Quantum Control and Coordination in Bio-Systems: part II

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Abstract

This chapter is devoted to the aspects of quantum control and coordination involving the intentional action of the magnetic body and classical em and possibly Z^0 fields (as suggested by large parity breaking effects in living matter). The previous chapters are warmly recommended in order to get an overall view about basic philosophy and ideas. The general understanding of the dynamics of Kähler action provides a considerable light to how topologically quantized induced Kähler field defines templates for bio-structures and for their self-organized dynamics with self-organization understood in 4-D sense selecting 4-D time evolution patterns. Time mirror mechanism is the most convincing mechanism for realizing intentional action discovered hitherto. Also the possible role of classical Z^0 force in condensed matter and bio-chemistry is discussed.

In the original version of the chapter I did not yet know anything about zero energy ontology (ZEO), the hierarcy of Planck constants defining dark matter hierachy nor the notion of magnetic body carrying dark matter. ZEO provides justification and precise definition what negative energy signals propagating into past are. The notion of magnetic body containing macroscopic quantum phases responsible for bio-control, and the fact that dark matter would reside at magnetic flux tubes, motivate the hypothesis that living matter is actually dark matter with the large value of Planck constant determining the characteristic time and length scales of the conscious system.

1 Introduction

This chapter is devoted to the aspects of quantum control and coordination involving the intentional action of the magnetic body and classical em and Z^0 fields. The previous chapters are warmly recommended in order to get an overall view about basic philosophy and ideas. The general understanding of the dynamics of Kähler action provides a considerable light to how topologically quantized induced Kähler field defines templates for bio-structures and for their self-organized dynamics. Time mirror mechanism is the most convincing mechanism for realizing intentional action discovered hitherto. The scalar wave pulses of Tesla might have TGD counterpart and provide perhaps the most elegant manner to transform intentions to actions. Also the possible role of classical Z^0 force in condensed matter and bio-chemistry is discussed.

1.1 Preferred Extremals Of Kähler Action, Thermodynamics, And Biology

The vanishing of Lorentz 4-force for the induced Kähler field means that the vacuum 4-currents are in a mechanical equilibrium. Lorentz 4-force vanishes for all known solutions of field equations which inspires the hypothesis that at least the preferred extremals of Kähler action satisfy the condition. The vanishing of the Lorentz 4-force in turn implies local conservation of the ordinary energy momentum tensor. The corresponding condition is implied by Einstein's equations in General Relativity. The hypothesis would mean that the solutions of field equations are what might be called generalized Beltrami fields. The condition implies that vacuum currents can be non-vanishing only provided the dimension D_{CP_2} of the CP_2 projection of the space-time surface is less than four so that in the regions with $D_{CP_2} = 4$, Maxwell's vacuum equations are satisfied.

The hypothesis that Kähler current is proportional to a product of an arbitrary function ψ of CP_2 coordinates and of the instanton current generalizes Beltrami condition and reduces to it when electric field vanishes. Kähler current has vanishing divergence for $D_{CP_2} < 4$, and Lorentz 4-force indeed vanishes. The remaining task would be the explicit construction of the imbeddings of these fields and the demonstration that field equations can be satisfied.

By quantum classical correspondence the non-deterministic space-time dynamics should mimic the dissipative dynamics of the quantum jump sequence. Beltrami fields appear in physical applications as asymptotic self organization patterns for which Lorentz force and dissipation vanish. This suggests that the preferred extremals of Kähler action correspond to space-time sheets which asymptotically satisfy generalized Beltrami conditions so that one can indeed assign to the final (rather than initial!) 3-surface a unique 4-surface apart from effects related to non-determinism. Preferred extremal property stating that the extremal allows infinite number of deformations with a vanishing second variation of Kähler action abstracted to purely algebraic generalized Beltrami conditions would make sense also in the p-adic context.

This picture can be claimed to be internally contradictory since all known extremals would correspond to asymptotic self organization patterns. One should have space-time correlates also for the non-asymptotic situations.

1. The progress made in understanding the definition of the theory using the reduction to Kähler-Dirac action clarified the situation [K14]. It turned out that one must add to the Kähler-Dirac action a measurement interaction term coupling space-time geometry to conserved quantum numbers. One of the motivations for this was quantum classical correspondence. This induces also to Kähler action measurement interaction term and the asymptotic self-organization patters represented by the known extremals have the property that measurement interaction term vanishes.

   A further crucial step was the realization that well-definedness of em charge for the modes of induced spinor field forces their localization to 2-D surfaces in the generic case. These surfaces carry vanishing induced gauge fields and possibly also Z^0 field and naturally so above weak scale. This resolves problems related to the possible large parity breaking effects and makes strings part of TGD. One might understand large parity breaking effects in living manner since for large values of $h_{eff} = n \times h$ weak scale is scaled up.

2. Also the long-standing issue relating to the identification of preferred extremals playing the role of Bohr orbits in positive energy ontology (in zero energy ontology Bohr orbit like behavior would mean strong correlations between the 3-surfaces at the opposite boundaries of causal diamond (CD)) and implying quantum holography was resolved. The preferred extremals defining the analogs of Bohr orbits must be critical in the sense of having an infinite number of deformations for which the second variation of Kähler action vanishes. The criticality of Kähler action would thus the basic dynamical principle of space-time dynamics and provide space-time correlate for quantum criticality required by quantum classical correspondence. Purely number theoretic conditions in turn lead to the conclusion that space-time surfaces must be hyper-quaternionic in the sense that the Kähler-Dirac gamma matrices span associative or co-associative plane at each point of the space-time surface. "Co-" means that the orthogonal complement of this plane is hyper-quaternionic (associative). Whether criticality and associativity (co-associativity) are consistent is not quite clear.

The intricate topological structures of DNA, RNA, and protein molecules are known to have a deep significance besides their chemical structure, and they could even define something analogous to the genetic code. Usually the topology and geometry of bio-molecules is believed to reduce to chemistry. TGD suggests that topologically quantized generalized Beltrami fields with space-like Kähler current serve as templates for the formation of bio-molecules and bio-structures in general. Indeed, Beltrami fields can be extremely complex but at the same time they are highly organized and ordered structures. The dynamics of bio-systems could in turn utilize periodic generalized Beltrami fields with time-like Kähler current as templates. There could even exist a mapping from the topology of magnetic flux tube structures serving as templates for bio-molecules to the templates of self-organized dynamics.

Thus the natural conjecture is that topologically quantized many-sheeted magnetic and Z^0 magnetic generalized Beltrami fields serve as templates for the helical molecules populating living matter, and explain both chirality selection, the complex linking and knotting of DNA and protein molecules, and even the extremely complex and self-organized dynamics of biological systems at the molecular level.

1.2 Time Mirror Mechanism As A Fundamental Mechanism Transforming Intentions To Actions

1.2.1 What causality means in TGD framework?

In order to minimize confusion it is in order to clarify the various meanings that one can give to causality in TGD framework.

1. At the level of space-time surfaces the criticality of the preferred extremals defines dynamics of the space-time surfaces and defines the causality of passive events at classical level. Induced spinors (spinors of the 8-D imbedding space restricted to the space-time surface) obey

the super-symmetric variant of field equations for the space-time surface and single particle Schrödinger equation can be identified as the non-relativistic limit for the dynamics of the induced spinor fields. The finite size of the space-time sheet defines naturally the notions of coherence length and time for both classical fields and spinor fields. In both cases classical determinism is broken in its naive form. For p-adic space-time sheets p-adic variants of field equations hold true and have the inherent p-adic non-determinism.

2. At configuration space ("world of classical worlds" (WCW)) level general coordinate invariance together with huge super-conformal invariance related symmetries can be said to dictate the behavior configuration space spinor fields playing a role analogous to quantum states of quantum field theories. If the naive classical determinism of Kähler were not broken, the physics would reduce to the boundary of the future light cone, the moment of big bang and time would be lost as in the canonical quantization of General Relativity. Fortunately this does not happen.

3. Quantum jumps can be said to realize the causality with respect to the subjective time, the causality of deeds. Selves can be seen as self-organization patterns acting as causal agents. At this level system's behavior is based on rules analogous to those governing the behavior of statistical cellular automatons and are a result of self-organization. The laws are not absolute but analogous to traffic rules obeyed or possibly disobeyed by intentional agents.

A further question concerns causal agents: everyday thinking suggests that deeds indeed have doers. In quantum consciousness theories based on standard quantum measurement theory doers are "observers" somewhere outside. In TGD causal agents are rather abstract: ensembles of quantum jumps deciding to some degree what kind of quantum jump they want to add to the ensemble defining them.

1.2.2 Materialization of intentions

Em fields, in particular ELF em fields, are crucial for the TGD inspired model of brain and a natural assumption is that p-adic–real phase transitions occur also for massless extremals (MEs).

A concrete picture about the materialization of intentions emerges, when one asks how a precisely targeted intention could be realized at the atomic or molecular level. The basic point is that molecules can only intend to make simple quantum transitions.

1. If the transition occurs to a lower energy state it can occur spontaneously whereas the transitions to a higher energy states cannot. Spontaneous transitions mask the possibly occurring intended transitions so that only the transitions which cannot occur spontaneously allow precisely targeted intention.

2. What would happen is that first a p-adic ME representing the intention to perform the transition is generated. Then the transition occurs and conservation laws require that the p-adic ME is transformed to a negative energy ME in the transition. Physical intuition suggests that the p-adic ME and the corresponding real ME resemble each other maximally in the sense that they go through the same rational imbedding space points in some p-adic resolution and with respect to the p-adic topology which is effective topology In the case of the real ME.

3. Quite generally, it seems that intention can be realized in a precisely targeted manner only for the transitions which cannot occur spontaneously, and thus involve the emission of negative energy MEs.

4. The generation of negative energy MEs utilizes the buy now-let others pay mechanism of metabolism, which implies extreme flexibility. Of course, there must exist an unselfish self, which is able to pay and this puts severe constraints on the mechanism.

1.2.3 Time mirror mechanism, scalar wave pulses, and wormhole magnetic fields

Many-sheeted space-time makes possible many-sheeted lasers since cold space-time sheets can contain Bose-Einstein condensates of ions and their Cooper pairs. If the system contains population inverted many-sheeted laser for which the increment of zero point kinetic energy corresponds to the energy of photons associated with negative energy MEs, the absorption of negative energy photons gives rise to a phase transition like dropping of particles to larger space-time sheet by the induced emission mechanism, and the control signal represented by negative energy MEs can be amplified if a critical number of particles drops to the larger space-time sheet. This control mechanism allows an instantaneous motor control in which intention is transformed to desired represented by negative energy MEs and generates in geometric past a reaction representing the desired response, say neuronal activity giving rise to motor action. This process probably involves entire hierarchy of magnetic selves realizing their intentions as desires communicated to lower level magnetic selves and the lowest level corresponds to the regions of brain responsible for liberating metabolic energy.

The simplest possibility is that the transformation of the intention to action corresponds to p-adic-to-real phase transition for negative energy topological light ray. A generation of p-adic scalar wave pulse transformed to real one is an alternative mechanism assuming that scalar wave pulses are possible in TGD framework in some sense.

Are scalar pulses then possible in TGD? This might not be the case at the level of single space-time sheet. Many-sheeted space-time however allows to have parallel MEs with pulses travelling in opposite spatial directions. The test particle experiences the the sum of the effects caused by the two MEs and effectively the induced gauge potentials sum up. This gives rise to to a standing wave lasting for some time - that is scalar wave pulse. The effect is like that caused by scalar wave pulse and behaves effectively like massive particle. Pulse can carry charges since MEs can carry light-like current whose effects correspond to their sum - charge density but vanishing current in the rest system.

When scalar wave pulse moves in matter, charges end up to the space-time sheet of the scalar wave pulse and accelerate without dissipation. Instead of brehmstrahlung the accelerated charges emit negative energy "acceleration radiation" having negative energy MEs as space-time correlates. Since dissipation is negligible this leads to a generation of a strong negative energy signal. The resulting negative energy photons in turn induce the phase-transition like dropping of particles of population inverted many-sheeted laser to larger space-time sheets liberating a beam of positive energy photons which is much more intense than the control signal consisting of negative energy photons.

A good guess is that scalar wave pulses provide a fundamental control mechanism in living matter, and that nerve pulse represents only a special case of this control mechanism. p-Adic length scale hypothesis suggests the existence of a hierarchy of cognitive codes such that $p \simeq 2^k$, k integer, corresponds to a hierarchy of cognitive codes such that the code word has duration given by n-ary p-adic time scale $T(n,k)$, and the number of bits is a factor of k. These codes allow both pulse representations and frequency representations. For pulse representations bit 1/0 is represented by the presence/absence of scalar wave pulse. For frequency representations bit 1/0 would correspond to Fourier component with particular harmonic of fundamental frequency $f(n,k) = 1/T(n,k)$ above or below critical intensity. Pulse representations would be ideal for a precise bio-control whereas frequency representations might be ideal for communications of data from brain to magnetic body.

Intentions could be transformed also to actions by generation of magnetic flux tubes: so called wormhole magnetic fields correspond to pairs of magnetic flux tubes having opposite time orientations and therefore also opposite energies. Wormhole magnetic fields could be created by first generating their p-adic counterparts, and then transforming them to their real counterparts in quantum jump. The phase transition like changes of EEG spectrum involving emergence or disappearance of EEG band might be due to the generation of wormhole magnetic fields giving rise to EEG resonance frequencies via cyclotron transitions and thus represent motor actions of magnetic body [K10, K30]. Wormhole magnetic fields are discussed in detail in [K37].

1.3 Electrets And Scalar Waves Of Tesla

Living matter is full of electrets. Basic examples are micro-tubuli carrying a longitudinal electric field and cell membrane carrying a transversal electric field. One can see electret as a structure consisting of a topological field quantum of electric field plus atomic space-time sheets carrying ordinary bio-matter. Electrets carrying an electric field which has in a good approximation a constant magnitude, are indeed basic solutions of the field equations, and are in a well defined sense dual to the magnetic flux tubes. This duality reflects the fundamental duality of quantum TGD itself analogous to the duality of super string theories but having different physical content. Quantum criticality of TGD predicts that space-time sheets carrying electric field *resp.* magnetic fields with negative *resp.* positive Kähler action are like two phases, say water and ice, at the critical point. What is interesting is that electret type solutions contain as a special case electric pulses propagating with light velocity. These solutions are identifiable as TGD counterparts of Tesla's scalar waves having electric field in the direction of propagation. These solutions are not possible in Maxwell's electrodynamics. Bio-systems might use scalar waves for communication and control purposes. For instance, the generation of nerve pulse might induce scalar wave which in turn could induce nerve pulses and this could lead to a cascade of coherent neural firing. Second interesting aspect is that electret type solutions carry strong classical gravitational fields at their boundaries and the coupling of the classical gravitation to the field energy is given essentially by the square of CP_2 radius squared and is thus about 10^7 times stronger than the coupling of gravitons to the ordinary matter. Hence classical gravitation might be important for the functioning of living matter. The spin glass degeneracy broken only by classical gravitational energy suggests the same.

1.4 Ideas Related To Dark Matter And Living Matter

I ended up with the idea about quantization of Planck constant and the identification of dark matter as phase with a non-standard value of Planck constant after having learned about the work of Da Rocha and Nottale. After that ideas developed rapidly and led to a profound generalization of the notion of imbedding space and the idea about dark matter as being responsible for the properties of living matter emerged.

1.4.1 Dark matter as a macroscopic quantum phase with gigantic Planck constant

D. Da Rocha and Laurent Nottale, the developer of Scale Relativity, have ended up with an highly interesting quantum theory like model for the evolution of astrophysical systems [E2] (I am grateful for Victor Christianto for informing me about the article). The model is simply Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant

$$\hbar \quad \rightarrow \quad \hbar_{gr} = \frac{GmM}{v_0} \quad . \tag{1.1}$$

Here I have used units $\hbar = c = 1$. v_0 is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. The peak orbital velocity of stars in galactic halos is 142 ± 2 km/s whereas the average velocity is 156 ± 2 km/s. Also subharmonics and harmonics of v_0 seem to appear.

The model makes fascinating predictions which hold true. For instance, the radii of planetary orbits fit nicely with the prediction of the hydrogen atom like model. The inner solar system (planets up to Mars) corresponds to v_0 and outer solar system to $v_0/5$.

It is important to notice that effectively a multiplication $n \rightarrow 5n$ of the principal quantum number is in question in the case of outer planets. If one accepts the interpretation that visible matter has concentrated around dark matter, which is in macroscopic quantum phase around Bohr orbits, this allows to consider also the possibility that $\hbar_{gr}$ has same value for all planets.

1. Some external gravitational perturbations have kicked dark matter from inner orbits to $n \; mod \; 5 = 0$ orbits. Gravitational perturbations might have caused the same for visible matter. The fact that the tilt angles of Earth and outer planets other than Pluto are nearly the same suggests that the orbits of these planets might be an outcome of some violent quantum process for dark matter preserving the orbital plane in a good approximation but

kicking dark matter from $n = 5$ orbit of Earth to the orbits $n = 5k$, $k = 2, .., 7$. Pluto might in turn have experienced some violent collision changing its orbital plane.

2. There could exist at least small amounts of dark matter at all orbits but visible matter is concentrated only around orbits containing some critical amount of dark matter and these orbits satisfy $n = 5k$, $k = 2, 3, ...$ for some reason.

The predictions for the distribution of major axis and eccentricities have been tested successfully also for exo-planets. Also the periods of 3 planets around pulsar PSR B1257+12 fit with the predictions with a relative accuracy of few hours/per several months. Also predictions for the distribution of stars in the regions where morphogenesis occurs follow from the Schödinger equation.

What is important is that there are no free parameters besides v_0. In [E2] a wide variety of astrophysical data is discussed and it seem that the model works and has already now made predictions which have been later verified. A rather detailed model for the formation of solar system making quantitatively correct predictions follows from the study of inclinations and eccentricities predicted by the Bohr rules: the model proposed seems to differ from that of Nottale which makes predictions for the probability distribution of eccentricities and inclinations.

I had proposed already earlier the possibility that Planck constant is quantized. The inverse of the gravitational Planck constant could correspond a gravitational perturbation of this as $1/\hbar_{gr} = v_0/GMm$. The general philosophy would be that when the quantum system would become non-perturbative, a phase transition increasing the value of $\hbar$ occurs to preserve the perturbative character.

TGD predicts correctly the value of the parameter v_0 assuming that cosmic strings and their decay remnants are responsible for the dark matter. The harmonics of v_0 can be understood as corresponding to perturbations replacing cosmic strings with their n-branched coverings so that tension becomes n^2-fold: much like the replacement of a closed orbit with an orbit closing only after n turns. $1/n$-sub-harmonic would result when a magnetic flux tube split into n disjoint magnetic flux tubes.

The study of inclinations (tilt angles with respect to the Earth's orbital plane) leads to a concrete model for the quantum evolution of the planetary system. Only a stepwise breaking of the rotational symmetry and angular momentum Bohr rules plus Newton's equation (or geodesic equation) are needed, and gravitational Schrödinger equation holds true only inside flux quanta for the dark matter.

1. During pre-planetary period dark matter formed a quantum coherent state on the (Z^0) magnetic flux quanta (spherical cells or flux tubes). This made the flux quantum effectively a single rigid body with rotational degrees of freedom corresponding to a sphere or circle (full SO(3) or SO(2) symmetry).

2. In the case of spherical shells associated with inner planets the $SO(3) \to SO(2)$ symmetry breaking led to the generation of a flux tube with the inclination determined by m and j and a further symmetry breaking, kind of an astral traffic jam inside the flux tube, generated a planet moving inside flux tube. The semiclassical interpretation of the angular momentum algebra predicts the inclinations of the inner planets. The predicted (real) inclinations are 6 (7) resp. 2.6 (3.4) degrees for Mercury resp. Venus). The predicted (real) inclination of the Earth's spin axis is 24 (23.5) degrees.

3. The $v_0 \to v_0/5$ transition allowing to understand the radii of the outer planets in the model of Da Rocha and Nottale can be understood as resulting from the splitting of (Z^0) magnetic flux tube to five flux tubes representing Earth and outer planets except Pluto, whose orbital parameters indeed differ dramatically from those of other planets. The flux tube has a shape of a disk with a hole glued to the Earth's spherical flux shell.

It is important to notice that effectively a multiplication $n \to 5n$ of the principal quantum number is in question. This allows to consider also alternative explanations. Perhaps external gravitational perturbations have kicked dark matter from the orbit or Earth to $n = 5k$, $k = 2, 3, ..., 7$ orbits: the fact that the tilt angles for Earth and all outer planets except Pluto are nearly the same, supports this explanation. Or perhaps there exist at least small amounts of dark matter at

all orbits but visible matter is concentrated only around orbits containing some critical amount of dark matter and these orbits satisfy $n\ mod\ 5 = 0$ for some reason.

The most interesting predictions from the point of view of living matter are following.

1. The dark matter is still there and forms quantum coherent structures of astrophysical size. In particular, the (Z^0) magnetic flux tubes associated with the planetary orbits define this kind of structures. The enormous value of h_{gr} makes the characteristic time scales of these quantum coherent states extremely long and implies macro-temporal quantum coherence in human and even longer time scales.

2. The rather amazing coincidences between basic bio-rhythms and the periods associated with the orbits in solar system suggest that the frequencies defined by the energy levels of the gravitational Schrödinger equation might entrain with various biological frequencies such as the cyclotron frequencies associated with the magnetic flux tubes. For instance, the period associated with $n = 1$ orbit in the case of Sun is 24 hours within experimental accuracy for v_0. Second example is the mysterious 5 second time scale associated with the Comorosan effect [I11, I3].

1.4.2 How the scaling of $\hbar$ affects physics and how to detect dark matter?

It is relatively easy to deduce the basic implications of the scaling of $\hbar$.

1. If the rate for the process is non-vanishing classically, it is not affected in the lowest order. For instance, scattering cross sections for say electron-electron scattering and e^+e^- annihilation are not affected in the lowest order since the increase of Compton length compensates for the reduction of α_{em}. Photon-photon scattering cross section, which vanishes classically and is proportional to $\alpha_{em}^4\hbar^2/E^2$, scales down as $1/\hbar^2$.

2. Higher order corrections coming as powers of the gauge coupling strength α are reduced since $\alpha = g^2/4\pi\hbar$ is reduced. Since one has $\hbar_s/\hbar = \alpha Q_1Q_2/v_0$, αQ_1Q_2 is effectively replaced with a universal coupling strength v_0. In the case of QCD the paradoxical sounding implication is that α_s would become very small.

1.4.3 Dark matter as quantum controller of ordinary matter

The notion of magnetic body containing macroscopic quantum phases responsible for bio-control, and the fact that dark matter would reside at magnetic flux tubes, motivate the hypothesis that living matter is actually dark matter with the large value of Planck constant determining the characteristic time and length scales of the conscious system. Complex conformal weights for single particles states and closely related to the zeros of Riemann Zeta would make the many-particle system living. p-Adic fractality allows to deduce rather striking similarities between biology, cosmology, and hadron physics.

