of the irradiation inducing quantum jumps has no effect during the transition process and why a stimulation inducing opposite quantum jump can stop the process. Also the findings of Libet related to the active aspects of consciousness [J1] showing that neural activity seems to preceded volitional act can be understood in this framework without giving up the notion of free will.

   The first half of the nerve pulse would correspond to this apparent evolution to the time reversed final state with opposite membrane potential but actually being time reversed evolution from the final state. The second half of nerve pulse would correspond to opposite state function reduction establishing the original arrow of time. This model looks attractive but many details remain to be checked.

Why hyper-polarization should cause the temporary death of neuron or its subself?

1. Metabolic energy feed is needed to preserve the polarization of neuron since membrane potential tends to get reduced by second law stating that all gradients are bound to decrease. There should be some maximal polarization possible to preserve using the existing metabolic energy resources.

2. Does quantum jump to a state with opposite arrow of time happen as this limit is reached? Why? Could the metabolic energy feed stop causing the neuron to die to starvation? Why the death of neuron should happen so fast? Could the quantum criticality against the change of rotation to oscillation be the reason. When neuron cannot rotate anymore it would die immediately: the mental image "I am rotating" would die and reincarnate as its time reversal. Does the neuron feeded by metabolic energy become a provider metabolic energy during this period somewhat like dead organisms after their death. Can one conclude that this energy goes to some purpose inside neuron?

4.3 Sensory perception and qualia

Sensory perception (time reversal of motor action [L14]) could involve generation of coherent phases of dark matter carrying collective quantum numbers in 1-1 corresponds with the sensory qualia. This would represent a general charge separation process.

Consider first sensory capacitor model for color qualia [K3].

1. The notion of QCD color as analog of ordinary visual colors was originally introduced as a joke since the algebra of color summation resembles that for the summation of QCD colors in tensor product. In TGD however the dark hierarchy (h_{eff}) and p-adic length scale hierarchy predict that scaled variants of QCD type physics are possible for arbitrarily large length scales. In cellular scales scaled up QCDs are predicted. In the length scale range between cell membrane thickness and nucleus size there are as many as 4 Gaussian Mersennes, which is a number theoretical miracle. They could label copies of QCDs with size scale for the analogs of hadrons given by the corresponding p-adic length scales. QCD type colors could correspond to perceived colors [K3] [L11].

2. Gluons or quarks labelled by color charge characterizing particular color quale would flow between the plates of "capacitor" associated with the sensory receptor. The amount of particular color charge increases at the other plate giving rise to sensation of this particular color quale and its complement at the other plate - by color confinement also the same plate could also contain regions with complementary colors. This would explain why we see around a region of particular color a narrow boundary with complementary color.

3. The model for sensory perception as sequences of analogs of weak measurements suggest that the flow of color charges could induce color qualia. The prediction emerging from the structure of SU(3) color algebra would be four pairs of basic color and complement color: 3 ordinary pairs and white-black pair. They could correspond to particular changes of color quantum numbers and color quantum numbers of gluons. Also color mixing could be understood.

4. Photons are not coloured but gluons (and also quarks) are, and the latter and could be responsible for color sensation. How photon flux can generate a flow of color quantum numbers? The notion of induced gauge field -classical color gauge potentials would be projections of $SU(3)$ Killing vectors - explains this.

   In TGD classical em field is sum of two terms induced Kähler form and neutral vectorial component of spinor curvature [K1]. Classical gluon field has components proportional to classical color Hamiltonian (function in CP_2 which can be said to have quantum numbers of gluon) and induced Kähler form. In general case any classical em field is accompanied by a classical color field.

   Photons are accompanied by classical em fields and therefore also by classical gluon fields at the fundamental level: this correspondence disappears at QFT limit unable to describe biology and sensory experience. The flow of photons to retina would be accompanied by classical em and color fields and therefore a flow of gluons. Also quark flow between the plates of sensory capacitor could generate the color qualia.

5. A simple model for the visual qualia is in terms of a phase transition transforming gluons of a scaled copy of QCD to ordinary gluons. Dark gluons would form a BE condensate and force a formation its shadow at the level of ordinary matter. This is a variant of sensory receptor as quantum capacitor. The plates of capacitor correspond to dark and ordinary phase and the analog of electric breakdown means formation of the dark phase. Cooper pairs of quarks with quantum numbers of gluon would be second option but gluons in TGD framework are actually this kind of pairs!!

Hearing [K6] as a quale could be associated to a generation of dark variants of vibrating flux tubes connecting molecular or larger structures. The variation of the length of flux tube would be fundamental representation for the quale of hearing. Also now Bose-Einstein condensate like state would be involved but it is not quite clear what the conserved charge would be now: it could be that the collective excitations at dark level correspond to those at the level of ordinary matter. At even more fundamental level the vibrations of fermionic strings assignable to the 2-D string world singularities of space-time surfaces (at which minimal surface property fails since there is transfer of canonical momentum currents between Kähler action and volume term) would correspond to hearing quale.

REFERENCES

Theoretical Physics

[B1] Minev ZK et al. To catch and reverse a quantum jump mid-flight. arXiv:1803.00545 [quant-ph]. Available at: https://arxiv.org/abs/1803.00545, 2019.

[B2] Haken H. *Synergetics*. Springer Verlag, 1978.

[B3] Haken H. *Information and Self-Organization*. Springer Verlag, Berlin, 1988.