One important implication is the possibility to relate the hierarchy of the time scales of consciousness defined by the effective durations of quantum jumps to the hierarchy of Planck constants. A beautiful mathematical formulation in terms of von Neumann algebras [A7, A5] as a hierarchy of quantum states emerges [K36]. The lowest level states represents ordinary matter whereas higher levels provide self representations of the dynamics of the system with S-matrix coding for the quantum physical laws represented as entanglement coefficients between positive and negative energy states forming states with vanishing net quantum numbers. The general construction of S-matrix gives also the Feynman rules for self representations and means a precise formulation of the quantum dynamics of cognition.

A refinement to the previously developed model of cold fusion [K32, K9] results in terms of a phase transition increasing the Compton length of protons and explains the known strange violations of standard nuclear physics rules [C2]. Sono-fusion [C4] can be seen as a special case of cold fusion. The fact that nuclear transmutations are reported to occur in living matter [C1] suggests that this phase might be important for living matter. Also the claimed properties of so called mono-atomic elements [H1] fit nicely with an interpretation as "partially dark" matter.

To sum up, the riddle of life, the riddle of dark matter, and the mysterious ability of living matter to behave like macroscopic quantum system despite the fact that ordinary quantum physics

does not allow this, might have common very simple solution: $\hbar$ is dynamical rather than God given.

It must be added that the ideas about dark matter emerged about decade later than the first version of this chapter was written. I have not seen sensible to try to insert the dark matter related ideas to the existing text and this means that the representation is somewhat lopsided and partially out of date and should be taken as a documentary about how ideas have developed rather than a final summary.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L2].

2 Preferred Extremals Of Kähler Action, Second Law Of Thermodynamics, And Bio-systems

In this section field equations and their physical interpretation and relevance for bio-systems are discussed. Quantum classical correspondence suggests that the non-deterministic dynamics of Kähler action makes possible self-referential dynamics in the sense that larger space-time sheet perform smoothed out mimicry of the dynamics at smaller space-time sheets. The fact that the divergence of the energy momentum tensor, Lorentz 4-force, does not vanish in general makes possible the mimicry of even dissipation and of the second law. For asymptotic self organization patterns for which dissipation is absent the Lorentz 4-force must vanish. This condition is guaranteed if Kähler current is proportional to the instanton current in the case that CP_2 projection of the space-time sheet is smaller than four and vanishes otherwise. An attractive identification for the vanishing of Lorentz 4-force is as a condition equivalent with preferred extremal property of Kähler action. In General Relativity this condition means vanishing of covariant divergence of energy momentum tensor leading to Einstein's equations.

What preferred extremal property means is however not at all obvious. Absolute minimization of Kähler action was the first guess. The notion of absolute minimization does not however make sense in p-adic context unless one manages to reduce it to purely algebraic conditions. Therefore it is better to talk just about preferred extremals of Kähler action and accept as the fact that there are several proposals for what this notion could mean. For instance, one can consider the identification of space-time surface as quaternionic sub-manifold meaning that tangent space of space-time surface can be regarded as quaternionic sub-manifold of complexified octonions defining tangent space of imbedding space. One manner to define "quaternionic sub-manifold" is by introducing octonionic representation of imbedding space gamma matrices identified as tangent space vectors. It must be also assumed that the tangent space contains a preferred complex (commutative) subspace at each point and defining an integrable distribution having identification as string world sheet (also slicing of space-time sheet by string world sheets can be considered). Associativity and commutativity would define the basic dynamical principle. A closely related approach is based on so called Hamilton-Jacobi structure [K2] defining also this kind of slicing and the approaches could be equivalent. A further approach is based on the identification of preferred extremal property as quantum criticality [K2].

For a vanishing Kähler electric field the topologication of the Kähler current means that Kähler magnetic field is so called Beltrami field, that is an eigen vector of curl operator so that field pattern is typically helical unless the Kähler current vanishes. Beltrami field is characterized by a chirality defined by the relative sign of the current and magnetic field, which means parity breaking. Beltrami fields appear in hydrodynamics and magnetohydrodynamics, and a natural guess is that many-sheeted magnetic and Z^0 magnetic Beltrami fields and their generalizations serve as templates for the helical molecules populating living matter and explain both chirality selection and complex linking and knotting of DNA and protein molecules.

2.1 Field Equations

The requirement that Kähler action is stationary leads to the following field equations in the interior of the four-surface

$$\begin{aligned} D_\beta(T^{\alpha\beta}h^k_\alpha) &- j^\alpha J_\alpha{}^\beta J^k_l \partial_\beta h^l = 0 \ , \\ T^{\alpha\beta} &= J^{\nu\alpha}J_\nu{}^\beta - \frac{1}{4}g^{\alpha\beta}J^{\mu\nu}J_{\mu\nu} \ . \end{aligned} \tag{2.1}$$

Here $T^{\alpha\beta}$ denotes the traceless canonical energy momentum tensor associated with the Kähler action. An equivalent form for the first equation is

$$\begin{aligned} T^{\alpha\beta}H^k_{\alpha\beta} &+ j^\alpha(J_\alpha{}^\beta h^k_{\ l} - J^k_l\partial_\alpha h^l) = 0 \ . \\ H^k_{\alpha\beta} &= D_\beta\partial_\alpha h^k \ . \end{aligned} \tag{2.2}$$

$H^k_{\alpha\beta}$ denotes the components of the second fundamental form and $j^\alpha = D_\beta J^{\alpha\beta}$ is the gauge current associated with the Kähler field.

On the boundaries of X^4 the field equations are given by the expression

$$T^{n\beta}\partial_\beta h^k + J^{n\alpha}(J_\alpha{}^\beta\partial_\beta h^k - J^k_l)\partial_\alpha h^k) = 0 \ . \tag{2.3}$$

A general manner manner to solve the field equations on the boundaries is to assume that the induced Kähler field associated with the boundaries vanishes:

$$J_{\alpha\beta}(\delta) = 0 \ . \tag{2.4}$$

In this case the energy-momentum tensor vanishes identically on the boundary component. On the outer boundaries of the 3-surface this solution ansatz makes sense only provided the gauge fluxes and gravitational flux (defined by Newtonian potential in the non-relativistic limit) associated with the matter in the interior go somewhere. The only possibility seems to be that 3-surface is topologically condensed on a larger 3-surface and feeds its gauge fluxes to the larger 3-surface via # contacts (topological sum). This assumption forces the concept of topological condensate defined as a hierarchical structure of 3-surfaces condensed on each other and thus giving rise to the many-sheeted space-time.

An important thing to notice is that the boundary conditions do not force the normal components of the gauge fields to zero even if the Kähler electric field vanishes near the boundaries. This makes in principle possible gauge charge renormalization classically resulting from the hierarchical structure of the topological condensation.

2.2 Topologization And Light-Likeness Of The Kähler Current As Alternative Manners To Guarantee Vanishing Of Lorentz 4-Force

The general solution of 4-dimensional Einstein-Yang Mills equations in Euclidian 4-metric relies on self-duality of the gauge field, which topologizes gauge charge. This topologization can be achieved by a weaker condition, which can be regarded as a dynamical generalization of the Beltrami condition. An alternative manner to achieve vanishing of the Lorentz 4-force is light-likeness of the Kähler 4-current. This does not require topologization.

2.2.1 Topologization of the Kähler current for $D_{CP_2} = 3$: covariant formulation

The condition states that Kähler 4-current is proportional to the instanton current whose divergence is instanton density and vanishes when the dimension of CP_2 projection is smaller than four: $D_{CP_2} < 4$. For $D_{CP_2} = 2$ the instanton 4-current vanishes identically and topologization is equivalent with the vanishing of the Kähler current.

$$j^\alpha \equiv D_\beta J^{\alpha\beta} = \psi \times j^\alpha_I = \psi \times \epsilon^{\alpha\beta\gamma\delta}J_{\beta\gamma}A_\delta \ . \tag{2.5}$$

Here the function ψ is an arbitrary function $\psi(s^k)$ of CP_2 coordinates s^k regarded as functions of space-time coordinates. It is essential that ψ depends on the space-time coordinates through the

CP_2 coordinates only. Hence the representation as an imbedded gauge field is crucial element of the solution ansatz.

The field equations state the vanishing of the divergence of the 4-current. This is trivially true for instanton current for $D_{CP_2} < 4$. Also the contraction of $\nabla\psi$ (depending on space-time coordinates through CP_2 coordinates only) with the instanton current is proportional to the winding number density and therefore vanishes for $D_{CP_2} < 4$.

The topologization of the Kähler current guarantees the vanishing of the Lorentz 4-force. Indeed, using the self-duality condition for the current, the expression for the Lorentz 4-force reduces to a term proportional to the instanton density:

$$\begin{aligned} j^\alpha J_{\alpha\beta} &= \psi \times j_I^\alpha J_{\alpha\beta} \\ &= \psi \times \epsilon^{\alpha\mu\nu\delta} J_{\mu\nu} A_\delta J_{\alpha\beta} \ . \end{aligned} \tag{2.6}$$

Since all vector quantities appearing in the contraction with the four-dimensional permutation tensor are proportional to the gradients of CP_2 coordinates, the expression is proportional to the instanton density, and thus winding number density, and vanishes for $D_{CP_2} < 4$.

Remarkably, the topologization of the Kähler current guarantees also the vanishing of the term $j^\alpha J^{k_l} \partial_\alpha s^k$ in the field equations for CP_2 coordinates. This means that field equations reduce in both M_+^4 and CP_2 degrees of freedom to

$$T^{\alpha\beta} H^k_{\alpha\beta} = 0 \ . \tag{2.7}$$

These equations differ from the equations of minimal surface only by the replacement of the metric tensor with energy momentum tensor. The earlier proposal that quaternion conformal invariance in a suitable sense might provide a general solution of the field equations could be seen as a generalization of the ordinary conformal invariance of string models. If the topologization of the Kähler current implying effective dimensional reduction in CP_2 degrees of freedom is consistent with quaternion conformal invariance, the quaternion conformal structures must differ for the different dimensions of CP_2 projection.

2.2.2 Topologization of the Kähler current for $D_{CP_2} = 3$: non-covariant formulation

In order to gain a concrete understanding about what is involved it is useful to repeat these arguments using the 3-dimensional notation. The components of the instanton 4-current read in three-dimensional notation as

$$\overline{j}_I = \overline{E} \times \overline{A} + \phi \overline{B} \ , \quad \rho_I = \overline{B} \cdot \overline{A} \ . \tag{2.8}$$

The self duality conditions for the current can be written explicitly using 3-dimensional notation and read

$$\begin{aligned} \nabla \times \overline{B} - \partial_t \overline{E} &= \overline{j} = \psi \overline{j}_I = \psi \left(\phi \overline{B} + \overline{E} \times \overline{A} \right) \ , \\ \nabla \cdot E &= \rho = \psi \rho_I \ . \end{aligned} \tag{2.9}$$

For a vanishing electric field the self-duality condition for Kähler current reduces to the Beltrami condition

$$\nabla \times \overline{B} = \alpha \overline{B} \ , \quad \alpha = \psi\phi \ . \tag{2.10}$$

The vanishing of the divergence of the magnetic field implies that α is constant along the field lines of the flow. When ϕ is constant and $\overline{A}$ is time independent, the condition reduces to the Beltrami condition with $\alpha = \phi = constant$, which allows an explicit solution [B2].

One can check also the vanishing of the Lorentz 4-force by using 3-dimensional notation. Lorentz 3-force can be written as

$$\rho_I \overline{E} + \overline{j} \times \overline{B} = \psi \overline{B} \cdot \overline{AE} + \psi \left(\overline{E} \times \overline{A} + \phi \overline{B} \right) \times \overline{B} = 0 \ . \tag{2.11}$$

The fourth component of the Lorentz force reads as

$$\overline{j} \cdot \overline{E} = \psi \overline{B} \cdot \overline{E} + \psi \left(\overline{E} \times \overline{A} + \phi \overline{B} \right) \cdot \overline{E} = 0 \ . \tag{2.12}$$

The remaining conditions come from the induction law of Faraday and could be guaranteed by expressing $\overline{E}$ and $\overline{B}$ in terms of scalar and vector potentials.

The density of the Kähler electric charge of the vacuum is proportional to the the helicity density of the so called helicity charge $\rho = \psi \rho_I = \psi B \cdot A$. This charge is topological charge in the sense that it does not depend on the induced metric at all. Note the presence of arbitrary function ψ of CP_2 coordinates.

Further conditions on the functions appearing in the solution ansatz come from the 3 independent field equations for CP_2 coordinates. What is remarkable that the generalized self-duality condition for the Kähler current allows to understand the general features of the solution ansatz to very high degree without any detailed knowledge about the detailed solution. The question whether field equations allow solutions consistent with the self duality conditions of the current will be dealt later. The optimistic guess is that the field equations and topologization of the Kähler current relate to each other very intimately.

2.2.3 Vanishing or light likeness of the Kähler current guarantees vanishing of the Lorentz 4-force for $D_{CP_2} = 2$

For $D_{CP_2} = 2$ one can always take two CP_2 coordinates as space-time coordinates and from this it is clear that instanton current vanishes so that topologization gives a vanishing Kähler current. In particular, the Beltrami condition $\nabla \times \overline{B} = \alpha \overline{B}$ is not consistent with the topologization of the instanton current for $D_{CP_2} = 2$.

$D_{CP_2} = 2$ case can be treated in a coordinate invariant manner by using the two coordinates of CP_2 projection as space-time coordinates so that only a magnetic or electric field is present depending on whether the gauge current is time-like or space-like. Light-likeness of the gauge current provides a second manner to achieve the vanishing of the Lorentz force and is realized in case of massless extremals having $D_{CP_2} = 2$: this current is in the direction of propagation whereas magnetic and electric fields are orthogonal to it so that Beltrami conditions is certainly not satisfied.

2.2.4 Under what conditions topologization of Kähler current yields Beltrami conditions?

Topologization of the Kähler 4-current gives rise to magnetic Beltrami fields if either of the following conditions is satisfied.

1. The $\overline{E} \times \overline{A}$ term contributing besides $\phi \overline{B}$ term to the topological current vanishes. This requires that $\overline{E}$ and $\overline{A}$ are parallel to each other

$$\overline{E} \quad = \quad \nabla \Phi - \partial_t \overline{A} = \beta \overline{A} \tag{2.13}$$

   This condition is analogous to the Beltrami condition. Now only the 3-space has as its coordinates time coordinate and two spatial coordinatesand$\overline{B}$ is replaced with $\overline{A}$. Since E and B are orthogonal, this condition implies $\overline{B} \cdot \overline{A} = 0$ so that Kähler charge density is vanishing.

2. The vector $\overline{E} \times \overline{A}$ is parallel to $\overline{B}$.

$$\overline{E} \times \overline{A} \quad = \quad \beta \overline{B} \tag{2.14}$$

The condition is consistent with the orthogonality of $\overline{E}$ and $\overline{B}$ but implies the orthogonality of $\overline{A}$ and $\overline{B}$ so that electric charge density vanishes

In both cases vector potential fails to define a contact structure since $B \cdot A$ vanishes (contact structures are discussed briefly below), and there exists a global coordinate along the field lines of $\overline{A}$ and the full contact structure is lost again. Note however that the Beltrami condition for magnetic field means that magnetic field defines a contact structure irrespective of whether $\overline{B} \cdot \overline{A}$ vanishes or not. The transition from the general case to Beltrami field would thus involve the replacement

$$(\overline{A}, \overline{B}) \rightarrow_{\nabla\times} (\overline{B}, \overline{j})$$

induced by the rotor.

One must of course take these considerations somewhat cautiously since the inner product depends on the induced 4-metric and it might be that induced metric could allow small vacuum charge density and make possible genuine contact structure.

2.2.5 Hydrodynamic analogy

The field equations of TGD are basically hydrodynamic equations stating the local conservation of the currents associated with the isometries of the imbedding space. Therefore it is intriguing that Beltrami fields appear also as solutions of ideal magnetohydrodynamics equations and as steady solutions of non-viscous incompressible flow described by Euler equations [B4].

In hydrodynamics the role of the magnetic field is taken by the velocity field. For incompressible flow occurring along the field lines of the Z^0 magnetic field the velocity field is proportional to the Z^0 magnetic field and the Beltrami condition for the velocity field reduces to that for Z^0 magnetic field. Thus the flow lines of hydrodynamic flow should directly correspond to those of Z^0 magnetic field. The generalized Beltrami flow based on the topologization of the Z^0 current would allow to model also the non-stationary incompressible non-viscous hydrodynamical flows.

It would seem that one cannot describe viscous flows using flows satisfying generalized Beltrami conditions since the vanishing of the Lorentz 4-force says that there is no local dissipation of the classical field energy. One might claim that this is not a problem since in TGD framework viscous flow could be seen as a practical description of a quantum jump sequence by replacing the corresponding sequence of space-time surfaces with a single space-time surface.

One the other hand, quantum classical correspondence requires that also dissipative effects have space-time correlates. Kähler fields, which are dissipative, and thus correspond to a non-vanishing Lorentz 4-force, represent one candidate for correlates of this kind. If this is the case, then the fields satisfying the generalized Beltrami condition provide space-time correlates only for the asymptotic self organization patterns for which the viscous effects are negligible, and also the solutions of field equations describing effects of viscosity should be possible.

One must however take this argument with a grain of salt. Dissipation, that is the transfer of conserved quantities to degrees of freedom corresponding to shorter scales, could correspond to a transfer of these quantities between different space-time sheets of the many-sheeted space-time. Here the opponent could however argue that larger space-time sheets mimic the dissipative dynamics in shorter scales and that classical currents represent "symbolically" averaged currents in shorter length scales, and that the local non-conservation of energy momentum tensor consistent with local conservation of isometry currents provides a unique manner to mimic the dissipative dynamics. This view will be developed in more detail below.

2.2.6 The stability of generalized Beltrami fields

The stability of generalized Beltrami fields is of high interest since unstable points of space-time sheets are those around which macroscopic changes induced by quantum jumps are expected to be localized.

1. Contact forms and contact structures

The stability of Beltrami flows has been studied using the theory of contact forms in three-dimensional Riemann manifolds [B3]. Contact form is a one-form A (that is covariant vector field

A_α) with the property $A \wedge dA \neq 0$. In the recent case the induced Kähler gauge potential A_α and corresponding induced Kähler form $J_{\alpha\beta}$ for any 3-sub-manifold of space-time surface define a contact form so that the vector field $A^\alpha = g^{\alpha\beta}A_\beta$ is not orthogonal with the magnetic field $B^\alpha = \epsilon^{\alpha\beta\delta}J_{\beta\gamma}$. This requires that magnetic field has a helical structure. Induced metric in turn defines the Riemann structure.

If the vector potential defines a contact form, the charge density associated with the topologized Kähler current must be non-vanishing. This can be seen as follows.

1. The requirement that the flow lines of a one-form X_μ defined by the vector field X^μ as its dual allows to define a global coordinate x varying along the flow lines implies that there is an integrating factor ϕ such that $\phi X = dx$ and therefore $d(\phi X) = 0$. This implies $dlog(\phi) \wedge X = -dX$. From this the necessary condition for the existence of the coordinate x is $X \wedge dX = 0$. In the three-dimensional case this gives $\overline{X} \cdot (\nabla \times \overline{X}) = 0$.

2. This condition is by definition not satisfied by the vector potential defining a contact form so that one cannot identify a global coordinate varying along the flow lines of the vector potential. The condition $\overline{B} \cdot \overline{A} \neq 0$ states that the charge density for the topologized Kähler current is non-vanishing. The condition that the field lines of the magnetic field allow a global coordinate requires $\overline{B} \cdot \nabla \times \overline{B} = 0$. The condition is not satisfied by Beltrami fields with $\alpha \neq 0$. Note that in this case magnetic field defines a contact structure.

Contact structure requires the existence of a vector ξ satisfying the condition $A(\xi) = 0$. The vector field ξ defines a plane field, which is orthogonal to the vector field A^α. Reeb field in turn is a vector field for which $A(X) = 1$ and $dA(X;) = 0$ hold true. The latter condition states the vanishing of the cross product $X \times B$ so that X is parallel to the Kähler magnetic field B^α and has unit projection in the direction of the vector field A^α. Any Beltrami field defines a Reeb field irrespective of the Riemannian structure.

2. Stability of the Beltrami flow and contact structures

Contact structures are used in the study of the topology and stability of the hydrodynamical flows [B3], and one might expect that the notion of contact structure and its proper generalization to the four-dimensional context could be useful in TGD framework also. An example giving some idea about the complexity of the flows defined by Beltrami fields is the Beltrami field in R^3 possessing closed orbits with all possible knot and link types simultaneously [B3] !

Beltrami flows associated with Euler equations are known to be unstable [B3]. Since the flow is volume preserving, the stationary points of the Beltrami flow are saddle points at which also vorticity vanishes and linear instabilities of Navier-Stokes equations can develop. From the point of view of biology it is interesting that the flow is stabilized by vorticity which implies also helical structures. The stationary points of the Beltrami flow correspond in TGD framework to points at which the induced Kähler magnetic field vanishes. They can be unstable by the vacuum degeneracy of Kähler action implying classical non-determinism. For generalized Beltrami fields velocity and vorticity (both divergence free) are replaced by Kähler current and instanton current.

More generally, the points at which the Kähler 4-current vanishes are expected to represent potential instabilities. The instanton current is linear in Kähler field and can vanish in a gauge invariant manner only if the induced Kähler field vanishes so that the instability would be due to the vacuum degeneracy also now. Note that the vanishing of the Kähler current allows also the generation of region with $D_{CP_2} = 4$. The instability of the points at which induce Kähler field vanish is manifested in quantum jumps replacing the generalized Beltrami field with a new one such that something new is generated around unstable points. Thus the regions in which induced Kähler field becomes weak are the most interesting ones. For example, unwinding of DNA could be initiated by an instability of this kind.

2.3 How To Satisfy Field Equations?

The topologization of the Kähler current guarantees also the vanishing of the term $j^\alpha J^{kl}\partial_\alpha s^k$ in the field equations for CP_2 coordinates. This means that field equations reduce in both M^4_+ and CP_2 degrees of freedom to

$$T^{\alpha\beta}H^k_{\alpha\beta} \;=\; 0 \;. \tag{2.15}$$

These equations differ from the equations of minimal surface only by the replacement of the metric tensor with energy momentum tensor. The earlier proposal that quaternion conformal invariance in a suitable sense might provide a general solution of the field equations could be seen as a generalization of the ordinary conformal invariance of string models. If the topologization of the Kähler current implying effective dimensional reduction in CP_2 degrees of freedom is consistent with quaternion conformal invariance, the quaternion conformal structures must differ for the different dimensions of CP_2 projection. In the following somewhat different approach is however considered utilizing the properties of Hamilton Jacobi structures of M^4_+ introduced in the study of massless extremals and contact structures of CP_2 emerging naturally in the case of generalized Beltrami fields.

2.3.1 String model as a starting point

String model serves as a starting point.

1. In the case of Minkowskian minimal surfaces representing string orbit the field equations reduce to purely algebraic conditions in light cone coordinates (u, v) since the induced metric has only the component g_{uv}, whereas the second fundamental form has only diagonal components H^k_{uu} and H^k_{vv}.

2. For Euclidian minimal surfaces (u, v) is replaced by complex coordinates $(w, \overline{w})$ and field equations are satisfied because the metric has only the component $g^{w\overline{w}}$ and second fundamental form has only components of type H^k_{ww} and $H^{\overline{k}}_{\overline{w}\overline{w}}$. The mechanism should generalize to the recent case.

2.3.2 The general form of energy momentum tensor as a guideline for the choice of coordinates

Any 3-dimensional Riemann manifold allows always a orthogonal coordinate system for which the metric is diagonal. Any 4-dimensional Riemann manifold in turn allows a coordinate system for which 3-metric is diagonal and the only non-diagonal components of the metric are of form g^{ti}. This kind of coordinates might be natural also now. When $\overline{E}$ and $\overline{B}$ are orthogonal, energy momentum tensor has the form

$$T = \begin{pmatrix} \frac{E^2+B^2}{2} & 0 & 0 & EB \\ 0 & \frac{E^2+B^2}{2} & 0 & 0 \\ 0 & 0 & \frac{-E^2+B^2}{2} & 0 \\ EB & 0 & 0 & \frac{E^2-B^2}{2} \end{pmatrix} \tag{2.16}$$

in the tangent space basis defined by time direction and longitudinal direction $\overline{E}\times\overline{B}$, and transversal directions $\overline{E}$ and $\overline{B}$. Note that T is traceless.

The optimistic guess would be that the directions defined by these vectors integrate to three orthogonal coordinates of X^4 and together with time coordinate define a coordinate system containing only g^{ti} as non-diagonal components of the metric. This however requires that the fields in question allow an integrating factor and, as already found, this requires $\nabla\times X\cdot X = 0$ and this is not the case in general.

Physical intuition suggests however that X^4 coordinates allow a decomposition into longitudinal and transversal degrees freedom. This would mean the existence of a time coordinate t and longitudinal coordinate z the plane defined by time coordinate and vector $\overline{E}\times\overline{B}$ such that the coordinates $u = t - z$ and $v = t + z$ are light like coordinates so that the induced metric would have only the component g^{uv} whereas g^{vv} and g^{uu} would vanish in these coordinates. In the transversal space-time directions complex space-time coordinate coordinate w could be introduced. Metric could have also non-diagonal components besides the components $g^{w\overline{w}}$ and g^{uv}.

2.3.3 Hamilton Jacobi structures in M^4_+

Hamilton Jacobi structure in M^4_+ can understood as a generalized complex structure combing transversal complex structure and longitudinal hyper-complex structure so that notion of holomorphy and Kähler structure generalize.

1. Denote by m^i the linear Minkowski coordinates of M^4. Let (S^+, S^-, E^1, E^2) denote local coordinates of M^4_+ defining a *local* decomposition of the tangent space M^4 of M^4_+ into a direct, not necessarily orthogonal, sum $M^4 = M^2 \oplus E^2$ of spaces M^2 and E^2. This decomposition has an interpretation in terms of the longitudinal and transversal degrees of freedom defined by local light-like four-velocities $v_\pm = \nabla S_\pm$ and polarization vectors $\epsilon_i = \nabla E_i$ assignable to light ray. Assume that E^2 allows complex coordinates $w = E^1 + iE^2$ and $\overline{w} = E^1 - iE^2$. The simplest decomposition of this kind corresponds to the decomposition ($S^+ \equiv u = t + z, S^- \equiv v = t - z, w = x + iy, \overline{w} = x - iy$).

2. In accordance with this physical picture, S^+ and S^- define light-like curves which are normals to light-like surfaces and thus satisfy the equation:

$$(\nabla S_\pm)^2 = 0 \quad .$$

   The gradients of $S_\pm$ are obviously analogous to local light like velocity vectors $v = (1, \overline{v})$ and $\tilde{v} = (1, -\overline{v})$. These equations are also obtained in geometric optics from Hamilton Jacobi equation by replacing photon's four-velocity with the gradient ∇S: this is consistent with the interpretation of massless extremals as Bohr orbits of em field. $S_\pm = constant$ surfaces can be interpreted as expanding light fronts. The interpretation of $S_\pm$ as Hamilton Jacobi functions justifies the term Hamilton Jacobi structure.

   The simplest surfaces of this kind correspond to $t = z$ and $t = -z$ light fronts which are planes. They are dual to each other by hyper complex conjugation $u = t - z \to v = t + z$. One should somehow generalize this conjugation operation. The simplest candidate for the conjugation $S^+ \to S^-$ is as a conjugation induced by the conjugation for the arguments: $S^+(t - z, t + z, x, y) \to S^-(t - z, t + z, x, y) = S^+(t + z, t - z, x, -y)$ so that a dual pair is mapped to a dual pair. In transversal degrees of freedom complex conjugation would be involved.

3. The coordinates $(S_\pm, w, \overline{w})$ define local light cone coordinates with the line element having the form

$$\begin{aligned} ds^2 &= g_{+-} dS^+ dS^- + g_{w\overline{w}} dw d\overline{w} \\ &+ g_{+w} dS^+ dw + g_{+\overline{w}} dS^+ d\overline{w} \\ &+ g_{-w} dS^- dw + g_{-\overline{w}} dS^- d\overline{w} \quad . \end{aligned} \tag{2.17}$$

   Conformal transformations of M^4_+ leave the general form of this decomposition invariant. Also the transformations which reduces to analytic transformations $w \to f(w)$ in transversal degrees of freedom and hyper-analytic transformations $S^+ \to f(S^+), S^- \to f(S^-)$ in longitudinal degrees of freedom preserve this structure.

4. The basic idea is that of generalized Kähler structure meaning that the notion of Kähler function generalizes so that the non-vanishing components of metric are expressible as

$$\begin{aligned} g_{w\overline{w}} &= \partial_w \partial_{\overline{w}} K \quad , \quad g_{+-} = \partial_{S^+} \partial_{S^-} K \quad , \\ g_{w\pm} &= \partial_w \partial_{S^\pm} K \quad , \quad g_{\overline{w}\pm} = \partial_{\overline{w}} \partial_{S^\pm} K \quad . \end{aligned} \tag{2.18}$$

   for the components of the metric. The expression in terms of Kähler function is coordinate invariant for the same reason as in case of ordinary Kähler metric. In the standard light-cone coordinates the Kähler function is given by

$$K = w_0\overline{w}_0 + uv \quad , \quad w_0 = x + iy \quad , \quad u = t - z \quad , \quad v = t + z \quad . \tag{2.19}$$

The Christoffel symbols satisfy the conditions

$$\{ {k \atop w\ \overline{w}} \} = 0 \quad , \quad \{ {k \atop +-} \} = 0 \quad . \tag{2.20}$$

If energy momentum tensor has only the components $T^{w\overline{w}}$ and T^{+-}, field equations are satisfied in M^4_+ degrees of freedom.

5. The Hamilton Jacobi structures related by these transformations can be regarded as being equivalent. Since light-like 3- surface is, as the dynamical evolution defined by the light front, fixed by the 2-surface serving as the light source, these structures should be in one-one correspondence with 2-dimensional surfaces with two surfaces regarded as equivalent if they correspond to different time=constant snapshots of the same light front, or are related by a conformal transformation of M^4_+. Obviously there should be quite large number of them. Note that the generating two-dimensional surfaces relate also naturally to quaternion conformal invariance and corresponding Kac Moody invariance for which deformations defined by the M^4 coordinates as functions of the light-cone coordinates of the light front evolution define Kac Moody algebra, which thus seems to appear naturally also at the level of solutions of field equations.

The task is to find all possible local light cone coordinates defining one-parameter families 2-surfaces defined by the condition $S_i = constant$, $i = +\ or\ = -$, dual to each other and expanding with light velocity. The basic open questions are whether the generalized Kähler function indeed makes sense and whether the physical intuition about 2-surfaces as light sources parameterizing the set of all possible Hamilton Jacobi structures makes sense.

2.3.4 Contact structure and generalized Kähler structure of CP_2 projection

In the case of 3-dimensional CP_2 projection it is assumed that one can introduce complex coordinates $(\xi, \overline{\xi})$ and the third coordinate s. These coordinates would correspond to a contact structure in 3-dimensional CP_2 projection defining transversal symplectic and Kähler structures. In these coordinates the transversal parts of the induced CP_2 Kähler form and metric would contain only components of type $g_{w\overline{w}}$ and $J_{w\overline{w}}$. The transversal Kähler field $J_{w\overline{w}}$ would induce the Kähler magnetic field and the components J_{sw} and $J_{s\overline{w}}$ the Kähler electric field.

It must be emphasized that the non-integrability of the contact structure implies that J cannot be parallel to the tangent planes of $s = constant$ surfaces, s cannot be parallel to neither A nor the dual of J, and ξ cannot vary in the tangent plane defined by J. A further important conclusion is that for the solutions with 3-dimensional CP_2 projection topologized Kähler charge density is necessarily non-vanishing by $A \wedge J \neq 0$ whereas for the solutions with $D_{CP_2} = 2$ topologized Kähler current vanishes.

Also the CP_2 projection is assumed to possess a generalized Kähler structure in the sense that all components of the metric except s_{ss} are derivable from a Kähler function by formulas similar to M^4_+ case.

$$s_{w\overline{w}} = \partial_w \partial_{\overline{w}} K \quad , \quad s_{ws} = \partial_w \partial_s K \quad , \quad s_{\overline{w}s} = \partial_{\overline{w}} \partial_s K \quad . \tag{2.21}$$

Generalized Kähler property guarantees that the vanishing of the Christoffel symbols of CP_2 (rather than those of 3-dimensional projection), which are of type $\{ {k \atop \xi\ \overline{\xi}} \}$.

$$\{ {k \atop \xi\ \overline{\xi}} \} \quad = \quad 0 \quad . \tag{2.22}$$

Here the coordinates of CP_2 have been chosen in such a manner that three of them correspond to the coordinates of the projection and fourth coordinate is constant at the projection. The upper

index k refers also to the CP_2 coordinate, which is constant for the CP_2 projection. If energy momentum tensor has only components of type T^{+-} and $T^{w\overline{w}}$, field equations are satisfied even when if non-diagonal Christoffel symbols of CP_2 are present. The challenge is to discover solution ansatz, which guarantees this property of the energy momentum tensor.

A stronger variant of Kähler property would be that also s_{ss} vanishes so that the coordinate lines defined by s would define light like curves in CP_2. The topologization of the Kähler current however implies that CP_2 projection is a projection of a 3-surface with strong Kähler property. Using $(s, \xi, \overline{\xi}, S^-)$ as coordinates for the space-time surface defined by the ansatz $(w = w(\xi, s), S^+ = S^+(s))$ one finds that g_{ss} must be vanishing so that stronger variant of the Kähler property holds true for $S^- = constant$ 3-surfaces.

The topologization condition for the Kähler current can be solved completely generally in terms of the induced metric using $(\xi, \overline{\xi}, s)$ and some coordinate of M^4_+, call it x^4, as space-time coordinates. Topologization boils down to the conditions

$$\begin{aligned} \partial_\beta(J^{\alpha\beta}\sqrt{g}) &= 0 \text{ for } \alpha \in \{\xi, \overline{\xi}, s\} \ , \\ g^{4i} &\neq 0 \ . \end{aligned} \tag{2.23}$$

Thus 3-dimensional empty space Maxwell equations and the non-orthogonality of x^4 coordinate lines and the 3-surfaces defined by the lift of the CP_2 projection.

2.3.5 A solution ansatz yielding light-like current in $D_{CP_2} = 3$ case

The basic idea is that of generalized Kähler structure and solutions of field equations as maps or deformations of canonically imbedded M^4_+ respecting this structure and guaranteeing that the only non-vanishing components of the energy momentum tensor are $T^{\xi\xi}$ and T^{s-} in the coordinates $(\xi, \overline{\xi}, s, S^-)$.

1. The coordinates (w, S^+) are assumed to holomorphic functions of the CP_2 coordinates (s, ξ)

$$S^+ = S^+(s) \ , \quad w = w(\xi, s) \ . \tag{2.24}$$

   Obviously S^+ could be replaced with S^-. The ansatz is completely symmetric with respect to the exchange of the roles of (s, w) and (S^+, ξ) since it maps longitudinal degrees of freedom to longitudinal ones and transverse degrees of freedom to transverse ones.

2. Field equations are satisfied if the only non-vanishing components of the energy momentum tensor are of type $T^{\xi\overline{\xi}}$ and T^{s-}. The reason is that the CP_2 Christoffel symbols for projection and projections of M^4_+ Christoffel symbols are vanishing for these lower index pairs.

3. By a straightforward calculation one can verify that the only manner to achieve the required structure of energy momentum tensor is to assume that the induced metric in the coordinates $(\xi, \overline{\xi}, s, S^-)$ has as non-vanishing components only $g_{\xi\overline{\xi}}$ and g_{s-}

$$g_{ss} = 0 \ , \quad g_{\xi s} = 0 \ , \quad g_{\overline{\xi} s} = 0 \ . \tag{2.25}$$

   Obviously the space-time surface must factorize into an orthogonal product of longitudinal and transversal spaces.

4. The condition guaranteeing the product structure of the metric is

$$\begin{aligned} s_{ss} &= m_{+w}\partial_s w(\xi, s)\partial_s S^+(s) + m_{+\overline{w}}\partial_s \overline{w}(\xi, s)\partial_s S^+(s) \ , \\ s_{s\xi} &= m_{+w}\partial_\xi w(\xi)\partial_s S^+(s) \ , \\ s_{s\overline{\xi}} &= m_{+w}\partial_{\overline{\xi}} w(\overline{\xi})\partial_s S^+(s) \ . \end{aligned} \tag{2.26}$$

Thus the function of dynamics is to diagonalize the metric and provide it with strong Kähler property. Obviously the CP_2 projection corresponds to a light-like surface for all values of S^- so that space-time surface is foliated by light-like surfaces and the notion of generalized conformal invariance makes sense for the entire space-time surface rather than only for its boundary or elementary particle horizons.

5. The requirement that the Kähler current is proportional to the instanton current means that only the j^- component of the current is non-vanishing. This gives the following conditions

$$\begin{aligned} j^{\xi}\sqrt{g} = \partial_\beta(J^{\xi\beta}\sqrt{g}) = 0 \ , \quad j^{\bar{\xi}}\sqrt{g} = \partial_\beta(J^{\bar{\xi}\beta}\sqrt{g}) = 0 \ , \\ j^{+}\sqrt{g} = \partial_\beta(J^{+\beta}\sqrt{g}) = 0 \ . \end{aligned} \tag{2.27}$$

Since $J^{+\beta}$ vanishes, the condition

$$\sqrt{g}j^{+} = \partial_\beta(J^{+\beta}\sqrt{g}) \quad = \quad 0 \tag{2.28}$$

is identically satisfied. Therefore the number of field equations reduces to three.

The physical interpretation of the solution ansatz deserves some comments.

1. The light-like character of the Kähler current brings in mind CP_2 extremals for which CP_2 projection is light like. This suggests that the topological condensation of CP_2 type extremal occurs on $D_{CP_2} = 3$ helical space-time sheet representing zitterbewegung. In the case of many-body system light-likeness of the current does not require that particles are massless if particles of opposite charges can be present. Field tensor has the form $(J^{\xi\bar{\xi}}, J^{\xi -}, J^{\bar{\xi}-})$. Both helical magnetic field and electric field present as is clear when one replaces the coordinates (S^+, S^-) with time-like and space-like coordinate. Magnetic field dominates but the presence of electric field means that genuine Beltrami field is not in question.

2. Since the induced metric is product metric, 3-surface is metrically product of 2-dimensional surface X^2 and line or circle and obeys product topology. If preferred extremals correspond to asymptotic self-organization patterns, the appearance of the product topology and even metric is not so surprising. Thus the solutions can be classified by the genus of X^2. An interesting question is how closely the explanation of family replication phenomenon in terms of the topology of the boundary component of elementary particle like 3-surface relates to this. The heaviness and instability of particles which correspond to genera $g > 2$ (sphere with more than two handles) might have simple explanation as absence of (stable) $D_{CP_2} = 3$ solutions of field equations with genus $g > 2$.

3. The solution ansatz need not be the most general. Kähler current is light-like and already this is enough to reduce the field equations to the form involving only energy momentum tensor. One might hope of finding also solution ansätze for which Kähler current is time-like or space-like. Space-likeness of the Kähler current might be achieved if the complex coordinates $(\xi, \bar{\xi})$ and hyper-complex coordinates (S^+, S^-) change the role. For this solution ansatz electric field would dominate. Note that the possibility that Kähler current is always light-like cannot be excluded.

4. Suppose that CP_2 projection quite generally defines a foliation of the space-time surface by light-like 3-surfaces, as is suggested by the conformal invariance. If the induced metric has Minkowskian signature, the fourth coordinate x^4 and thus also Kähler current must be time-like or light-like so that magnetic field dominates. Already the requirement that the metric is non-degenerate implies $g_{s4} \neq 0$ so that the metric for the $\xi = constant$ 2-surfaces has a Minkowskian signature. It might well be that there are no solutions with a space-like Kähler current, that the topologization of the Kähler current is equivalent with its light-likeness, and that $D_{CP_2} = 3$ solutions carry dominantly magnetic fields. Thus space-like Kähler current does not allow the lift of the CP_2 projection to be light-like.

2.3.6 Are solutions with time-like or space-like Kähler current possible in $D_{CP_2} = 3$ case?

The following ansatz gives good hopes for obtaining solutions with space-like and time-like Kähler currents.

1. Assign to light-like coordinates coordinates (T, Z) by the formula $T = S^+ + S^-$ and $Z = S^+ - S^-$. Space-time coordinates are taken to be $(\xi, \overline{\xi}, s)$ and coordinate Z. The solution ansatz with time-like Kähler current results when the roles of T and Z are changed. It will however found that same solution ansatz can give rise to both space-like and time-like Kähler current.

2. The solution ansatz giving rise to a space-like Kähler current is defined by the equations

$$T = T(Z, s) \ , \quad w = w(\xi, s) \ . \tag{2.29}$$

   If T depends strongly on Z, the g_{ZZ} component of the induced metric becomes positive and Kähler current time-like.

3. The components of the induced metric are

$$\begin{aligned} g_{ZZ} &= m_{ZZ} + m_{TT}\partial_Z T \partial_s T \ , \quad & g_{Zs} &= m_{TT}\partial_Z T \partial_s T \ , \\ g_{ss} &= s_{ss} + m_{TT}\partial_s T \partial_s T \ , & g_{w\overline{w}} &= s_{w\overline{w}} + m_{w\overline{w}}\partial_\xi w \partial_{\overline{\xi}} \overline{w} \ , \\ g_{s\xi} &= s_{s\xi} \ , & g_{s\overline{\xi}} &= s_{s\overline{\xi}} \ . \end{aligned} \tag{2.30}$$

   Topologized Kähler current has only Z-component and 3-dimensional empty space Maxwell's equations guarantee the topologization.

In CP_2 degrees of freedom the contractions of the energy momentum tensor with Christoffel symbols vanish if T^{ss}, $T^{\xi s}$ and $T^{\xi\xi}$ vanish as required by internal consistency. This is guaranteed if the condition

$$J^{\xi s} \quad = \quad 0 \tag{2.31}$$

holds true. Note however that $J^{\xi Z}$ is non-vanishing. Therefore only the components $T^{\xi\overline{\xi}}$ and $T^{Z\xi}$, $T^{Z\overline{\xi}}$ of energy momentum tensor are non-vanishing, and field equations reduce to the conditions

$$\begin{aligned} \partial_{\overline{\xi}}(J^{\xi\overline{\xi}}\sqrt{g}) + \partial_Z(J^{\xi Z}\sqrt{g}) &= 0 \ , \\ \partial_{\xi}(J^{\overline{\xi}\xi}\sqrt{g}) + \partial_Z(J^{\overline{\xi} Z}\sqrt{g}) &= 0 \ . \end{aligned} \tag{2.32}$$

In the special case that the induce metric does not depend on z-coordinate equations reduce to holomorphicity conditions. This is achieve if T depends linearly on Z: $T = aZ$.

The contractions with M^4_+ Christoffel symbols come from the non-vanishing of $T^{Z\xi}$ and vanish if the Hamilton Jacobi structure satisfies the conditions

$$\begin{aligned} \{^k_{T\ w}\} = 0 \ , \quad \{^k_{T\ \overline{w}}\} = 0 \ , \\ \{^k_{Z\ w}\} = 0 \ , \quad \{^k_{Z\ \overline{w}}\} = 0 \end{aligned} \tag{2.33}$$

hold true. The conditions are equivalent with the conditions

$$\{^k_{\pm\ w}\} = 0 \ , \quad \{^k_{\pm\ \overline{w}}\} = 0 \ . \tag{2.34}$$

These conditions possess solutions (standard light cone coordinates are the simplest example). Also the second derivatives of $T(s, Z)$ contribute to the second fundamental form but they do not give rise to non-vanishing contractions with the energy momentum tensor. The cautious conclusion is that also solutions with time-like or space-like Kähler current are possible.

2.3.7 $D_{CP_2} = 4$ case

The preceding discussion was for $D_{CP_2} = 3$ and one should generalize the discussion to $D_{CP_2} = 4$ case.

1. Hamilton Jacobi structure for M^4_+ is expected to be crucial also now.

2. One might hope that for $D = 4$ the Kähler structure of CP_2 defines a foliation of CP_2 by 3-dimensional contact structures. This requires that there is a coordinate varying along the field lines of the normal vector field X defined as the dual of the three-form $A \wedge dA = A \wedge J$. By the previous considerations the condition for this reads as $dX = d(log\phi) \wedge X$ and implies $X \wedge dX = 0$. Using the self duality of the Kähler form one can express X as $X^k = J^{kl}A_l$. By a brief calculation one finds that $X \wedge dX \propto X$ holds true so that (somewhat disappointingly) a foliation of CP_2 by contact structures does not exist.

For $D_{CP_2} = 4$ case Kähler current vanishes and this case corresponds to what I have called earlier Maxwellian phase since empty space Maxwell's equations would be indeed satisfied, provided this phase exists at all. It however seems that Maxwell phase is probably realized differently.