Cosmology and Astro-Physics

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

Fringe Physics

[H1] Godin SM Roshchin VV. An Experimental Investigation of the Physical Effects in a Dynamic Magnetic System. *New Energy Technologies*, 1, 2001.

Biology

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

Neuroscience and Consciousness

[J1] Libet B. Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts. Available at: http://tinyurl.com/jqp1, 1982.

Books related to TGD

[K1] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. In *Towards M-matrix*. Online book. Available at: http://www.tgdtheory.fi/public_html/pdfpool/append.pdf, 2006.

[K2] Pitkänen M. Anomalies Related to the Classical Z^0 Force and Gravitation. In *TGD and Fringe Physics*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/freenergy.html#Zanom, 2006.

[K3] Pitkänen M. General Theory of Qualia. In *Bio-Systems as Conscious Holograms*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/holography.html#qualia, 2006.

[K4] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and EEG*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdeeg.html#biosupercondI, 2006.

[K5] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and EEG*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdeeg.html#biosupercondII, 2006.

[K6] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdeeg.html#hearing, 2006.

[K7] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdeeg.html#pulse, 2006.

[K8] Pitkänen M. Construction of Quantum Theory: More about Matrices. In *Towards M-Matrix*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdquantum.html#UandM, 2012.

[K9] Pitkänen M. Quantum Mind and Neuroscience. In *TGD based view about living matter and remote mental interactions*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdlian.html#lianPN, 2012.

[K10] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD based view about living matter and remote mental interactions*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdlian.html#lianPB, 2012.

[K11] Pitkänen M. Are dark photons behind biophotons? In *TGD based view about living matter and remote mental interactions*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdlian.html#biophotonslian, 2013.

[K12] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdgeom.html#wcwnew, 2014.

[K13] Pitkänen M. The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis? In *TGD based view about living matter and remote mental interactions: Part I*. Available at: http://www.tgdtheory.fi/tgdhtml/tgdlian.html#godin, 2016.

Articles about TGD

[L1] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: http://tgdtheory.fi/public_html/articles/PollackYoutube.pdf, 2014.

[L2] Pitkänen M. Cold Fusion Again . Available at: http://tgdtheory.fi/public_html/articles/cfagain.pdf, 2015.

[L3] Pitkänen M. More about physical interpretation of algebraic extensions of rationals. Available at: http://tgdtheory.fi/public_html/articles/ramifiedmore.pdf, 2015.

[L4] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: http://tgdtheory.fi/public_html/articles/genecodemodels.pdf, 2016.

[L5] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: http://tgdtheory.fi/public_html/articles/krivit.pdf, 2017.

[L6] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry? Available at: http://tgdtheory.fi/public_html/articles/ratpoints.pdf, 2017.

[L7] 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.

[L8] Pitkänen M. Philosophy of Adelic Physics. Available at: http://tgdtheory.fi/public_html/articles/adelephysics.pdf, 2017.

[L9] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: http://tgdtheory.fi/public_html/articles/conscrit.pdf, 2017.

[L10] Pitkänen M. About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code. Available at: http://tgdtheory.fi/public_html/articles/codedarkcode.pdf, 2018.

[L11] Pitkänen M. Dark valence electrons and color vision. Available at: http://tgdtheory.fi/public_html/articles/colorvision.pdf, 2018.

[L12] Pitkänen M. Getting philosophical: some comments about the problems of physics, neuroscience, and biology. Available at: http://tgdtheory.fi/public_html/articles/philosophic.pdf, 2018.

[L13] Pitkänen M. Morphogenesis in TGD Universe. Available at: http://tgdtheory.fi/public_html/articles/morphoTGD.pdf, 2018.

[L14] Pitkänen M. Sensory perception and motor action as time reversals of each other: a royal road to the understanding of other minds? Available at: http://tgdtheory.fi/public_html/articles/timemirror.pdf, 2018.

[L15] Pitkänen M. About $h_{eff}/h = n$ as the number of sheets of space-time surface as Galois covering. Available at: http://tgdtheory.fi/public_html/articles/Galoisext.pdf, 20187.

[L16] Pitkänen M. About a model for the control of biological body by magnetic body. Available at: http://tgdtheory.fi/public_html/articles/rotcyclo.pdf, 2019.

[L17] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: http://tgdtheory.fi/public_html/articles/Bohrdead.pdf, 2019.

[L18] Pitkänen M. Scattering amplitudes and orbits of cognitive representations under subgroup of symplectic group respecting the extension of rationals . Available at: http://tgdtheory.fi/public_html/articles/symplorbsm.pdf, 2019.

[L19] Pitkänen M. Secret Link Uncovered Between Pure Math and Physics. Available at: http://tgdtheory.fi/public_html/articles/KimTGD.pdf, 2019.

[L20] Pitkänen M. TGD view about McKay Correspondence, ADE Hierarchy, and Inclusions of Hyperfinite Factors. Available at: http://tgdtheory.fi/public_html/articles/McKay.pdf, 2019.

[L21] Pitkänen M. TGD view about McKay Correspondence, ADE Hierarchy, Inclusions of Hyperfinite Factors, $M^8 - H$ Duality, SUSY, and Twistors. Available at: http://tgdtheory.fi/public_html/articles/McKaygeneral.pdf, 2019.

[L22] Pitkänen M. Trying to understand why ramified primes are so special physically. Available at: http://tgdtheory.fi/public_html/articles/ramified.pdf, 2019.

[L23] Pitkänen M. Twistor lift of TGD and WCW geometry. Available at: http://tgdtheory.fi/public_html/articles/wcwnewest.pdf, 2019.