1. Solution ansatz with a 3-dimensional M^4_+ projection

The basic idea is that the complex structure of CP_2 is preserved so that one can use complex coordinates (ξ^1, ξ^2) for CP_2 in which CP_2 Christoffel symbols and energy momentum tensor have automatically the desired properties. This is achieved the second light like coordinate, say v, is non-dynamical so that the induced metric does not receive any contribution from the longitudinal degrees of freedom. In this case one has

$$S^+ = S^+(\xi^1, \xi^2) \ , \quad w = w(\xi^1, \xi^2) \ , \quad S^- = constant \ . \tag{2.35}$$

The induced metric does possesses only components of type $g_{i\bar{j}}$ if the conditions

$$g_{+w} = 0 \ , \quad g_{+\overline{w}} = 0 \ . \tag{2.36}$$

This guarantees that energy momentum tensor has only components of type $T^{i\bar{j}}$ in coordinates (ξ^1, ξ^2) and their contractions with the Christoffel symbols of CP_2 vanish identically. In M^4_+ degrees of freedom one must pose the conditions

$$\{^k_{w+}\} = 0 \ , \quad \{^k_{\overline{w}+}\} = 0 \ , \quad \{^k_{++}\} = 0 \ . \tag{2.37}$$

on Christoffel symbols. These conditions are satisfied if the the M^4_+ metric does not depend on S^+:

$$\partial_+ m_{kl} \quad = \quad 0 \ . \tag{2.38}$$

This means that m_{-w} and $m_{-\overline{w}}$ can be non-vanishing but like m_{+-} they cannot depend on S^+.

The second derivatives of S^+ appearing in the second fundamental form are also a source of trouble unless they vanish. Hence S^+ must be a linear function of the coordinates ξ^k:

$$S^+ \quad = \quad a_k \xi^k + \overline{a}_k \overline{\xi}^k \ . \tag{2.39}$$

Field equations are the counterparts of empty space Maxwell equations $j^\alpha = 0$ but with M^4_+ coordinates (u, w) appearing as dynamical variables and entering only through the induced metric. By holomorphy the field equations can be written as

$$\partial_j(J^{j\bar{i}}\sqrt{g}) = 0 \ , \quad \partial_{\bar{j}}(J^{\bar{j}i}\sqrt{g}) = 0 \ , \tag{2.40}$$

and can be interpreted as conditions stating the holomorphy of the contravariant Kähler form.

What is remarkable is that the M^4_+ projection of the solution is 3-dimensional light like surface and that the induced metric has Euclidian signature. Light front would become a concrete geometric object with one compactified dimension rather than being a mere conceptualization. One could see this as topological quantization for the notion of light front or of electromagnetic shock wave, or perhaps even as the realization of the particle aspect of gauge fields at classical level.

If the latter interpretation is correct, quantum classical correspondence would be realized very concretely. Wave and particle aspects would both be present. One could understand the interactions of charged particles with electromagnetic fields both in terms of absorption and emission of topological field quanta and in terms of the interaction with a classical field as particle topologically condenses at the photonic light front.

For CP_2 type extremals for which M^4_+ projection is a light like curve correspond to a special case of this solution ansatz: transversal M^4_+ coordinates are constant and S^+ is now arbitrary function of CP_2 coordinates. This is possible since M^4_+ projection is 1-dimensional.

2. Are solutions with a 4-dimensional M^4_+ projection possible?

The most natural solution ansatz is the one for which CP_2 complex structure is preserved so that energy momentum tensor has desired properties. For four-dimensional M^4_+ projection this ansatz does not seem to make promising since the contribution of the longitudinal degrees of freedom implies that the induced metric is not anymore of desired form since the components $g_{ij} = m_{+-}(\partial_{\xi^i} S^+ \partial_{\xi^j} S^- + m_{+-}\partial_{\xi^i} S^- \partial_{\xi^j} S^+)$ are non-vanishing.

1. The natural dynamical variables are still Minkowski coordinates $(w, \overline{w}, S^+, S^-)$ for some Hamilton Jacobi structure. Since the complex structure of CP_2 must be given up, CP_2 coordinates can be written as (ξ, s, r) to stress the fact that only "one half" of the Kähler structure of CP_2 is respected by the solution ansatz.

2. The solution ansatz has the same general form as in $D = 3$ case and must be symmetric with respect to the exchange of M^4_+ and CP_2 coordinates. Transverse coordinates are mapped to transverse ones and longitudinal coordinates to longitudinal ones:

$$(S^+, S^-) = (S^+(s, r), S^-(s, r)) \quad , \quad w = w(\xi) \quad . \tag{2.41}$$

This ansatz would describe ordinary Maxwell field in M^4_+ since the roles of M^4_+ coordinates and CP_2 coordinates are interchangeable.

It is however far from obvious whether there are any solutions with a 4-dimensional M^4_+ projection. That empty space Maxwell's equations would allow only the topologically quantized light fronts as its solutions would realize quantum classical correspondence very concretely.

The recent view conforms with this intuition. The Maxwell phase is certainly physical notion but would correspond effective fields experience by particle in many-sheeted space-time. Test particle topological condenses to all the space-time sheets with projection to a given region of Minkowski space and experiences essentially the sum of the effects caused by the induced gauge fields at different sheets. This applies also to gravitational fields interpreted as deviations from Minkowski metric.

The transition to GRT and QFT picture means the replacement of many-sheeted space-time with piece of Minkowski space with effective metric defined as the sum of Minkowski metric and deviations of the induced metrics of space-time sheets from Minkowski metric. Effective gauge potentials are sums of the induced gauge potentials. Hence the rather simple topologically quantized induced gauge fields associated with space-time sheets become the classical fields in the sense of Maxwell's theory and gauge theories.

2.3.8 $D_{CP_2} = 2$ case

Hamilton Jacobi structure for M^4_+ is assumed also for $D_{CP_2} = 2$, whereas the contact structure for CP_2 is in $D = 2$ case replaced by the induced Kähler structure. Topologization yields vanishing

Kähler current. Light-likeness provides a second manner to achieve vanishing Lorentz force but one cannot exclude the possibility of time- and space-like Kähler current.

1. Solutions with vanishing Kähler current

1. String like objects, which are products $X^2 \times Y^2 \subset M^4_+ \times CP_2$ of minimal surfaces Y^2 of M^4_+ with geodesic spheres S^2 of CP_2 and carry vanishing gauge current. String like objects allow considerable generalization from simple Cartesian products of $X^2 \times Y^2 \subset M^4 \times S^2$. Let $(w, \overline{w}, S^+, S^-)$ define the Hamilton Jacobi structure for M^4_+. $w = constant$ surfaces define minimal surfaces X^2 of M^4_+. Let ξ denote complex coordinate for a sub-manifold of CP_2 such that the imbedding to CP_2 is holomorphic: $(\xi^1, \xi^2) = (f^1(\xi), f^2(\xi))$. The resulting surface $Y^2 \subset CP_2$ is a minimal surface and field equations reduce to the requirement that the Kähler current vanishes: $\partial_{\overline{\xi}}(J^{\xi\overline{\xi}}\sqrt{g_2}) = 0$. One-dimensional strings are deformed to 3-dimensional cylinders representing magnetic flux tubes. The oscillations of string correspond to waves moving along string with light velocity, and for more general solutions they become TGD counterparts of Alfven waves associated with magnetic flux tubes regarded as oscillations of magnetic flux lines behaving effectively like strings. It must be emphasized that Alfven waves are a phenomenological notion not really justified by the properties of Maxwell's equations.

2. Also electret type solutions with the role of the magnetic field taken by the electric field are possible. $(\xi, \overline{\xi}, u, v)$ would provide the natural coordinates and the solution ansatz would be of the form

$$(s, r) = (s(u, v), r(u, v)) \quad , \quad \xi = constant \quad , \tag{2.42}$$

and corresponds to a vanishing Kähler current.

3. Both magnetic and electric fields are necessarily present only for the solutions carrying non-vanishing electric charge density (proportional to $\overline{B} \cdot \overline{A}$). Thus one can ask whether more general solutions carrying both magnetic and electric field are possible. As a matter fact, one must first answer the question what one really means with the magnetic field. By choosing the coordinates of 2-dimensional CP_2 projection as space-time coordinates one can define what one means with magnetic and electric field in a coordinate invariant manner. Since the CP_2 Kähler form for the CP_2 projection with $D_{CP_2} = 2$ can be regarded as a pure Kähler magnetic field, the induced Kähler field is either magnetic field or electric field.

The form of the ansatz would be

$$(s, r) = (s, r)\,(u, v, w, \overline{w}) \quad , \quad \xi = constant \quad . \tag{2.43}$$

As a matter fact, CP_2 coordinates depend on two properly chosen M^4 coordinates only.

1. Solutions with light-like Kähler current

There are large classes of solutions of field equations with a light-like Kähler current and 2-dimensional CP_2 projection.

1. Massless extremals for which CP_2 coordinates are arbitrary functions of one transversal coordinate $e = f(w, \overline{w})$ defining local polarization direction and light like coordinate u of M^4_+ and carrying in the general case a light like current. In this case the holomorphy does not play any role.

2. The string like solutions thickened to magnetic flux tubes carrying TGD counterparts of Alfven waves generalize to solutions allowing also light-like Kähler current. Also now Kähler metric is allowed to develop a component between longitudinal and transversal degrees of freedom so that Kähler current develops a light-like component. The ansatz is of the form

$$\xi^i = f^i(\xi) \quad , \quad w = w(\xi) \quad , \quad S^- = s^- \quad , \quad S^+ = s^+ + f(\xi, \overline{\xi}) \quad .$$

Only the components $g_{+\xi}$ and $g_{+\bar{\xi}}$ of the induced metric receive contributions from the modification of the solution ansatz. The contravariant metric receives contributions to $g^{-\xi}$ and $g^{-\bar{\xi}}$ whereas $g^{+\xi}$ and $g^{+\bar{\xi}}$ remain zero. Since the partial derivatives $\partial_\xi \partial_+ h^k$ and $\partial_{\bar{\xi}} \partial_+ h^k$ and corresponding projections of Christoffel symbols vanish, field equations are satisfied. Kähler current develops a non-vanishing component j^-. Apart from the presence of the electric field, these solutions are highly analogous to Beltrami fields.

3. Do scalar wave pulses represent a solution type with non-vanishing but not light-like Kähler current?

Since longitudinal polarizations are possible only for off mass shell virtual photons, physical intuition suggests that scalar wave pulse solutions describing the propagation of longitudinal electric field with light velocity cannot appear as asymptotic field patterns. This is also consistent with the claim that scalar wave pulses are associated with the transients involved with sudden switching of electric voltage on or off. Let $M^4 = M^2 \oplus E^2$ be the standard decomposition of M^4 to flat longitudinal and transversal spaces, and S^2 a homologically non-trivial geodesic sphere of CP_2. The simplest solution ansatz corresponds to a surface $X^2 \times Y^2$, $X^2 \subset E^2$, such that Y^2 is a surface defined by a map $S^2 \to M^2$ (or vice versa).

Energy momentum tensor is in both longitudinal and transversal degrees of freedom proportional to the corresponding part of the induced metric. Field equations are trivially true in the transversal degrees of freedom. The calculation of the divergence of energy momentum tensor demonstrates that Kähler current can be regarded as a vector field

$$j^\alpha = \frac{1}{4} J^{\alpha\beta} \partial_\beta L$$

defined by the Kähler action density acting as Hamiltonian. Poisson bracket is defined by the pseudo-symplectic form associated with the induced Kähler form with respect to the induced metric rather that that of S^2 (using S^2-coordinates as coordinates for Y^2, the square of this pseudo-symplectic form is equal to metric multiplied by the ratio $det(g(Y^2))/det(g(S^2))$).

In longitudinal degrees of freedom field equations are minimal surface equations with a source term proportional to the Kähler current divided by the Kähler action density. The vanishing of the Kähler current is possible only if Kähler action density is constant. This condition is true in the approximation that the induced metric for Y^2 is flat, that is at the limit when M^4 projection has size larger than size of CP_2 projection and that induced metric has Minkowskian signature). It is not clear whether the minimal surface property of Y^2 in $M^2 \times S^2$ is consistent with the constancy of the Kähler action density. This would suggest that classical gravitational interactions eliminate scalar wave pulses as asymptotic field patterns and cause the deviation from the minimal surface property and the non-vanishing of the Kähler current. The fact that solution becomes "instanton" like Euclidian solution when S^+ and S^- become constant suggests that the M^4 projection of the solution quite generally has a finite extension in time direction.

2.3.9 Could $D_{CP_2} = 2 \to 3$ transition occur in rotating magnetic systems?

I have studied the imbeddings of simple cylindrical and helical magnetic fields in various applications of TGD to condensed matter systems, in particular in attempts to understand the strange findings about rotating magnetic systems [K33].

Let S^2 be the homologically non-trivial geodesic sphere of CP_2 with standard spherical coordinates $(U \equiv cos(\theta), \Phi)$ and let (t, ρ, ϕ, z) denote cylindrical coordinates for a cylindrical space-time sheet. The simplest possible space-time surfaces $X^4 \subset M^4_+ \times S^2$ carrying helical Kähler magnetic field depending on the radial cylindrical coordinate ρ, are given by:

$$\begin{array}{lll} U = U(\rho) \ , & \Phi = n\phi + kz \ , \\ J_{\rho\phi} = n\partial_\rho U \ , & J_{\rho z} = k\partial_\rho U \ . \end{array} \tag{2.44}$$

This helical field is not Beltrami field as one can easily find. A more general ansatz corresponding defined by

$$\Phi = \omega t + kz + n\phi$$

would in cylindrical coordinates give rise to both helical magnetic field and radial electric field depending on ρ only. This field can be obtained by simply replacing the vector potential with its rotated version and provides the natural first approximation for the fields associated with rotating magnetic systems.

A non-vanishing vacuum charge density is however generated when a constant magnetic field is put into rotation and is implied by the condition $\overline{E} = \overline{v} \times \overline{B}$ stating vanishing of the Lorentz force. This condition does not follow from the induction law of Faraday although Faraday observed this effect first. This is also clear from the fact that the sign of the charge density depends on the direction of rotation.

The non-vanishing charge density is not consistent with the vanishing of the Kähler 4-current and requires a 3-dimensional CP_2 projection and topologization of the Kähler current. Beltrami condition cannot hold true exactly for the rotating system. The conclusion is that rotation induces a phase transition $D_{CP_2} = 2 \to 3$. This could help to understand various strange effects related to the rotating magnetic systems [K33]. For instance, the increase of the dimension of CP_2 projection could generate join along boundaries bonds/flux tubes and wormhole contacts (see **Fig. ??** in the appendix of this book) leading to the transfer of charge between different space-time sheets. The possibly resulting flow of gravitational flux to larger space-time sheets might help to explain the claimed antigravity effects.

2.4 Is Preferred ExtremalProperty Equivalent With The Topologization/Light-Likeness Of Kähler Current And With Second Law?

The basic question is whether the Kähler current is either topologized or light-like for all extremals or only for the preferred extremals of Kähler action in some sense, presumably asymptotically as suggested by the fact that generalized Beltrami fields correspond to asymptotic self-organization patterns, when dissipation has become insignificant.

1. The generalized Beltrami conditions or light-likeness can hold true only asymptotically. First of all, generic non-asymptotic field configurations have $D_{CP_2} = 4$, and would thus carry a vanishing Kähler four-current if Beltrami conditions were satisfied universally rather than only asymptotically. $j^\alpha = 0$ would obviously hold true also for the asymptotic configurations, in particular those with $D_{CP_2} < 4$ so that empty space Maxwell's field equations would be universally satisfied for asymptotic field configurations with $D_{CP_2} < 4$.

2. The failure of the generalized Beltrami conditions would mean that Kähler field is completely analogous to a dissipative Maxwell field since $\overline{j} \cdot \overline{E}$ is non-vanishing (note that isometry currents are conserved although energy momentum tensor is not). Quantum classical correspondence states that classical space-time dynamics is by its classical non-determinism able to mimic the non-deterministic sequence of quantum jumps at space-time level, in particular dissipation in various length scales defined by the hierarchy of space-time sheets. Classical fields could represent "symbolically" the average dynamics, in particular dissipation, in shorter length scales. For instance, vacuum 4-current would be a symbolic representation for the average of the currents consisting of elementary particles.

2.4.1 Is preferred extremal property equivalent with generalized Beltrami conditions?

Previous findings inspire the hypothesis that generalized Beltrami conditions express algebraically the absolute minimization conditions so that they make sense also in the p-adic case.

1. Generalized Beltrami conditions are satisfied by the asymptotic field configurations representing self-organization patterns. For non-asymptotic fields vacuum Lorentz force is non-vanishing and does work in Maxwellian sense so that $\overline{j} \cdot \overline{E}$ is non-vanishing. This would mean that the dynamics defined by Kähler action could in principle predict even the values of the parameters related to dissipation such as conductivities and viscosities. The space-time

sheets of the many-sheeted space-time would be busily modelling its own physics in shorter length scales.

2. Preferred extremal property implies that single space-time surface goes through given 3-surface apart from the non-uniqueness caused by the non-determinism of Kähler action. This gives *four* additional local conditions to the initial values of field equations fixing the time derivatives of the four dynamical imbedding space coordinates (conditions are analogous to Bohr conditions).

   The topologization of the Kähler current current gives also *four* local conditions:
   i) For $D_{CP_2} < 4$ the vanishing of instanton density gives one condition, and the proportionality of the Kähler current to instanton current gives 3 conditions since the proportionality factor is an arbitrary function of CP_2 coordinates. Altogether this makes four conditions.
   ii) For $D_{CP_2=4}$ the vanishing of the Kähler current gives four conditions.
   This encourages to think that the preferred extremal property forces the asymptotic behavior (final values instead of initial values) to correspond to dissipation-less state characterized by the generalized Beltrami conditions.

2.4.2 Is preferred extremal property equivalent with the second law?

The fact that Beltrami conditions are associated with the asymptotic dynamics suggests that preferred extremal property is equivalent with the second law at space-time level. Or putting it more cautiously: second law at space-time level could be equivalent with preferred extremal property.

For space-time sheets with negative time orientation and negative energy, say "massless extremals" representing phase conjugate laser waves, field configurations would approach non-dissipating ones in the geometric past, and the arrow of geometric time would be opposite to the standard one in this case. This situation is possible for space-time sheets of finite duration, in particular virtual particle like space-time sheets or the negative energy space-time sheets extending down to the boundary of imbedding space (moment of "big bang"). This would explain at the space-time level the change of arrow of time and breaking of the second law observed for the phase conjugate laser waves (used to generate healing and error correction for instance). In TGD framework second law is not a producer of a thermal chaos but Darwinian selector since state function reduction and state preparation by self measurements lead from a state with positive entanglement entropy to that with a negative entanglement entropy (defined number theoretically), and possessing only finitely extended rational entanglement identifiable as a bound state entanglement.

According to the recent view preferred extremal property corresponds to space-time correlate for quantum criticality and indeed induces long range correlations. The resulting non-local long range correlations could serve as correlates for bound state entanglement. More concretely, the stable join along boundaries bonds/flux tubes would be the correlates for bound state entanglement whereas topological light rays analogous to the exchange of virtual photons could serve as classical correlates for unbound entanglement. The closedness (periodicity) of the field lines of Beltrami fields for space-like Kähler current and periodicity of the field pattern for the time like Kähler current could be space-time correlates for the rational entanglement. The pinary expansions of rational numbers which are periodic after finite number of pinary digits indeed represent closed orbits in the set of integers modulo p. Amusingly, the first non-periodic pits of the expansion would in fact be analogous to the dissipative period.

Macro-temporal quantum coherence integrates sequences of quantum jumps to single effective quantum jump so that effectively a fractal hierarchy of quantum jumps emerges having the fractal hierarchy of time scales of dissipation resulting from many-sheetedness as a correlate. Even the anatomy of quantum jump could have space-time correlate. The final state of the quantum jump would correspond to highly negentropic and non-dissipating topologically quantized generalized Beltrami fields. State function reduction and preparation would correspond to the non-deterministic dissipative approach to the non-dissipative Beltrami field configuration. The points of space-time sheets with vanishing Kähler 4-currents would be unstable against quantum jumps generating an instability of the Beltrami field leading to a field configuration with a non-vanishing Lorentz 4-force and emission of topological light rays representing unstable entanglement. Quantum jump would have this kind of instability as a natural space-time correlate.

To sum up, the main lessons would be following.

1. The ability of basically non-dissipative dynamics to mimic dissipative dynamics in terms of energy momentum tensor would be the basic reason for why space-times must be 4-surfaces.

2. If prefered extremal property is correct principle, it must provide a space-time correlate for the second law, which is the Darwinian selector of the most information rich patterns rather than a thermal killer.

2.5 Generalized Beltrami Fields And Biological Systems

The following arguments support the view that generalized Beltrami fields play a key role in living systems, and that $D_{CP_2} = 2$ corresponds to ordered phase, $D_{CP_2} = 3$ to spin glass phase and $D_{CP_2} = 4$ to chaos, with $D_{CP_2} = 3$ defining life as a phenomenon at the boundary between order and chaos.

2.5.1 Why generalized Beltrami fields are important for living systems?

Chirality, complexity, and high level of organization make $D_{CP_2} = 3$ generalized Beltrami fields excellent candidates for the magnetic bodies of living systems.

1. Chiral selection is one of the basic signatures of living systems. Beltrami field is characterized by a chirality defined by the relative sign of the current and magnetic field, which means parity breaking. Chirality reduces to the sign of the function ψ appearing in the topologization condition and makes sense also for the generalized Beltrami fields.

2. Although Beltrami fields can be extremely complex, they are also extremely organized. The reason is that the function α is constant along flux lines so that flux lines must in the case of compact Riemann 3-manifold belong to 2-dimensional $\alpha = constant$ closed surfaces, in fact two-dimensional invariant tori [B4].

For generalized Beltrami fields the function ψ is constant along the flow lines of the Kähler current. Space-time sheets with 3-dimensional CP_2 projection serve as an illustrative example. One can use the coordinates for the CP_2 projection as space-time coordinates so that one space-time coordinate disappears totally from consideration. Hence the situation reduces to a flow in a 3-dimensional sub-manifold of CP_2. One can distinguish between three types of flow lines corresponding to space-like, light-like and time-like topological current. The 2-dimensional $\psi = constant$ invariant manifolds are sub-manifolds of CP_2. Ordinary Beltrami fields are a special case of space-like flow with flow lines belonging to the 2-dimensional invariant tori of CP_2. Time-like and light-like situations are more complex since the flow lines need not be closed so that the 2-dimensional $\psi = constant$ surfaces can have boundaries.

For periodic self-organization patterns flow lines are closed and $\psi = constant$ surfaces of CP_2 must be invariant tori. The dynamics of the periodic flow is obtained from that of a steady flow by replacing one spatial coordinate with effectively periodic time coordinate. Therefore topological notions like helix structure, linking, and knotting have a dynamical meaning at the level of CP_2 projection. The periodic generalized Beltrami fields are highly organized also in the temporal domain despite the potentiality for extreme topological complexity.

For these reasons topologically quantized generalized Beltrami fields provide an excellent candidate for a generic model for the dynamics of biological self-organization patterns. A natural guess is that many-sheeted magnetic and Z^0 magnetic fields and their generalizations serve as templates for the helical molecules populating living matter, and explain both chiral selection, the complex linking and knotting of DNA and protein molecules, and even the extremely complex and self-organized dynamics of biological systems at the molecular level.

The intricate topological structures of DNA, RNA, and protein molecules are known to have a deep significance besides their chemical structure, and they could even define something analogous to the genetic code. Usually the topology and geometry of bio-molecules is believed to reduce to chemistry. TGD suggests that space-like generalized Beltrami fields serve as templates for the formation of bio-molecules and bio-structures in general. The dynamics of bio-systems would in turn utilize the time-like Beltrami fields as templates. There could even exist a mapping from the

topology of magnetic flux tube structures serving as templates for bio-molecules to the templates of self-organized dynamics. The helical structures, knotting, and linking of bio-molecules would thus define a symbolic representation, and even coding for the dynamics of the bio-system analogous to written language.

2.5.2 $D_{CP_2} = 3$ systems as boundary between $D_{CP_2} = 2$ order and $D_{CP_2} = 4$ chaos

The dimension of CP_2 projection is basic classifier for the asymptotic self-organization patterns.

1. $D_{CP_2} = 4$ phase, dead matter, and chaos

$D_{CP_2} = 4$ corresponds to the ordinary Maxwellian phase in which Kähler current and charge density vanish and there is no topologization of Kähler current. By its maximal dimension this phase would naturally correspond to disordered phase, ordinary dead matter. If one assumes that Kähler charge corresponds to either em charge or Z^0 charge then the signature of this state of matter would be em neutrality or Z^0 neutrality.

2. $D_{CP_2} = 2$ phase as ordered phase

By the low dimension of CP_2 projection $D_{CP_2} = 2$ phase is the least stable phase possible only at cold space-time sheets. Kähler current is either vanishing or light-like, and Beltrami fields are not possible. This phase is highly ordered and much like a topological quantized version of ferro-magnet. In particular, it is possible to have a global coordinate varying along the field lines of the vector potential also now. The magnetic and Z^0 magnetic body of any system is a candidate for this kind of system.

3. $D_{CP_2} = 3$ corresponds to living matter

$D_{CP_2} = 3$ corresponds to highly organized phase characterized in the case of space-like Kähler current by complex helical structures necessarily accompanied by topologized Kähler charge density $\propto \overline{A} \cdot \overline{B} \neq 0$ and Kähler current $\overline{E} \times \overline{A} + \phi \overline{B}$. For time like Kähler currents the helical structures are replaced by periodic oscillation patterns for the state of the system. By the non-maximal dimension of CP_2 projection this phase must be unstable against too strong external perturbations and cannot survive at too high temperatures. Living matter is thus excellent candidate for this phase and it might be that the interaction of the magnetic body with living matter makes possible the transition from $D_{CP_2} = 2$ phase to the self-organizing $D_{CP_2} = 3$ phase.

Living matter which is indeed populated by helical structures providing examples of space-like Kähler current. Strongly charged lipid layers of cell membrane might provide example of time-like Kähler current. Cell membrane, micro-tubuli, DNA, and proteins are known to be electrically charged and Z^0 charge plays key role in TGD based model of catalysis discussed in [K15]. For instance, denaturing of DNA destroying its helical structure could be interpreted as a transition leading from $D = 3$ phase to $D = 4$ phase. The prediction is that the denatured phase should be electromagnetically (and/or Z^0) neutral.

Beltrami fields result when Kähler charge density vanishes. For these configurations magnetic field and current density take the role of the vector potential and magnetic field as far as the contact structure is considered. For Beltrami fields there exist a global coordinate along the field lines of the vector potential but not along those of the magnetic field. As a consequence, the covariant consistency condition $(\partial_s - qeA_s)\Psi = 0$ frequently appearing in the physics of super conducting systems would make sense along the flow lines of the vector potential for the order parameter of Bose-Einstein condensate. If Beltrami phase is super-conducting, then the state of the system must change in the transition to a more general phase. Since the field lines of the vector potential define chaotic orbits in this phase, the loss of coherence of the order parameter implying the loss of superconductivity by random collisions of particles is what one expects to happen.

The existence of these three phases brings in mind systems allowing chaotic de-magnetized phase above critical temperature T_c, spin glass phase at the critical point, and ferromagnetic phase below T_c. Similar analogy is provided by liquid phase, liquid crystal phase possible in the vicinity of the critical point for liquid to solid transition, and solid phase. Perhaps one could regard $D_{CP_2} = 3$ phase and life as a boundary region between $D_{CP_2} = 2$ order and $D_{CP_2} = 4$ chaos. This would naturally explain why life as it is known is possible in relatively narrow temperature interval.

3 The Scalar Waves Of Tesla, Bio-Systems AsElectrets, And Electric-Magnetic Duality

The scalar waves or so called non-Hertzian waves of Nikola Tesla belong to the fringe region of science. Many proponents of free energy believe that scalar waves might provide a basis for a new energy and communication technologies. Tesla himself was isolated from the official science and found no place in text books because his hypothesis about scalar waves did not fit within the framework of the Maxwell's electrodynamics. Personally I justified my personal prejudices against scalar waves by the observation that the formulations for the notion of scalar waves that I had seen seemed to be in a conflict with the cherished gauge invariance of gauge theories. The discussions with a Finnish free energy enthusiast Juha Hartikka however led me to reconsider the status of the scalar waves.

The surprise was that the non-Hertzian waves of Tesla might be possible in TGD framework. One can imagine two alternative manners to obtain them.

1. TGD allows so called massless extremals (MEs, topological light rays) as non-linear generalization of Maxwellian plane waves. They are characterized by light-like wave vector and polarization vector orthogonal to it and these vectors can also depend on space-time position [K2]. The most general wave is a pulse with arbitrary profile moving along ME with light-velocity along them and preserving its shape.

   Since TGD space-time is many-sheeted one can take two waves of this kind on top of each other in the sense that their M^4 projections intersect in some region of M^4. The effective space-time is defined by a piece of Minkowski space with effective metric which is sum of M^4 metric and deviations of the metrics of sheets from M^4 metric. Effective gauge potentials are sums of the induced gauge potentials. For two MEs the potentials at the two sheets and if the wave vectors can be chosen to be in opposite direction in which case one obtains an effective standing wave with non-vanishing net energy but vanishing 3-momentum and classical spin. Since MEs can carry light-like charge current the resulting system carries non-vanishing charge density and vanishing current Fourier transforms of the pair give rise to massive spinless states having identification as scalar waves possibly carrying em charge.

   In TGD framework classical gauge boson fields of standard model correspond two-sheeted structures - perhaps pairs of MEs connected by wormhole contact pairs having interpretation as gauge boson. One can consider the possibility that the classical space-time correlate for gauge bosons massivation at the level of MEs is this kind of pair of spacetime sheets. For massive gauge bosons the wave vector directions of the two sheets would be opposite in the rest system and spin would be vanishing.

2. The original proposal could have been inspired by the electric-magnetic duality of TGD suggesting a large number of solutions of field equations representing constant energy density configurations of electric field assignable to bio-electrets, which would be in a well-defined sense dual to the magnetic flux tube structures with analogous properties. Also classical gravitational fields generated by classical field energy could be important in the living matter. One must however take this proposal with a big grain of salt since there is no proof for the actual existence of this kind of solutions. Furthermore, one can obtain TGD counterparts of scalar waves as pairs of MEs.

In the following only the candidate for scalar waves obtained as single-sheeted space-time is considered.

3.1 The Properties Of The Scalar Waves

Perhaps the most important properties of the scalar waves are following.

1. Scalar waves involve some kind of oscillatory process in the direction of the propagation of the wave. The analogy with sound waves suggests that the oscillation could relate to charge density, or more generally to 4-current in the direction of the wave. Even massless extremals (MEs), which are essentially topological light rays, involve vacuum current and vacuum charge density which oscillates in the direction of propagation.

2. Scalar waves are believed to carry electric field in the direction of the wave motion so that the identification of MEs as scalar waves is not possible. The presence of only electric field means that scalar wave is characterized solely by the scalar potential. This kind of solution is excluded by the gauge invariance and linearity of Maxwell's electrodynamics in vacuum.

3.2 Could Nonlinearity Of TGD Allow Scalar Waves?

One is led to ask whether the nonlinearity of TGD might allow existence for scalar waves.

1. In TGD based electrodynamics CP_2 coordinates are the primary dynamical degrees of freedom gauge fields being secondary dynamical variables induced from the spinor curvature of CP_2. Field equations are extremely nonlinear allowing among other things vacuum 4-currents (even Faraday's unipolar generator involves vacuum charge density changing its sign when the direction of rotation of magnet changes its sign). This gives hopes about finding solutions of field equations with the properties assigned to the hypothetical scalar waves.

2. Interestingly, in TGD framework the canonical symmetries of CP_2 are dynamical symmetries and act as isometries of WCW of 3-surfaces. Canonical transformations act formally as $U(1)$ gauge transformations but, rather than being gauge symmetries, they are dynamical generating new physical configurations and are partially responsible for the quantum spin glass degeneracy of the TGD universe. As a matter fact, also diffeomorphisms of M^4 act as dynamical symmetries in the lowest order.

3. Magnetic flux tubes represent fundamental solutions of field equations and the simplest magnetic flux tubes can be characterized as maps from a region of a 2-dimensional Euclidian hyperplane E^2 of Minkowski space to a geodesic sphere S^2 of CP_2.

4. Electric-magnetic duality is a fundamental symmetry of the WCW geometry. Therefore there should exist solutions dual to the magnetic flux tubes carrying only electric fields and perhaps allowing interpretation as waves. These solutions would be characterized by a map from a region of the Minkowskian hyperplane M^2 of Minkowski space to S^2. This kind solution ansatz makes sense since it formally provides the solutions of a field theory from M^2 to S^2.

3.3 Lowest Order Solution Ansatz

One can write the field equations exlicitely. They are however extremely nonlinear and without physical intuition one cannot say much about the solution spectrum of these equations. One can however make simplifying assumptions to get grasp to the problem.

1. The effect of classical gravitation can be assumed to be extremely weak except possibly at some singular regions associated with the solutions.

2. In Maxwellian theory without sources gauge current vanishes identically. This would suggest that it is good to start from a zeroth order solution ansatz with this property so that the non-vanishing of the vacuum current would be solely due to gravitational effects. It deserves to be noticed that Tesla proposed also that non-Hertzian radiation fields involve a kind of radiation charge.

   In principle, one can imbed a portion of any solution of Maxwell's equations in empty space as a space-time sheet (note the occurrence of the topological quantization) using M^4 coordinates as preferred coordinates. Field equations are satisfied in the lowest order in R^2. The canonical symmetries of CP_2 act as dynamical symmetries for these solution ansätze and one obtains infinite degeneracy of the space-time surfaces representing the same Kähler field.

3. Constant electric field represents the simplest field configuration one can imagine. Therefore it is reasonable to start with this kind of solution ansatz and to look whether gravitational corrections affect the solution and bring in the wave aspect.

4. Since wave motion is hoped to result, it is useful to choose the space-time coordinates in an appropriate manner. Light like coordinates (x^+, x^-, x, y) of M^4 are thus very natural. They are defined by the conditions

$$t = (x^+ + x^-)/2 \ , \quad z = (x^+ - x^-)/2 \ ,$$

with (t, x, y, z) referring to the linear Minkowski coordinates such that t is time coordinate. In these coordinates the line element of M^2 has the form $ds^2 = -2dx^+dx^-$ so that one has $g_{+-} = -1$.

5. Using the spherical coordinates $(u = cos(\Theta), \Phi)$ for the geodesic sphere S^2 of CP_2, the zeroth order solution ansatz has the following form:

$$u \equiv u_0 = \omega_1 x^+ \ , \quad \Phi \equiv \Phi_0 = \omega_2 x^- \ . \tag{3.1}$$

Since electromagnetic, Z^0 and color fields are proportional to Kähler form for the solution type considered, one can restrict the consideration to the induced Kähler form. Denoting the Kähler form of CP_2 by J_{kl}, by noticing that S^2 Kähler form is given by $J_{u\Phi} = 1$ (forgetting the precise normalization factor), and using the expressions $\left[s_{uu} = R^2/(1-u^2), s_{\Phi\Phi} = R^2(1-u^2)\right]$ for the metric of S^2, one can write the induced line element and the non-vanishing component of the induced Kähler form as

$$\begin{aligned} ds^2 &= -2dx^+dx^- + \frac{R^2\omega_1^2}{1-u^2}(dx^+)^2 + R^2\omega_2^2(1-u^2)(dx^-)^2 - dx^2 - dy^2 \ , \\ J_{+-} &= \partial_+ u \partial_- \Phi = \omega_1\omega_2 \ , \\ J^{+-} &= \frac{\omega_1\omega_2}{det(g)} \ . \end{aligned} \tag{3.2}$$

Since the determinant of the induced metric is constant, J^{+-} describes constant electric field and that Kähler current j^α is vanishes. This means that Maxwell's equations hold true in the zeroth order approximation as required.

Apart from the normalization factors the energy momentum tensor in the longitudinal degrees of freedom is given by

$$T^{\alpha\beta}(long) = g^{\alpha\beta}L/4 \ ,$$

In the transversal degrees of freedom similar expression but with opposite sign holds true. Here L is Kähler action which is essentially electric energy density and constant.

In M^4 degrees of freedom the field equations express conservation of the energy momentum currents and are satisfied to order R^2 since the action is constant. These equations imply that action density is constant. This forces to ask whether all perturbatively constructible solutions represent a constant Kähler electric field locally.

In CP_2 degrees of freedom field equations involve a sum of two terms: the first term involves the contraction of the energy momentum tensor with the second fundamental form whereas the second term involves Kähler current. Since Kähler current vanishes, the latter term vanishes and one can say that field equations are satisfied in zeroth order approximation (the term involving energy momentum tensor is proportional to CP_2 length squared and thus small). For exactly vanishing vacuum current the field equations would reduce to the equations for a minimal surface:

$$g^{\alpha\beta}D_\beta\partial_\alpha h^k = 0 \ , \tag{3.3}$$

where the imbedding space coordinates h^k corresponds to u and Φ now. The same equations result also in M^4 degrees of freedom by requiring that the terms of order R^2 in the equation for the energy momentum conservation vanish.

This equation is not satisfied exactly as is easy to see. The non-vanishing components of the trace of the second fundamental form are given by

$$\begin{aligned} g^{\alpha\beta}D_\beta\partial_\alpha u &= -\{{}^{u}_{\Phi\ \Phi}\}\omega_2^2 \times \left[1 - g^{++}\omega_1^2 R^2/(1-u^2)\right] \ , \\ g^{\alpha\beta}D_\beta\partial_\alpha \Phi &= -\{{}^{\Phi}_{u\ \Phi}\}\omega_1\omega_2 \times \left[1 - g^{--}\omega_2^2 R^2(1-u^2)\right] \ . \end{aligned} \tag{3.4}$$

Here $\{{}^{\alpha}_{\beta\ \gamma}\}$ denote the components of the Riemann connection for sphere. It is seen that the connection term gives contributions which vanish only at $u = 0$ which corresponds to the equator of the geodesic sphere S^2. At poles the minimal surface condition fails to be satisfied.

3.4 First Order Corrections To The Solution Ansatz

To take into account gravitational corrections one must modify the solution ansatz in such a manner that x^- does not appear in the field equations at all: this guarantees that field equations reduce to ordinary differential equations. The modification is following:

$$u = u_0 + u_1(x^+) \ , \quad \Phi = \Phi_0 + \Phi_1(x^+) \ . \tag{3.5}$$

The modification affects the electric field and vacuum current and allows the compensation of the terms resulting form the contractions of the energy momentum tensor and vacuum current. The modification means that wave equations are still satisfied for u and Φ. Note that second fundamental form does not contain second derivative terms in the lowest order approximation.

The derivation of the differential equations for u_1 and Φ_1 is completely straightforward but requires some patience with numerical factors (reader should check sign factors and numerical factors).

1. Calculate the current contraction term

   $$j^\alpha \left[J^k_r \, \partial_\alpha h^r - J^\mu{}_\alpha \partial_\mu h^k\right]$$

   and energy momentum tensor contraction term

   $$T^{\alpha\beta}D_\beta\partial_\alpha h^k$$

   and equate these terms. Effective two-dimensionality makes the explicit calculations relatively simple.

2. The equations for u and Φ in terms of $j^\pm$ read as

   $$\begin{aligned} j^-(1-u_0^2) + j^+\epsilon_1\epsilon_2 &= \{{}^{u}_{\Phi\ \Phi}\}\tfrac{K\epsilon_2^2}{2} \equiv X_1 \ , \\ j^+\tfrac{1}{(1-u_0^2)}j^-\epsilon_2^2 &= -2\{{}^{\Phi}_{u\ \Phi}\}K\epsilon_1\epsilon_2 \equiv X_2 \ , \end{aligned}$$

   Here the notations $\epsilon_i = \omega_i R$ and $K = \omega_1\omega_2^2$ are used. Linear second order differential equations are in question with the right side serving as an inhomogenuity term.

3. One can solve j^+ and j^- from these equations to get

   $$\begin{pmatrix} j^+ \\ \\ j^- \end{pmatrix} = \tfrac{1}{\epsilon_1\epsilon_2^3 - 1} \times \begin{pmatrix} \epsilon_2^2 & -(1-u_0^2) \\ \\ -1/(1-u_0^2) & \epsilon_1\epsilon_2 \end{pmatrix} \times \begin{pmatrix} X_1 \\ \\ X_2 \end{pmatrix} \equiv \begin{pmatrix} Y_1 \\ \\ Y_2 \end{pmatrix}$$

   From this form one can see that j^- becomes singular at $u_0 = \pm 1$ as $1/(1-u_0^2)$ which means that light like vacuum current is generated. The physical interpretation is that vacuum charge density at these points which correspond to the boundaries of the solution acting as the source of the vacuum electric field is in question.

4. One can calculate $j^{\pm}$ by calculating the covariant divergence of the induce Kähler field in the lowest non-trivial order. The calculation gives the following expression

$$\begin{pmatrix} j^+ \\ \\ j^- \end{pmatrix} = \omega_1 \begin{pmatrix} u_0\partial_+^2 u_1 + \epsilon_1\epsilon_2(1-u_0^2)\partial_+^2\Phi_1 \\ \\ \omega_1\epsilon_2\partial_+^2 u_1 - \epsilon_1(1-u_0^2)\partial_+^2\Phi_1 \end{pmatrix}$$

5. For u_1 one finds the equation

$$\begin{aligned} \partial_+^2 u_1 &+ \epsilon_1\epsilon_2^2\omega_1 u_0\partial_+ u_1 = \frac{1}{\omega_1}\times(Y_1+\epsilon_1 Y_2) \\ &= \frac{\omega_2^2}{2}\frac{\epsilon_1}{\epsilon_1\epsilon_2^3-1}\times u_0\times\left[-\epsilon_2^4(1-u_0^2)+\epsilon_1\epsilon_2(-2+\epsilon_1)-\epsilon_1^3\epsilon_2\frac{1}{1-u_0^2}\right] . \end{aligned} \quad (3.6)$$

This equation reduces to a first order differential equation for u_1 and one can solve it by variation of integration constants. The singularity at $u=\pm 1$ implies a logarithmic singularity of the derivative

$$\partial_+ u_1 \sim log(1-u_0^2)$$

but u remains finite as it should.

6. One can integrate Φ_1 from the second order inhomogenous and linear equation

$$\begin{aligned} \partial_2^+\Phi_1 &= \frac{1}{\epsilon_1\epsilon_2(1-u_0^2)}\left[j^- - \omega_2\partial_+^2 u_1\right] , \\ j^- &= \frac{\omega_1\omega_2^2\epsilon_1\epsilon_2}{2(\epsilon_1\epsilon_2^3-1)}\times u_0\times\left[1-\frac{2\epsilon_1^2}{1-u_0^2}\right] , \end{aligned} \quad (3.7)$$

once the solution for u_1 is known. Note that the most singular part corresponds to $u_0/(1-u_0^2)^2$ type term and one obtains logarithmic singularity also now.

3.5 Properties Of The Solution Ansatz

The form of the differential equations for the first order corrections allows to conclude that the North and South poles of the geodesic sphere S^2 (the points $u_0=\pm 1$) correspond to singularities of the solution. Both the components of the induced metric and the induced Kähler form become singular at these points. This means that classical gravitation becomes important near these points. These points correspond in the lowest order approximation to the lines $x^+ = \pm 1/\omega_1 \equiv T$ plus possibly the lines obtained by continuing the solution by assuming that $x^- = constant$ lines define a motion identifiable constant rotation along the big circle from $\theta = 0$ ($x_+ = T$) to $\theta = \pi$ ($x_+ = -T$) continuing in the same manner to $\theta = 0$ at ($x = 2T$) and so on. Therefore gravitational effects induce a periodical behavior of the solution such that gravitational effects become strong at $x^+ = (2n+1)T$.

In the next order electric field is not constant anymore and vacuum current is generated. The contravariant component of electric field, being proportional to $1/\partial_+ u$ near singularity, vanishes at the singularity whereas the tangential component j^- of the vacuum current diverges. The vacuum current should generate coherent photons.

By a straightforward calculation one finds that the curvature scalar behaves as $R \propto 1/(1-u_0^2)$ at the singularities so that the energy density of vacuum becomes singular and could generate a coherent state of gravitons. Since Einstein tensor vanishes identically in two-dimensional case, the longitudinal components G^{++}, G^{--} and G^{+-} of Einstein tensor vanish. The components of Einstein tensor in transverse degrees of freedom are given by $G^{alpha\beta} = -g^{\alpha\beta}R/2$. Therefore the energy momentum tensor defined by Einstein's equations would involve only space like momentum

currents. The singularity is amplified by the fact that field energy couples to the classical gravitation with coupling which is 10^8 times stronger than the ordinary gravitational coupling. The singularity might relate to the claimed gravitational anomalies associated with the scalar waves.

As already found, Einstein tensor and gauge current have no components in the direction of x^+. Energy-momentum tensor behaves as $1/det(g)^{3/2}$ at the end points of the interval $[-T, T]$ and thus vanishes. Therefore conservation laws allow to restrict the solution into the x^+ interval $(-T, T)$. This restricted solution defines geometrically a particle like structure moving in x^- direction but with fields moving in x^+ direction so that one would have rather exotic kind of particle-wave dualism. In accordance with the quantum-classical correspondence, one could interpret this as classical space-time representation of the particle wave duality and the solution would be a particular example of topological field quantization.

3.6 More General Solutions Representing Electric Field Of ConstantAction Density Are Possible

The solution ansatz just discussed represents a constant electric field in a region of space-time moving with ligth velocity in the direction of x^- coordinate. Also ordinary constant electric fied is a possible solution and is constructed iteratively in an essentially identical manner by starting from the solution ansatz

$$u = kz \quad , \quad \Phi = \omega t \quad . \tag{3.8}$$

Also now Kähler current vanishes in the lowest order and action density is constant so that lowest order field equations are satisfied. Higher order corrections are obtained using the ansatz $u_1 = u_1(z)$, $\Phi = \Phi_1(z)$. Minimal surface condition gives now essentially same kind of expressions for u_1 and Φ_1. Also now the singularities where gravitational interaction becomes strong are at $u = \pm 1$ and one can select the solution to represent a membrane like structure with thickness $L = 2/k$.

Cell membrane space-time sheets are good candidates for the realization of this kind of solutions. If so, one might expect that classical gravitational effects become important at the boundaries of the cell membrane. More generally, bio-systems are electrets and the proposed solution type might provide a fundamental model for bio-electrets. In particular, electrogravitic effects due to the energy of the classical electric field might be of importance.

This observation relates interestingly to the sol-gel phase transitions occurring inside cell. In these transitions large scale bound states of water molecules are formed and could make possible macro-temporally quantum coherent systems able to perform quantum computations in time scales of order say .1 seconds. These bound states would be characterized by spin glass degeneracy broken only by the classical gravitation and spin glass degeneracy would make these bound states long-lived. In the case of the proposed solution ansätze spin glass degeneracy corresponds to the canonical symmetries of CP_2 generating new solutions representing constant electric field.

Also M^4 diffeomorphisms are symmetries of the field equations broken only by the classical gravitation. Approximate diffeomorphism invariance means that one obtains solutions for which the lines of electric flux are curved and only the action density stays constant. In the case of magnetic flux tubes this symmetry makes possible curved magnetic flux tubes. Both electric fields and the magnetic flux tubes are fundamental for the TGD based model of living matter and relate deeply to the electric-magnetic duality symmetry and to the quantum criticality predicting that magnetic and electric space-time regions having opposite signs of Kähler action play a role similar to the ice and water regions at critical point of water, are important physically.

4 Time Mirror Mechanism

As explained in the introduction, time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book) is excellent candidate for the fundamental bio-control mechanism allowing magnetic body to act as an intentional agent and control biological body. For a physicist living in Newtonian world the idea that "me" corresponds to a field structure of an astrophysical size is of course difficult to swallow. p-Adic physics

as physics if intentionality and cognition however supports this view strongly: what is infinitesimal p-adically (cognitively) is literally infinite in the real sense so that cognition and intention are cosmic phenomena. In this section the possible role of scalar wave pulses in the realization of intentional action is considered. Also some aspects related to the role of time mirror mechanism for consciousness are discussed and it is shown that Libet's experiments related to the strange delays of conscious experience provide support for both time mirror mechanism and the notion of magnetic body.

4.1 Scalar Wave Pulses As Producers Of Phase Conjugate Waves And Time Mirror Mechanism

If one wants to produce negative energy photons, one must break the second law of thermodynamics. TGD predicts that in a given n-ary p-adic length scale $L(n,k)$ (size of the space-time sheet) this is possible below the n-ary p-adic time scale $T(n,k) = L(n,k)/c$. One must only produce pulses having duration shorter than the p-adic time scale $T(n,k)$. Scalar wave pulses are excellent candidates this kind of pulses since they accelerate the current carriers, which have ended up to the space-time sheet of the scalar wave pulse, and during this period they can emit negative energy photons as "acceleration radiation" with quantized frequencies $f_n = n/T_p$, T_p the duration of the scalar wave pulse. If the pulses correspond to their own space-time sheets dissipation is negligible and the intensity of acceleration radiation is maximal.

Scalar wave pulses could be produced by very rapidly rising electric pulses for which electronic currents are too slow to generate the voltage change between given points of circuit so that scalar wave pulse behaving like moving capacitor with vacuum charges at its electrodes must do the job. The duration of the scalar wave pulse would be most naturally the rising time τ_r of the pulse. Scalar wave pulse could be generated in a simple closed circuit. Assume that there is a voltage source V between points A and B and that A and B are connected to points A_1 and B_1 at which the wire branches to two wires going through a capacitor and current switch. When the current switch is off there is voltage V through capacitor. When the current is switched on, capacitor dis-charges very rapidly but the voltage between A and B must be still present. This is guaranteed if positive energy scalar wave pulse generates the voltage. The voltage through the capacitor is nullified by the absorption of negative energy scalar wave pulse coming from future and generated in the switching off process. In the geometric future the capacitor in turn absorbs the positive energy scalar wave pulse to generate the voltage V again.

An especially interesting situation arises when the energies of the negative photons radiated by the charged particles accelerated inside the scalar wave pulse correspond to the increment of a zero point kinetic energy for some charged particle when it drops to a larger space-time sheet. In this case the negative energy radiation could make possible time mirror mechanism by generating a cascade like dropping of charged particles and an amplified emission of positive energy photons. In case of nerve pulse the rising time of the pulse would be a good candidate for the duration of the scalar wave pulse.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

4.2 Bio-Systems And Unipolar Pulses

One might think that besides Tesla also bio-systems might have invented the sharp pulses as a manner to break second law temporarily and produce negative energy topological light rays crucial for all basic mechanisms in TGD based quantum biology and theory of consciousness. Perhaps one function of nerve pulse is to produce phase conjugate waves and perhaps nerve pulse can be switched on by a scalar wave pulse reducing the membrane potential below the critical value.

This suggests the existence of biological variants of binary coils. Bio-systems are full of binary structures such as DNA double strand and cell membrane (consisting of two lipid layers). It is

tempting to think that DNA double strand is a variant of bi-filar coil in which scalar wave pulses propagate along strand (associated with say gene) and return along the conjugate strand. Also now the effective inductance of the system would grow from zero to some maximum value and return back to zero and phase conjugate light would be generated. As a matter fact, the TGD based model for bio-photons lead to the hypothesis that the strand/conjugate strand generates positive/negative energy MEs and that these MEs move in opposite directions along strands [K21].

4.3 Sensory Perception, Motor Action, And Time Mirror Mechanism

TGD view about sensory perception differs dramatically from that of the standard neuroscience in that sensory organs are carriers of basic sensory representations and the magnetic body rather than body or brain is the experiencer with which we can identify ourselves.

4.3.1 Sensory organs as seats of qualia

According to the music metaphor, sensory organs are responsible for the music whereas brain writes it into notes by building symbolic and cognitive representations communicated to the magnetic body. Back projection to the sensory organs is an essential aspect of this process and is discussed in the article "Quantum model of sensory receptor" of [L1]. Sensory perception at the level of magnetic body involves the generation of negative energy MEs entangling with sensory organs involving possibly also brain as an intermediate entangler.

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K17].

Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia represented symbolically at the neuronal level. Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs.

Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable hypothesis about the character of the back projection for various sensory modalities. According to the hypothesis, one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

4.3.2 How motor action differs from sensory perception?

There is a deep similarity between sensory perception and motor action in TGD framework, the basic difference being that classical signals propagate in different direction in CNS. Motor action is initiated by the magnetic body by the sending of negative energy to motor organs by generating negative energy MEs, and proceeds by similar processes backwards in the geometric time to the level of brain and magnetic body, very much like an instruction of a boss at the top of organization to the lower levels of hierarchy and induces lower level instructions. The analogy with computer program calls (quantum communications, desires) and their executions (classical signals, actions) is also obvious. Also classical signals from the magnetic body to the body and brain are possible. Similar picture applies to sensory perception with motor organs replaced by sensory organs.

Sensory *resp.* motor imagination differ from sensory perception *resp.* motor action only in that the magnetic body entangles with some higher level of CNS. Therefore there is no danger that imagined motor action would become real or that imagined sensory perception would be experienced as real. This picture is in accordance with the idea of quantum credit card implying maximal flexibility, and with respect to the geometric time would mean that motor actions are only apparently initiated from the brain.

4.3.3 Time delays of consciousness: experiments related to the active role of consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [J13, J2]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body. The first class of experiments [J23, J2] is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [J23]. T_1 is very near to the p-adic time scale $T(6, 43) = .4$ seconds and T_2 to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

One can imagine two explanations for the paradoxical findings. The explanations turn out to be mutually consistent.

1. The geometric past changes in quantum jump

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

1. The simplest assumption is that the subjective experience of the hand movement corresponds to the moment, when subject person experiences that hand movement occurs.

2. The space-time surfaces (resulting as the final state of quantum jump) associated with the new quantum history differ in a detectable manner from the old quantum history already before the moment of hand movement since otherwise the new space-time surface would contain an instantaneous and discontinuous jump from the initial to final body configuration, which is not allowed by field equations. Same argument applies to the state of brain. $\Delta T \sim .5$ seconds seems to be the relevant time scale.

3. The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the hand movement with respect to geometric time. With respect to the subjective time the cause of the hand movement is the decision of the subject person.

2. Motor action is initiated from the magnetic body and proceeds to shorter length scales in reversed direction of geometric time

The vision that motor actions are initiated by magnetic body by feeding negative energy to motor organs and proceed upwards in CNS in a reversed time direction is in accordance with the idea of quantum credit card implying maximal flexibility and would mean that motor actions are only apparently initiated from brain. Motor organs send negative energy MEs to get metabolic energy, say to cortex. If there is lapse $\sim .5$ seconds involved then the observed lapse would find explanation. This view concretizes the idea about the editing of the geometric past and is consistent with the more general explanation discussed above.

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor motor action would be planned and initiated in

the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [I10]. Since quantum communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

4.3.4 Strange time delays of consciousness: experiments related to the passive role of consciousness

Libet's experiments [J13] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about these experiments, I feel equally confused and must start explanations from scratch.

What is so important and puzzling is that the backwards time referral of sensory experience is so immensely long: about.5 seconds. The time taken for nerve pulses to travel through brain is not more than .01 seconds and the time to arrive from sensory organs is at most.1 seconds (for axon with length of 1 meter and very slow conduction velocity 10 m/s). For the purposes of survival it would be advantageous to have a sensory input with a minimal time delay.

Why then this long delay? TGD inspired answer is simple: the "me" does not correspond to the material body but to the magnetic body associated with the physical body, and is analogous to the manual of electronic instrument, kind of a monitor screen to which sensory, symbolic and cognitive representations are projected by quantum and classical communications. Since the size of the magnetic body is measured using Earth's circumference as a natural unit, the long time lapse results from the finite velocity of light.

The following explanation is a variant of the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [K23]. The basic sensory representations are realized at the level of the sensory organs and entangled with magnetic body whereas symbolic representations are either shared as mental images by or communicated classically to the magnetic body. This differs from the original scenario in which sensory representations were assumed to result by classical communications from brain to the magnetic body.

1. Communications from brain to magnetic body

One must consider two kinds of communications from body to magnetic body corresponding to positive energy MEs generated by at least brain and negative energy ME sent by magnetic body to at least sensory organs. The assumptions are following.

1. Negative energy MEs bound state entangle the magnetic body with the sensory representations realized at the level of sensory organs, and constructed using back projection from brain and possibly also from higher levels. Fusion and sharing sensory mental images is involved. Also the classical communication of memories to magnetic body could be involved with the build up of sensory and symbolic representations at the magnetic body. In both cases sensory representations are memories with the same time lapse determined by the length of the MEs involved, a fraction of second typically if the magnetic body is of an astrophysical size. During sensory and motor imagination magnetic body entangles by negative energy MEs with some higher level of CNS.

2. Symbolic representations in brain can entangle with the sensory representations entangling in turn with the magnetic body so that CNS defines tree like structure with roots corresponding to sensory organs and branches and leaves corresponding to the higher levels of CNS. Direction of attention selects some path along this tree somewhat analogous to the path defining computer file in some subdirectory.

3. Symbolic representations of the perceptive field can be projected to the magnetic body using also classical signalling by positive energy MEs with phase velocity in a good approximation equal to the light velocity. For instance, if perceptive field contains something important, classical signal to the magnetic body could induce the generation of negative energy MEs

turning attention to a particular part of perceptive field. Projection to the magnetic flux tubes of the Earth's magnetic field is possible. The spatial direction of the object could be coded by the direction of ME located in brain whereas its distance could be coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results. Field pattern could be realized the coding of information to bits in some time scale, perhaps even in the time scale of millisecond associated with the memetic code. Positive energy MEs generated by brain realize the representation and this implies time delay. In the original model it was assumed that the direction and distance of the object of perceptive field are coded as direction and distance at the magnetic body. The representations are expected to be rather abstract, and it might be enough to perform this coding at the level of magnetic bodies associated with the sensory organs.

2. Libet's findings

Consider now Libet's findings. According to the summary of Penrose in his book "Emperor's New Mind" these experiments tell the following.

1. With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in $\sim .5$ seconds.

2. Subject person feels no time delay. For instance, she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation, which is basically a geometric memory, takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds.

3. One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds before the stimulation of the skin starts, both the stimulation of the skin and cortex are experienced separately but their time ordering is experienced as being reversed! If the cortical stimulation generates sensory mental image at sensory organ by back projection then one could understand the change of the time ordering as resulting from.5 second lapse for the generation of back projection.

4. If the stimulation of the cortex begins in the interval $.25 - .5$ seconds after the stimulation of the skin, the stimulation of the skin is not consciously perceived. This effect is known as a backward masking. From the source it is not clear whether a minimal duration of .5 seconds of cortical stimulation is required for backward masking.

3. Explanation of Libet's findings

Consider now how one could understand these strange findings in the proposed model.

1. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that the construction of symbolic representations at magnetic body is possible. The projection to the magnetic canvas by positive energy MEs and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds. The symbolic representation could contain also information about where to direct sensory attention. After this time interval negative energy ME possibly directing the attention to a particular part of the perceptive field would be generated and induce sharing of mental images .5 seconds in the geometric past. Note that this would automatically guarantee that symbolic and sensory representations at the magnetic bodies of sensory organs correspond to the same value of the geometric time.

2. The stimulation of the cortex lasting at least .5 seconds would generate a back projection to sensory organs. The minimal duration of .5 seconds for the cortical stimulation would seem rather natural in order to avoid back projections due to random neuronal fluctuations. This would explain why the temporal order of the sensory experiences generated by cortical and skin stimulation is reversed when cortical stimulation starts before the skin stimulation.

3. Consider now how the backwards masking could be understood. The cortical stimulation could generate a negative energy ME sent to the sensory organ and editing its geometric past at temporal distance of.5 seconds and depleting energy resources so that sensory organ cannot receive negative energy ME from magnetic body during the period of the cortical stimulation. Magnetic body would become sensorily blind to the input from the corresponding point of skin. Sensory blinding could be a clever manner to signal to the magnetic body that back projection is to be expected.

The stimulated point of the cortical map would share the sensory mental image instead of the magnetic body and also give rise to a back projection: sensory mental image would be conscious to cortex but not to us! Magnetic body and cortex could be seen as competitors for resources in this kind of situation. Perhaps the electric stimulation induces some kind of neuronal starvation and forces the neuron to generate negative energy MEs entangling it with the sensory organs.

5 Did Tesla Discover How To Change The Arrow Of Time?

After having made the inventions providing much of the basis technology for the modern electricity based society, Tesla used the rest of his life to study the strange phenomena related to sharp electric pulses. Tesla became convinced that pulse like rays carrying longitudinal electric fields exists although Maxwell's theory does not allow them. Needless to say, Tesla's findings were not taken seriously by the scientific establishment. On the other hand, for the developers of so called free energy technologies Tesla has remained a magic figure. To me it has gradually become clear that it might be possible to formulate the visions of Tesla using the language of modern physics, and the final breakthrough came with a discovery of a mechanism generating what I have used to call negative energy topological light rays having phase conjugate laser waves as physical counterparts.

Negative energy topological light rays provide the fundamental control mechanism in the TGD based model of living matter and appear in practically every mechanism of consciousness as a basic step. This is however not yet the whole story. One should also identify mechanisms allowing to control the generation of the negative energy topological light rays: direct transformation of p-adic MEs to negative energy MEs is probably not enough. The solution to the problem came from a quite unexpected direction. It was the attempt to understand the physics behind the visions of Tesla which led to an identification of a very general mechanism of this kind.

Phase conjugate laser waves break second law of thermodynamics and this is possible in TGD Universe below the p-adic time scale characterizing the system. Therefore short pulses are ideal for this purpose. Depending on the situation, electric pulses in electric circuits typically force the charge carriers to accelerate or decelerate. During deceleration positive energy photons are emitted as brehmstrahlung whereas during acceleration charges emit negative energy photons in order to receive energy. Thus generation of pulses provides a mechanism to generate negative energy topological rays which in turn serve for various control purposes. TGD indeed predicts the existence of scalar wave pulses propagating in vacuum with light velocity and carrying longitudinal electric fields.

One can understand the basic findings of Tesla at qualitative level in TGD framework and there are strong reasons to believe that Tesla was right after all. This of course raises the question how it is possible that the scientific community with all its technology remained silent about the findings of Tesla for an entire century. Experimentalists must have made occasional encounters with the phenomena reported by Tesla. Are modern experimentalists conditioned to take theorists quite too seriously?

5.1 Discussion Of The Basic Ideas And Concepts

5.1.1 Do negative energy space-time sheets have counterparts in quantum field theory?

Negative energy topological light rays seem to correspond to phase conjugate laser waves. In particular, the experiments of Feinberg [D2] are consistent with the transparency of matter for phase conjugate laser beams with photon energies above thermal energy. In optics phase conjugation requires optically non-linear system [D3]. For instance, in usual hologram the matter is optically

non-linear in the sense that dielectric constant depends on the external electric field so that the electromagnetic radiation induces a change of the refraction coefficient which in turn codes for the hologram.

The dynamics of classical fields is indeed extremely nonlinear in TGD: the topological field quantization is one of the most dramatic outcomes of this non-linearity. Whether the phenomenological models for phase conjugate waves and for their generation are enough in TGD framework is an open question. The mechanism based for the generation of negative energy topological light rays based on short pulses to be discussed in this section does not seem to reduce to the framework of non-nonlinear optics.

There are also questions of principle involved.

1. Is phase conjugation properly understood in quantum field theories?

At the level of quantum physics negative energy photons would correspond to a system quantized in such a manner that both bosonic and fermionic annihilation and creation operators have changed their roles. Negative energy photons and fermions do not correspond to (non-existing) "anti-photons" and anti-fermions. Using the terminology of Dirac's bra-ket formalism: negative energy systems are like bras if positive energy photons are kets. Kets and bras correspond to Hilbert space and linear functionals defined in it. The space of bras is actually not equivalent with that of kets but in a well defined sense a more general concept. This conforms with the role of negative energy space-time sheets in TGD inspired theory of consciousness.

In quantum field theories time reversal transforms creation operators for fermions to creation operators for anti-fermions. Vacuum state is not changed. Time reversal in TGD sense would transform ket vacuum to bra vacuum so that the earlier creation operators annihilate the new vacuum state and genuine negative energy states result. This would suggest that negative energy states are something genuinely new and a genuine outcome of the many-sheeted space-time concept allowing either bra and ket type vacuum at a given space-time sheet. This difference might relate to matter-antimatter asymmetry whose origin is one of the deepest problems of cosmology. Perhaps dynamics favors space-time sheets containing negative energy matter instead of antimatter.

2. Phase conjugation and irreversibility

One interesting aspect associated with negative energy topological light rays is that they seem to be irreversible systems. On the other hand, phase conjugation can be used to eliminate perturbations on signal caused by thermal noise since the evolution proceeds from perturbed to non-perturbed signal. This could be seen as an objection against TGD based interpretation stating that topological light rays are essentially non-dissipative structures of classical physics.

The objection can be circumvented. Classical-quantum correspondence implies that space-time physics mimics also the dissipative aspects of quantum dynamics defined by quantum jump sequences. The classical non-determinism of the basic variational principle makes this possible. Classical fields are non-dissipative structures are even able to represent information about dissipation, analogous to a written text telling a story about growth, flourishing, and decay. In fact, in TGD framework space-time itself provides symbolic classical representations for quantum jump sequences determining the subjective, experienced reality. The implications of this representative aspect for biology are highly non-trivial. For instance, phase conjugate waves could provide a fundamental mechanism of healing and error correction.

5.1.2 Matter-antimatter asymmetry, phase conjugation for fermions, and new energy technology

If photons with negative energies are allowed, it is difficult to deny the possibility of fermions with negative energies. The possibility of having both signs of energy suggests an elegant solution to the problem of matter-antimatter asymmetry and a powerful new energy technology.

1. The standard second quantization of Dirac spinors postulates that ground state is annihilated by annihilation operators for fermions and anti-fermions. One can construct explicitly the state annihilated by annihilation operators. Suppose that there is state which is not annihilated by any annihilation operator and apply the product of all annihilation operators to this state. Electrons and positrons represent holes in this sea and are created by applying

creation operators. The states have positive energy with respect to the ground state. The aesthetic problem of this quantization is that ground state has an infinitely high negative energy.

2. In TGD framework one could change the role of creation and annihilation operators so that the ground state would be obtained by applying the product of all creation operators to vacuum. This state would have infinite positive energy. Fermions and anti-fermions would be holes in Dirac sea of positive energy and behave as negative energy quanta. One might expect that these two quantizations correspond to two different time orientations for the space-time surface.

1. Two manners to circumvent the infinite vacuum energy

The infinite vacuum energy is definitely something very unsatisfactory, and one should overcome this problem somehow. The most elegant and predictive variant of TGD inspired cosmology assumes that the net energy of the Universe vanishes so that the universe could have been created intentionally from vacuum (and be created again and again in each quantum jump). The vanishing of the total energy follows automatically if one poses the condition that the energy flow through the light cone boundary ($H = M^4_+ \times CP_2$) vanishes. This requires that also fermionic vacuum energies cancel each other. There are two manners to achieve the cancellation.

1. If positive and negative energy space-time sheets are always created in a pairwise manner their vacuum energies could compensate each other, at least so if some additional conditions are satisfied. The success of elementary particle physics requires that this mechanism is at work in elementary particle length scales.

2. Vacuum energies could also cancel each other for each space-time sheet separately. This is achieved if the roles of creation and annihilation operators for either fermions or anti-fermions are exchanged. This implies automatically matter antimatter asymmetry since either fermions or anti-fermions would have negative energies. This option could be realized in long length scales and explain the absence of antimatter from the Universe as absence of positive energy antimatter. It would thus seem that all four ground states states are in principle possible and that the ground state characterizes the phase of matter.

2. Zero energy vacuum is matter-antimatter asymmetric

Consider now in more detail the latter option 2) assuming for definiteness that it is anti-fermions for which the roles of creation and annihilation operators are exchanged. The ground state is obtained by applying the product of all fermion annihilation operators and anti-fermion creation operators to vacuum. Fermions represent holes in a completely filled negative energy Dirac sea and have positive energy. Anti-fermions represent holes in positive energy Dirac sea and have thus negative energy. In this ground state annihilation of photon pair is possible only to an fermion with positive and anti-fermion with negative energy.

Obviously the state is matter-antimatter asymmetric since anti-fermions cannot appear as positive energy holes. Negative energy antimatter could be present but could have remained invisible. For instance, Pauli Exclusion Principle would make the scattering of negative energy anti-fermions impossible in the case that there are not sufficiently many holes in the sea. The same occurs for condensed matter electrons below the surface of the Fermi sphere. Even in the case that negative energy anti-fermions are present abundantly, they might have escaped detection. Due to the prevailing dogmas, no-one has tried to detect signatures for the scattering of negative energy anti-fermions or two photon annihilation to a pair of positive energy fermion and negative energy anti-fermion.

3. Creation of matter from vacuum by annihilation of laser waves and their phase conjugates?

The possibility of negative energy anti-fermions suggests a new energy technology. Photons and their phase conjugates with opposite energies could only annihilate to a pair of positive energy fermion and negative energy anti-fermion. Vacuum could effectively serve as an unlimited source

of positive energy and make creation of matter from nothing literally possible. The idea could be tested by allowing laser beams and their phase conjugates to interact and by looking whether fermions pop out via two-photon annihilation. Fermion-anti-fermion pairs with arbitrarily large fermion masses could be generated by utilizing photons of arbitrarily low energy. The energies of the final state fermion is completely fixed from conservation laws so that it should be relatively easy to check whether the process really occurs. Generalized Feynman rules predict the cross section for the process and it should behave as $\sigma \propto \alpha^2/m^2$, where m is the mass of the fermion so that annihilation to electrons is the best candidate for study. Bio-systems might have already invented intentional generation of matter in this manner. Certainly the possible new energy technology should be applied with some caution in order to not to build a new quasar!

4. New view about inertial and gravitational energy

A longstanding puzzle of TGD inspired cosmology has been the conservation of energy implied by Poincare invariance which seems to be in conflict with the non-conservation of gravitational energy. It took time to discover the natural resolution of the paradox. In TGD Universe matter and antimatter have opposite energies and gravitational four-momentum is identified as difference of the four momenta of matter and antimatter (or vice versa, so that gravitational energy is positive). The vanishing of the inertial energy density in cosmological length scales is the proper interpretation for the fact that Robertson-Walker cosmologies correspond to vacuum extremals of Kähler action. The assumption that the net quantum numbers of Universe vanish is maximally predictive and allows to get rid of unpleasant philosophical questions like "What are the net conserved quantum numbers of the Universe".

That particle reactions can correspond to a creation of zero energy states from vacuum is consistent with the crossing symmetry of particle physics and the proposed identification of gravitational energy in absence of appreciable annihilation of positive and negative energy matter creates the illusory western view about objective reality possessing positive inertial energy. The classical non-determinism of vacuum extremals carrying non-vanishing gravitational energy density can be interpreted as being space-time correlate for the fact that Universe is partially engineered.

5.1.3 Pulses, Tesla transformers, and bi-filar coils

The function of quite a many free energy systems involve sharp pulse sequences. Often the bi-filar invented by Tesla [H3] are used to produce magnetic pulses. Together with general TGD based vision this leads to a theoretical picture allowing to understand the visions of Tesla theoretically.

1. The vision briefly

A very concise summary of the model goes as follows.

1. The basic prediction of TGD are negative energy topological light rays propagating backwards in geometric time. They can be accompanied by self-generated negative energy photons since in general case topological light rays carry light like vacuum 4-current. The interpretation as counterparts of phase conjugate laser waves [D3] seems to make sense. A sequence of pulses carrying constant electric field forces charge carriers to accelerate repeatedly provided the frequency of the pulses is sufficiently low for charged to come at rest. A decelerating system emits its energy as positive energy photons whereas the accelerating system might receive its energy by emitting negative energy photons if deceleration and acceleration are genuine time reversals of each other.

2. Negative energy photons are absorbed by any system which contains (possibly many-sheeted) population inverted lasers with appropriate excitation energy when bosonic particles return to their ground states. If sufficiently many bosonic particles return to the ground state, a phase transition return to the ground state occurs and is analogous to induced emission. Large number of positive energy photons are generated and a weak negative energy control signal is amplified to much stronger positive energy signal. The resulting energy is identifiable as "free energy".

The generation of negative energy photons breaks second law. In TGD Universe second law however holds true at a given p-adic length scale only in time scales longer than the corresponding p-adic

time scale. This means that field patterns having a duration below the relevant p-adic time scale can appear as negative energy topological light rays. Sharp electric pulses carrying a constant electric field are ideal in this respect.

Suppose that electric pulses are fed into a bi-filar coil and induce currents in the primary coil. Due to the large mutual inductance between loops of the primary and secondary coils composing the bi-filar coil, the current generated by the pulse in the primary loop is transmitted inductively to the nearby second loop, which in turn generates a positive feedback to primary. Thus the current is amplified and the propagation of the electric pulse induces a propagation of large rapidly varying currents in coils rotating in opposite direction so that the magnetic flux inside the bi-filar coil is small. First of all, this means that the sequence of electric pulses induces a currents through the two components of the bi-filar coil by effectively reducing the inductance of the coil. Secondly, the amplification of the current means amplified acceleration of the charge carriers optimal for the generation of negative energy photons as time reversed brehmstrahlung.

There are good reasons to expect that living matter has discovered the analogs of bi-filar coils long before humans, even before Tesla. Binary structures, such as DNA double strand and cell membrane consisting of two lipid layers, are good candidates for the counterparts of bi-filar coils and might play key control in the bio-control by serving as generators of negative energy photons in turn controlling the generation of positive energy photons.

2. Do electric pulses correspond to scalar wave pulses?

Interesting questions are related to the behavior of the electric field inside coils, in particular bi-filar coils. It seems that the expressive power of Maxwell's theory might not be enough here. It seems that the electric pulses propagating in any circuit could correspond to TGD counterparts of Tesla's scalar wave pulses.

1. The unipolar electric field is discontinuous at the ends of the pulse. In Maxwell's equations the rotor of the magnetic field equates to the sum of the current term j and the displacement current $\partial E/\partial t$. Either an infinitely sharp induction peak is allowed in the magnetic field or the displacement current must be compensated by the current term.

2. In Maxwell's electrodynamics a very high (ideally infinitely strong instantaneous) ohmic current would be needed to compensate the displacement current. This seems implausible. In TGD however vacuum charges and currents are possible. The electric square pulse is analogous to a moving capacitor and the charges of the capacitor plates could correspond to vacuum charges. At the level of space-time geometry the plates would correspond to propagating edges of the 3-surface. The induced electric field E_{rot} would induce a current pulse, whose direction would change in the middle of the magnetic pulse.

3. TGD indeed predicts the existence of scalar wave pulses [H3]. These pulses represent electric flux quanta, 3-surfaces inside which there is an almost constant longitudinal electric field. A capacitor moving with the velocity of light would be the analogy. These solutions are not possible in Maxwell's theory. Because also the pulses moving in circuits are very similar, there is a large temptation to identify them as scalar wave pulses. In this case the effective propagation velocity is reduced below light velocity by the interaction with matter. Intuitively, the particles topologically condensed in the region of 3-surface representing the pulse make it massive and slow down the effective speed of propagation.

One might imagine that the scalar wave pulses could leak out of the system. For instance, this might happen if the second end of the coil is free. Tesla indeed reported a production of scalar wave pulses using a transformer whose primary coil was fed by a sequence of unipolar pulses. These pulses were amplified in a secondary coil in whose second end was free. Abnormally high voltage amplification with no current in secondary coil was reported [H2].

If the propagation velocity of the scalar wave pulse is light velocity, the time T would be the time taken by the pulse to propagate through the first half of the bi-filar coil: $T = Z/v$, where Z is the length of the wire in the bi-filar coil and $v = c$ is light velocity. For $v = c$ T would be 3.3 ns if the length of the wire is 1 meter. The interaction with the matter induces inertial effects and is expected to reduce the effective propagation velocity of the scalar wave pulse representing the electric pulse to $v < c$.

3. Could electric pulses in circuits correspond to separate space-time sheets?

Scalar wave pulses could correspond directly to the space-time sheets of electric flux quanta moving with light velocity predicted by TGD [K12] rather than being regions of constant electric field at the space-time sheet of wire. These flux quanta would move along wire and have flux tubes connecting the space-time sheet of the flux quantum with the boundaries of small co-moving holes associated with the circuit's space-time sheet. Charged particles could flow to the flux quantum along these bridges at the first end of the electric flux quantum, accelerate there practically without dissipation, and flow possibly also back at the second end of the flux quantum. The direction of the flow would be determined by the sign of the charge. This would allow anomalous acceleration of the charge carriers making it possible to emit negative energy photons up to energies determined by the voltage difference associated with the flux quantum. The lowering of the effective propagation velocity would be a genuine quantum effect based on the same mechanism as the lowering of the effect phase velocity of topological light rays.

Scalar wave pulse is like a moving capacitor and should be attracted or repelled by a real charged capacitor depending on the sign of its polarization. Therefore scalar wave pulse could be reflected from a capacitor and begin to move forth and back around the loop connecting the plates of the capacitor in a circuit. This is a testable effect. For instance, if bi-filar coil is coupled between the capacitor the pulse should move forth and back through it. If scalar wave pulses correspond to separate space-time sheets they can leak out of the system. The open ends of the secondary coils used by Tesla in his transformers might be the places where the leakage occurs. The emission of a new kind of radiation observed by Modanese and Pokletnov [H4] to accompany the discharge of a capacitor for which the negatively charged plate was super-conducting might represent the emission of scalar wave pulses [K12].

4. Sharp electric pulses as producers of phase conjugate waves?

Tesla transformers use ordinary coils as primary coils and open coil as a secondary coil. On basis of his experimental work Tesla claimed that Tesla transformers allow an anomalously high voltage amplification. Strangely, Tesla found no current in the secondary coil but the transformers induced charging of various metallic objects in large regions surrounding the transformer. This effect was able to penetrate even through Faraday cage.

The bi-filar coils discovered by Tesla [H3], which are fed by sharp unipolar electric pulses carrying constant electric field and analogous to moving capacitors, occur repeatedly in various free energy devices. This would suggest that bi-filar coils somehow produce phase conjugate laser waves (negative energy topological light rays accompanied by negative energy photons). These in turn would induce the dropping of bosonic charged particles to larger space-time sheets as a phenomenon analogous to induced emission when the intensity of negative energy photons is above some threshold. The challenge is to understand how square pulses propagating both in ordinary and bi-filar coils manage to produce phase conjugated light.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

What is so special in the unipolar electric pulses circulating in bi-filar coils?

1. If one wants to produce negative energy photons, one must break the second law of thermodynamics. TGD predicts that in a given n-ary p-adic length scale $L(n,k)$ (size of the space-time sheet) this is possible below the n-ary p-adic time scale $T(n,k) = L(n,k)/c$. One must only produce pulses having duration shorter than the p-adic time scale $T(n,k)$. The sharp electric pulses are excellent candidates for this kind of pulses since they accelerate the charge carriers and during this period they can emit negative energy photons.

2. One class of important frequencies would correspond to harmonic multiples for the frequency $f = 1/T^E_{1/2}$, $T^E_{1/2} = T^E/2$, where T^E is the duration of the electric square pulse. A second important time scale is the time interval between the pulses which must be so long that

the charges have time to come at rest. One expects that this time scale is of the order of $\tau = L/R$, where L and R characterize the (say) primary of the bi-filar coil. A third important time scale is the duration of the magnetic pulses generated in the pulsed bi-filar coil. The time T during which electric pulse propagates through the first half of the bi-filar coil is not so important as one might first think since mutual induction implies that the propagation of the electric pulse through the primary generates a propagation of a current also in the secondary. Besides these time scales important time scales are the time scales determined by the basic parameters L, C, R of the primary (secondary) of the bi-filar coil.

5. Bio-systems and unipolar pulses

One might think that besides Tesla also bio-systems might have invented the sharp pulses as a manner to break second law temporarily and produce negative energy topological light rays crucial for all basic mechanisms in TGD based quantum biology and theory of consciousness. Perhaps one function of nerve pulse is to produce phase conjugate waves and perhaps nerve pulse can be switched on by a scalar wave pulse reducing the membrane potential below the critical value.

This suggests the existence of biological variants of bi-filar coils. Bio-systems are full of binary structures such as DNA double strand and cell membrane (consisting of two lipid layers). It is tempting to think that DNA double strand is a variant of bi-filar coil in which scalar wave pulses propagate along strand (associated with say gene) and return along the conjugate strand. Also now the effective inductance of the system would grow from zero to some maximum value and return back to zero and phase conjugate light would be generated. As a matter fact, the TGD based model for bio-photons lead to the hypothesis that the strand/conjugate strand generates positive/negative energy MEs and that these MEs move in opposite directions along strands [K21] .

5.1.4 Could negative energy photons induce the transition to effective superconductivity?

The generation of negative energy photons involves temporary breakdown of the second law. Therefore the minimization of the resistance of the relevant part of the circuit, say bi-filar coil, should be favorable for the effect.

TGD based new physics might provide a possible mechanism reducing the resistance. If part of the current carrying electrons of the bi-filar coil drops down to the larger space-time sheets, where they propagate as Cooper pairs, the resistance of the system is reduced. The research group led by Hafedh Abdelmeik has found that the electric conductivity of axon grows by a factor of order 10 below a certain critical temperature, which is in the range 30-40 C of physiological temperatures [J8]. The TGD based model [K30] , [J7] explains the findings correctly at quantitative level.

A variant of this mechanism might be at work also in the case of electric circuits if appropriate conditions are satisfied.

1. The model for the realization of intentionality and motor activity relies on a process, which proceeds from long to short time and length scales, much like a desire for some action in an organization proceeds from boss to the bosses at lower level. In the same manner a hierarchy of phase transitions could proceed from longer to shorter length and time scales and reduce the resistance and increase the upper limit for the energy of negative energy photons.

2. The pulses propagating in say bi-filar coil could produce already in the normal situation a sufficient amount of negative energy photons at low frequencies to induce a phase transition increasing the conductivity. The growth of the intensity of the negative energy photons emitted at higher frequencies could in turn induce a similar phase transition in a shorter p-adic length scale and corresponding to higher zero point kinetic energy. At every stage the negative energy photons could first cool the system so that the phase transition occurs more easily. The dropped Cooper pairs would in turn increase the portion of the supra current flowing at the ground state space-time sheet and thus conductivity.

5.2 Does The Model Explain The Basic Observations Of Tesla?

The basic vision of Tesla was that the sharp pulses involve physics not understood in the framework of Maxwell's theory. Tesla ended up with this vision on basis of certain empirical findings and it is interesting to find whether this observations could be understood in the proposed conceptual framework. In other words, could time reversal and the breaking of the second law below the p-adic time scales explain these findings.

5.2.1 Switching the current on as a time reversal for switching the current off

The basic observation of Tesla was that a sudden switching on of the current circuit produced strange phenomena. Besides sparks and light arcs strong charges were induced in the metal objects in environment. Physiological effects like electric shocks, pressure, sensations of heat, etc.. appeared. Also energy seemed to be liberated. The effects propagated through Faraday cage.

This kind of findings inspired Tesla to develop a technics to produce series of sharp pulses. In the system developed by Tesla, a magnet was repeatedly posed between the capacitor plates between which current was flowing to turn off the current for a moment. The outcome was a fast method for producing sharp current pulses. Tesla developed devices utilizing sharp pulses such as bi-filar coils and transformers, which produced much higher voltage in the secondary coil than one might have expected on basis of Maxwell's theory. The second end of the secondary coil was in freely in air and no current was observed at the end of the coil.

What was the source of these effects? The chapter "Rosetta Stone" in the book of Vassilatos [H2] contains a statement which gives a hint: when the current was switched on, the current carriers behaved as if they had collided with a wall and stopped for a moment. This sounds paradoxical since it is what one might expect to happen when the current is switched off so that resistance suddenly increases. Now just the opposite happened.

A possible solution to the paradox is provided the reversal of geometric time. If the switching on of the current is time reversal of the switching off, the initial situation could be that the system is in a state resulting after closing off of the circuit and it might contain very high charge densities. The resulting high electric fields could even induce the evaporation of the wire. This would mean that the second law of thermodynamics would enter the game and the process would not proceed in the desired manner. In fact, it is not necessary to assume even this as following argument demonstrates.

Time reversal allows to understand what happens in the case that the time reversed process proceeds.

1. When the current is switched off, charge carriers decelerate and emit their energy as positive energy photons. When the current is switched on, charges accelerate and get their energy by emitting negative energy photons. If the system starts from a situation in which charges have "collided with a wall" the amount of energy needed is especially high. This is however not necessary.

2. Condensed matter like water or biological matter are full of population inverted many-sheeted lasers. At certain resonance frequencies corresponding to the differences of the zero point kinetic energies negative energy photons induce phase transitions discharging the population inversion of the many-sheeted laser. From certain space-time sheets charged "drop" to large space-time sheets, say magnetic flux tubes. A cascade of positive energy photons is liberated and manifests itself as "free energy".

3. The metallic (for instance) objects receiving negative energy photons lose net charge to the large space-time sheets and generate a net charge of opposite sign so that a high voltage with respect to the environment is generated. This indeed was found by Tesla to occur, and the charge definitely did not originate from the circuit generating the effect. This in fact led Tesla to postulate that ether carrying the charges was emitted in the process. Process can occur in a wide region since negative energy photons of sufficiently high energy do not respect Faraday cage. The reason is that there is not system able to absorb them and thus drop to a lower energy state. The net charge is developed because the negative energy topological light rays act as "bridges" along which the charge can move between space-time sheets. Since there

is an electric field in the direction of the bridges, the charges move only in second direction fixed by the sign of the charge.

4. Switching of the current on acts as a control process which switches much larger process in environment using negative energy photons. Basically the process is due to the inherent instability of the many-sheeted space-time. What happens is analogous to a transition from a bottom of potential well in a fractal spin glass energy landscape to a bottom of a deeper potential well. The process leads to a gradual transfer of matter to larger space-time sheets and cooling. The generation of larger space-time sheets means evolution of consciousness since the p-adic prime characterizing the space-time sheets identifiable as a kind of intelligence quotient grows in the process.

5. In order to maximize the intensity of negative energy photons and get as dramatic effect as possible, the parameters characterizing the pulse series can be optimized. The basic idea is that the system is rapidly shaken. This generates accelerations of opposite sign and the system is decelerated and accelerated in a fast tempo. There is however a limitation coming from the fact that charge carriers must have enough time to return to rest. We use instinctively this trick when we try to wake up a person who has lost consciousness.

5.2.2 Do scalar wave pulses appear also outside electric circuits?

The transients at the ends of voltage pulses correspond to a constant electric field propagating as scalar wave pulses with light velocity when the inertial quantum effects caused by the coupling with matter can be neglected. TGD allows solutions of field equations describing free scalar wave pulses with longitudinal electric field. Both positive and negative energy pulses are possible. The interesting question is whether the findings of Tesla necessitate the emission of free scalar wave pulses.

1. On basis of foregoing considerations it would seem that Tesla's scalar wave pulses outside the pulsed circuits are not necessary if one wants to understand the findings of Tesla. Of course, they could be involved.

2. In the chapter "Rosetta Stone" of the book of [H2] [H2] there is a summary of the properties of the electro-radiative event (ERE) observed by Tesla. It seems that one could understand them as effects induced by the emission of negative energy photons.

   In particular, ERE leaves wires and other circuit elements in a direction orthogonal to them. This favors strongly the interpretation in terms of topological light rays identifiable as TGD counterparts of ordinary radiation. In TGD topological light rays are however carriers of light like vacuum(!) 4-currents so that they generate coherent photons and can also carry Bose-Einstein condensates of parallel photons. The filament like light emitting structures orthogonal to metal coils could thus correspond to topological light rays. If they carry negative energy they should also generate coherent photons with negative energies.

3. Scalar wave pulses should leave an open wire in a direction parallel to the wire. The open secondary coil of Tesla transformer is a good candidate in this respect. From a capacitor the pulses should leave in a direction orthogonal to the capacitor plate and might reduce the voltage of the capacitor by carrying quanta of electric flux which are very much like small capacitors themselves moving with a light velocity.

5.2.3 Why the radiation observed by Tesla was so difficult to detect using photography?

In the chapter "Rosetta Stone" of his book [H2] Vassilatos tells that although the radiation emitted by the Tesla's circuits was perceived both visually and experienced as physiological effects it was very difficult to detect it instrumentally, for instance by photographing: long deposit times were required.

The explanation for this might be very simple. Body and especially retina are full of population inverted many-sheeted lasers which can amplify a weak signal of negative energy photons to a much

stronger signal consisting of positive energy photons. Ordinary photographic film very probably is not able to do this.

This idea is supported also by the TGD based model for sensory receptors [K17]. In TGD Universe sensory organs are the carriers of primary qualia like color, and one can say that brain only writes the sensory music to notes. Since brain processes the sensory input in a selective manner, a back projection from brain to sensory organs making virtual sensory experiences possible must be present. Negative energy photons provide the most elegant manner to realize this mechanism since bio-matter is transparent to them unless there are many-sheeted lasers tuned to the wavelength in question.

Photo receptors indeed contain a lot of mitochondria serving as energy plants of the cell and mitochondria are known to generate visible light which is not a mere side product of metabolism [I8]. This suggests that the signal consisting of negative energy photons is amplified to a positive energy visual signal in retina. This would occur during dreaming and explain rapid eye movements. The mechanism would make it possible to see using negative energy photons and even seeing even through physical objects using phase conjugated photons as the findings of Feinberg demonstrate [D3]. A camera using negative energy photons is a possible technological application. The camera would make it possible to take images through walls.

5.2.4 How Tesla transformer manages to yield so high voltage amplification?

Tesla reported that his transformers have an anomalously high voltage amplification. There are two cases to be considered corresponding to pulsed ordinary and bi-filar primary coils. In both cases it might be possible to understand Tesla's findings.

1. In the case of the ordinary coil the repeated acceleration of charges induced by electric pulses generates magnetic pulses inducing in turn voltage over the secondary coil. This is what also Maxwell's theory predicts. The emission of negative energy photons inducing the increase of conductivity and an anomalous amplification of the primary current would however mean that also the voltage induced in the secondary coil is anomalously high.

2. Only the net current flowing in the pulsed bi-filar coil induces electromotive force in the secondary coil. Thus the magnetic pulses should become much sharper than in the case of the ordinary coil. Already this implies that induce voltage along the secondary coil, being proportional to the time derivative of the magnetic flux, is very high during the short pulse. The currents induced by the electric pulse in the bi-filar coil increase also rapidly the resonance mechanism and eventually more or less compensate each other. The increase of conductivity is a further amplification mechanism possibly involved. By using a several primary bi-filar coils arranged around circle and having suitable phase lag, one could perhaps arrange a permanent anomalously large inductive effect.

5.2.5 Why no current was observed in the secondaries of Tesla transformers?

Tesla did not detect the emission of charge carriers from the open ends of the secondary coils of his transformers. What one would expect is that the voltage along the secondary generates a flow of charge carriers which are stuck to the open end and that part of them leaks out. Two factors are involved.

1. There was no current at atomic dissipative space-time sheets since the charge carriers were dropped to larger space-time sheets: perhaps at the flux tubes of the magnetic fields generated in the process or at the magnetic flux tubes of the Earth's magnetic field. An interesting possibility is that closed magnetic super conducting circuits involving primary and secondary coils are formed. The magnetic flux tubes could carry the charges also to environment and negative energy topological light rays might help to transfer the charge to the metallic objects in the environment.

2. Electric pulses correspond to a Tesla scalar wave pulses so that the surface charges associated with the ends of the pulse correspond to vacuum charges and vacuum currents. Therefore no ordinary charge carriers were associated with them.

6 Quantum Criticality, $1/F$ Noise And Consciousness

Criticality is a necessary prerequisite of control. Unless the system to be controlled has some critical variables in which small change induces large changes in the state of the system, control is very ineffective. The quantum criticality of TGD Universe indeed guarantees, not only the existence of macroscopic quantum systems, but also possibility of quantum control. What is encouraging is that quantum criticality can be correlated with $1/f$ noise, a phenomenon which has remained poorly understood in standard physics approach.

6.1 $1/F$ Noise

The so called $1/f$ noise deserves the often used attribute ubiqitous: it appears in widely different systems such as radio active decay, chemical systems, biology, fluid dynamics, astronomy, electronic devices, optical systems, network traffic and economics (references can be found in [D1]). An excellent article about $1/f$ noise in music by Martin Gardner in Scientific American [A8] gives a good grasp on the basic concepts. $1/f$ noise is less random than white noise with $1/f^0$ power spectrum and completely random correlation function and more random that Brownian noise having $1/f^2$ power spectrum (defined as the Fourier transform of the autocorrelation function $\langle A(t)A(t+T)\rangle$). In practice, the phrase $1/f$ noise is attributed also to power spectrum of form $1/f^\alpha$, $\alpha \simeq 1$.

There is no generally accepted explanation for $1/f$ noise. Power law with a negative value of exponent suggests that a system producing $1/f$ type noise is scaling invariant and has long range time and spatial correlations as a consequence. This suggests that fractal like structure is in question and Mandelbrot has indeed proposed that fractality is the basic underlying mechanism of $1/f$ noise. If this is the case, one however encounters the problem of identifying the underlying mechanism of fractality.

Critical systems are scaling invariant in the sense that regions of arbitrary large size of two phases can be present in the system. Critical systems are also known to exhibit fractal like structures. This suggests that criticality is the basic underlying cause of both fractals and $1/f^n$ type noise. The problem is however that critical systems are extremely unstable: arbitrarily small perturbation can change the value of the critical parameter (such as temperature) so that criticality is lost. This is certainly not in accordance with the universality of $1/f$ noise and of fractals.

The paradigm of self-organized criticality [B1] is based on the hypothesis that the dynamical systems have a tendency to develop asymptotically to critical states. It is however not at all clear whether these models can be derived from basic physics. It has been also argued [B10] that the criticality is somehow built into the structure of these models so that there actually exists a critical parameter and the dynamics is constructed in such a manner as to preserve the value of the critical parameter.

Topological Geometrodynamics (TGD) suggests quite different explanation of $1/f$ noise. The entire Universe predicted by TGD is quantum critical system in the sense that the vacuum functional of the theory is completely analogous to the partition function of a thermal system. The so called Kähler coupling strength α_K is analogous to temperature and the requirement that it corresponds to critical temperature fixes the theory uniquely. Since the critical parameter is fundamental constant of Nature, it is clearly not possible to generate perturbations leading away from criticality without Godly intervention and the basic argument against criticality as an explanation of $1/f$ noise can be circumvented.

Like its thermodynamical counterpart, quantum criticality implies long range quantum correlations. This in turn implies that macroscopic quantum systems of arbitrarily large size are possible. This result is a cornerstone for the TGD inspired theory of bio-systems as macroscopic quantum systems: what remains is to identify the mechanisms making bio-systems macroscopic quantum systems. TGD indeed predicts several, purely TGD based, mechanisms. Needless to emphasize, if quantum criticality could provide a general mechanism explaining the universality of the $1/f$ noise, one would have strong support not only for quantum criticality (and TGD!) but also for the possibility of macroscopic quantum systems. Therefore the hypothesis deserves a serious study.

6.2 Quantum Criticality Of TGD

6.2.1 Quantum criticality and p-adicity

As already explained quantum criticality emerges in TGD from the requirement that the theory is unique: as a consequence the value of the Kähler coupling strength, which is analogous to critical temperature, is fixed. The situation is actually somewhat more delicate. The considerations related to the value of gravitational constant lead to the hypothesis that WCW decomposes into regions characterized by p-adic prime p such that the critical value of Kähler coupling strength depends on p and hence on p-adic length scale $L(p)$ in the manner characteristic for the length scale evolution of $U(1)$ coupling strength.

The requirement that gravitational constant is invariant under the coupling constant evolution associated with p-adic prime p plus the requirement that electron mass scale is predicted correctly by p-adic mass calculations [K24], fix the evolution of the Kähler coupling strength as a function of the p-adic length scale:

$$\begin{aligned} \frac{1}{\alpha_K(p)} &= k\left[log(p) + log(K^2)\right] \quad , \\ K &= \frac{R}{\sqrt{G}} \simeq 1.367 \times 10^4 \quad . \end{aligned}$$

Here R denotes CP_2 "radius", G denotes gravitational constant and p is the p-adic prime. The value of the parameter k is $k = \frac{4}{\pi}$ in the scenario in which the value of Kähler function is integer for CP_2 type extremals and $k = 137/107$ in the scenario allowing the expansion of Kähler function as power series existing p-adically. One can say that instead of single critical value Kähler coupling allows infinite number of critical values labelled by primes and each critical value corresponds to a particular effective p-adic topology.

It seems that a successful p-adicization requires the extension of rational numbers by introducing an infinite group of real units defined by products of ratios $U = (m/n)X/\Pi(m/n)$, where X is product of all finite primes and $\Pi(m/n)$ is an infinite prime. One has $U = 1$ in a real sense but not p-adically. This extension is a multiplicative version for the addition of infinitesimals and seems much more better suited for the purposes of physicist. The p-adic norm of these units is $1/p$ for almost all primes and the remaining primes are cognitively very special. If the inverse of the Kähler coupling strength is proportional to this kind of unit the continuation of the Kähler function to p-adic realm becomes easy.

The notion of algebraic hologram suggests itself. This would mean that WCW decomposes into sectors D_Q, Q infinite rational, such that Q defines the subgroup of units for the rational numbers at that point. The value of Q would be reflected in the properties of single point of space-time sheet and would affect decisively the p-adic physics of cognition but would not reflect itself directly at the level of the real physics. At the imbedding space level Q would correspond to an octonionic unit. Since octonionic primes could quite well be able to code the quantum state of the entire universe to their structure, one must consider seriously the possibility that single point codes in its structure the quantum state of the universe!

6.2.2 How quantum criticality is realized?

It is not completely clear how criticality is precisely realized in quantum TGD. In fact, criticality seems to be realized in several senses. The most general action containing no dimensional coupling constants is super position of Yang-Mills action for induced CP_2 spinor connection and of Kähler action. This action allows all 4-surfaces with one-dimensional CP_2 projection as vacuum extremals. When the Yang-Mills part of the action vanishes (Yang-Mills coupling becomes formally infinite) action has the huge vacuum degeneracy of Kähler action: any 4-surface whose CP_2 projection belongs to so called Legendre sub-manifold (generically 2-dimensional) of CP_2, is vacuum extremal. It is not clear whether this criticality could give rise to spin glass analogy irrespective of the value of the Kähler coupling strength.

The value of Kähler coupling strength gives rise to additional criticality. From the fact that Kähler electric/magnetic fields give negative/positive contribution to Kähler action it is clear that vacuum functional favors the formation of Kähler magnetic/electric fields below/above the critical value. Therefore configurations containing Kähler magnetic fields, in particular so called cosmic strings, should be favored below criticality. CP_2 type extremals [K24] with negative and

finite Kähler action representing elementary particles and surfaces representable as deformations of vacuum extremals and containing Kähler electric fields should be more favored above criticality.

One possibility is that some kind of spontaneous Kähler magnetization occurs below criticality and that in criticality spin glass type structure consisting of regions containing Kähler magnetic fields is present whereas above criticality magnetization is absent. An attractive working hypothesis, motivated by the experience with critical systems, is that at criticality the formation of join along boundaries/flux tube condensates with arbitrarily large sizes is possible: depending on whether the flux tubes contain Kähler electric or magnetic gauge fluxes, single stable join along boundaries/flux tube condensate would be formed above/below criticality. This would mean that the topology of the many-sheeted space-time is extremely dynamical at criticality. This indeed would be necessary for the formation of macroscopic quantum systems of all possible sizes. Examples of join along boundaries bonds are color flux tubes between quarks, strong bonds between nucleons inside atomic nuclei, chemical bonds, MAPs between micro-tubuli and gap junctions between cells.

6.2.3 Information theoretic interpretation of Kähler function

The discovery that Kähler function has information theoretic interpretation led to a considerable progress in the understanding of quantum criticality. The work of Roy Frieden [B8, B9] suggest that the action principles of physics could have information theoretic interpretation. Although Frieden's original scenario does not seem to work in TGD framework, it turns out possible to deduce interpretation for the negative of the Kähler function as an entropy type measure for the cognitive information content of the space-time surface. Furthermore, the criticality of the Kähler action can be interpreted as a maximization of the cognitive information content of the space-time surface and quantum criticality makes TGD universe maximally interesting and maximizes its intelligence.

A detailed argument leading to these results goes as follows. The $I - J$ decomposition of the Kähler function in the manner suggested by Frieden's theory is not General Coordinate Invariant and therefore not promising in TGD context. On the other hand, the formal similarity of the vacuum functional with thermodynamical partition function suggests the interpretation of the vacuum functional as an exponent for the negative of some kind of entropy type variable so that the negative of the Kähler function would correspond to entropy.

The exponent $exp(-K_{cr})$ of the negative of Kähler function, for a suitable choice of the value α_{cr} of the Kähler coupling strength, should somehow measure the number of some kind of microstates. A natural identification of the "microstates" is as cognitive degeneracy caused by the classical nondeterminism of the Kähler action, which implies that WCW integration over 3-surfaces Y^3 at the light cone boundary involves summation over all possible association sequences going through the same 3-surface Y^3 on the light cone boundary and having the same value of the Kähler function. This summation brings in a degeneracy factor, which will be referred to as N_d.

An educated guess is that the degeneracy factor N_d is in a good approximation proportional to the exponent of the negative of the Kähler function, when Kähler coupling strength has critical value α_{cr}:

$$N_d \simeq exp(-K_{cr}) \ . \tag{6.1}$$

Note that α_{cr} depends on the sector D_p of the WCW since Kähler coupling strength depends on p-adic length scale in a logarithmic manner typically predicted by $U(1)$ gauge theories. This hypothesis allows to answer to the basic questions related to the definition of the Kähler function.

The first consequence of the hypothesis is that preferred extremal property maximizes cognitive information. This is achieved by generation of Kähler electric fields necessarily accompanied by mind like space-time sheets, whose contribution to N_d compensates the negative Kähler action. Perhaps this could partially explain why electric fields, in particular those associated with the cell membranes, are so important in bio-systems. The construction of cognitive systems artificially some day would thus involve construction of Kähler electric fields.

This hypothesis throws also new light to the precise mechanism of the quantum criticality. At quantum criticality the cognitive degeneracy factor N_d in the functional integral over WCW compensates the exponent of the negative Kähler function even when its value is infinite! Below

quantum criticality the probabilities for 3-surfaces having negative Kähler function suffer exponential cutoff so that only the 3-surfaces for which the value of Kähler function per volume vanishes, are important. The resulting universe is obviously much less interesting than quantum critical universe, which maximizes complexity. Also the maximum for the total cognitive information content of the quantum jump is always finite for subcritical universe unlike for quantum critical universe. Above quantum criticality cognitive degeneracy dominates over vacuum functional and configuration space integral of the vacuum functional diverges so that the theory becomes mathematically ill defined. Therefore quantum critical universe possesses maximal complexity and is as interesting and intelligent as universe can be! Note that quantum criticality was already earlier realized to be crucial for consciousness since it makes possible long range quantum correlations and hence arbitrarily large macroscopic quantum systems.

6.2.4 Quantum criticality and $1/f$ noise

Criticality and fractality in quantum TGD are closely related to the properties of the Kähler function defining the Kähler geometry of the WCW of all possible 3-surfaces in $H = M^4_+ \times CP_2$. Kähler function is defined as Kähler action for a preferred extremal of Kähler action. Kähler action allows huge number of vacuum extremals with finite size in both spatial and temporal degrees of freedom. These surfaces are not absolute minima of the Kähler action but one can consider the possibility that by gluing vacuum surfaces to non-vacuum surfaces the interaction with the non-vacuum surfaces makes them almost-vacuum extremals and as a consequence one obtains absolute minimum of Kähler action. Quantum criticality of the material system suggests that this weak interaction could generate large fluctuations with long time and length scales.

A natural hypothesis is that $1/f$ noise results when the space-time sheet containing the physical system is glued to a vacuum extremal. When almost vacuum extremal is created, some energy flows from the physical system to the vacuum extremal. On the other hand, when almost vacuum extremal disappears, this energy flows back to the space-time sheet of the physical system. This mechanism perturbs the physical system and causes a fluctuation. By quantum criticality even small energy flow can give rise to a large perturbation of the physical system. Spin glass analogy which is closely related to the vacuum degeneracy of the Kähler action, predicts that there indeed exist very many almost degenerate maxima of Kähler function and small perturbations could induce time development transforming the 3-surface to a new one. The transition would be analogous to a rapid classical time development leading from one sheet of a cusp catastrophe to another one.

Photons and gravitons (possibly virtual) are the most natural candidates for particles transferred to the non-vacuum space-time sheet. Uncertainty Principle suggests that the energy transferred by single quantum from a material space-time sheet to the almost vacuum space-time sheet of duration T is of order $E \simeq 1/T$. One can consider also a possibility that large number of quanta with energy $E \simeq 1/T$ is transferred to the non-vacuum space-time sheets. TGD predicts the presence of Bose-Einstein condensates of photons and gravitons generated by vacuum currents [K27] and a definite possibility is that a fraction of the topologically condensed coherent photons with energy $E \simeq 1/T$ are Bose-Einstein condensed at the almost non-vacuum space-time sheet. In this case only the amount of energy transferred would be larger and the changes to cause long length scale fluctuation of large amplitude and having frequency $\omega = E$ at the non-vacuum space-time sheet containing matter, would be better.

If one requires scaling invariance in the strongest possible sense, the only viable probability distribution for the durations of the almost vacuum space-time sheets is $dP(T) \propto dT/T$ since any other distribution law would necessarily contain some dimensional parameter. By Uncertainty Principle the same distribution gives also the distribution of energies: $dP(E) \propto dE/E$. Obviously the proposed distribution implies duality between energy and time variables and is especially natural from the view point of quantum theory. Actually the spectrum is of the same form as brehmstrahlung spectrum and one can consider the possibility that the space-time sheets of finite time duration could be regarded many particle states formed by real and virtual collinear photons and gravitons.

Quite generally, one can identify energy E as the frequency ω of the fluctuation generated by the transfer of energy. Quantum criticality suggests that the energy transferred to the non-vacuum space-time sheet serves only as a seed of a fluctuation whose average amplitude squared approaches constant at the limit $E = \hbar\omega = hf \to 0$. The non-vanishing of the constant in question follows

from quantum criticality implying the presence of fluctuations at arbitrarily long time scales. With these assumptions one indeed obtains $1/f$ power distribution for the frequencies

$$S(f) \propto \frac{df}{f} \quad . \tag{6.2}$$

6.3 $1/F$ Noise And Thermalized Arithmetic Quantum Field Theory

Following arguments demonstrate that $1/f$ noise follows automatically from either p-adic or real thermodynamics applied to arithmetic quantum field theory with energies quantized as multiples of $log(p)$, p prime. There are small corrections to $1/f$ spectrum and these reflect directly the distribution of primes. Obviously this serves as a high precision test for the proposed explanation of $1/f$ noise.

6.3.1 Arithmetic quantum field theory with broken conformal symmetry describes critical systems

Two-dimensional critical systems allow description in terms of conformal quantum field theories [A6]. On the other hand, quantum TGD relies crucially on the realization of super conformal invariance made possible by the miraculous properties of the boundary of the four-dimensional future light cone [K8]. This background inspires the hypothesis that critical systems quite generally possess some form of conformal invariance possibly broken to some sub-algebra.

The generators of the full number-theoretic conformal symmetries are

$$L_q = q^z \frac{d}{dz} \quad , \tag{6.3}$$

where q is rational number. Commutators satisfy the commutation law

$$[L_{q_1}, L_{q_2}] = log(\frac{q_2}{q_1}) L_{q_1 q_2} \tag{6.4}$$

respecting multiplication of rationals.

Generators are eigen states of $L_1 = d/dz$ under commutation. L_1 is analogous to energy (or momentum) since it generates translations. Energy eigenvalues are

$$E = E_0 log(q) = E_0 \sum_{k_i \in Z} k_i log(p_i) \quad , \tag{6.5}$$

where p_i are primes and k_i are integers which can be also negative. If physical states correspond to integers for which energy is always positive, one has

$$E = E_0 \sum_{k_i \geq 0} k_i log(p_i) \quad , \tag{6.6}$$

which is the energy spectrum of arithmetic quantum field theory, which describes the physics of infinite number of harmonic oscillators labelled by primes and having fundamental frequencies $f_p = log(p) f_0$ ($E_0 = h f_0$). The positivity of the spectrum suggests that the interpretation as energy rather than momentum is indeed more appropriate.

The generators L_p and $L_{1/p}$ generate the entire algebra by repeated commutations. What is remarkable, is that one obtains infinite hierarchy of symmetry breakings by dropping any subset of generators labelled by some subset of primes. An interesting hypothesis is that arithmetic quantum field theory with symmetry broken in this manner describes some critical systems. Analogous hierarchy of symmetry breakings is possible also for ordinary Super Virasoro algebra.

If one assumes $p \simeq 2^k$, k prime, one obtains special kind of breaking of conformal symmetry. In this case the scaled generators

$$\hat{L}_k \equiv \frac{L_{p\simeq 2^k}}{log(2)} \tag{6.7}$$

have energies $\hat{L_1} \simeq k$. The algebra commutators satisfy commutation relations

$$[L_{n_1}, L_{n_2}] \simeq (n_2 - n_1)L_{n_1+n_2} \ , \tag{6.8}$$

so that one has in a good approximation standard conformal algebra of string models and statistical models of critical systems [A6]. This observation suggests a symmetry-based justification for p-adic length scale hypothesis besides the justification coming from the generalization of Bekenstein-Hawking law for black-hole entropy to elementary particle context [K24].

6.3.2 Thermodynamics for arithmetic quantum field theory

$1/f$ spectrum follows in a straightforward manner by applying p-adic or ordinary thermodynamics to arithmetic quantum field theory.

1. The spectrum of frequencies in a mode p is harmonic oscillator spectrum:

$$f_n = nf_0 \times log(p) \ , \tag{6.9}$$

   where n is integer identifiable as number of arithmetic bosons. f_0 is infrared cutoff for frequencies.

2. The average number of particles in the mode p is calculable form p-adic thermodynamics. In p-adic thermodynamics Boltzmann weight $exp(-\beta H)$, $\beta = 1/T$ (the units are $\hbar = c = k = 1$ in the following), does not exist as such p-adically and one must replace it by power of p which exists under certain constraints on the energy spectrum satisfied in conformally invariant theory:

$$exp(-\beta H) \to p^{\beta H} \ . \tag{6.10}$$

   For number-theoretic reasons one must assume that

$$H \equiv \frac{L_1}{log(p)} \tag{6.11}$$

   having integer valued spectrum is in the role of Hamiltonian H. This operator has eigenvalues $p^{\beta n}$. Inverse temperature β must be positive-integer valued from the requirement that Boltzmann weights exist p-adically:

$$\beta = m \ . \tag{6.12}$$

3. The partition function for mode p is nothing but standard harmonic oscillator partition function

$$Z = 1 + p^m + p^{2m} + ... = \frac{1}{1 - p^m} \ . \tag{6.13}$$

   The average value of particle number in mode p is given by

$$\langle n\rangle = \frac{\sum_n np^{nm}}{Z} = \frac{p^m}{1-p^m} \quad . \tag{6.14}$$

The real counterpart of average particle number is obtained using canonical identification

$$\sum x_n p^n \to \sum_n x_n p^{-n} \tag{6.15}$$

mapping p-adic observables to real ones and one obtains

$$\langle n\rangle_R = \frac{p^{-m}}{1-p^{-m}} \quad . \tag{6.16}$$

For large primes one obtains in excellent approximation $\langle n\rangle_R \simeq p^{-m}$.

4. This construction applies with minor modification also in real context. In this case one has

$$\langle n\rangle = \frac{\sum_n np^{-\beta n}}{Z} \quad , \quad Z = \sum_n p^{-\beta n} \quad , \tag{6.17}$$

where one has $\beta = f_0/T$. The resuting expression is the same as given by p-adic thermodynamics except that β is now real-valued:

$$\langle n\rangle = \frac{p^{-\beta}}{1-p^{-\beta}} \quad . \tag{6.18}$$

6.3.3 $1/f$ noise from thermal arithmetic quantum field theory

To deduce $1/f$ spectrum it is enough to calculate the average number of states $N(f)$ with frequency smaller than f using the approximate expresssion

$$\pi(x) \simeq \frac{1}{u} \quad , \quad u = log(x) \tag{6.19}$$

for the density of primes in the set of reals x [A3]. Thus, in the approximation $\langle n\rangle = p^{-\beta}$, one has

$$\begin{aligned} N(f) &= \sum_p \frac{p^{-\beta}}{1-p^{-\beta}} \simeq \int dx \frac{x^{-\beta}}{1-x^{-\beta}} \times \frac{1}{u} \\ &= \int_{log(2)}^{log(p)} du \times \frac{exp[(1-\beta)u]}{1-exp(-\beta u)} \times \frac{1}{u} \quad . \end{aligned} \tag{6.20}$$

From this one has

$$\frac{dN}{df} = \frac{exp\left[(1-\beta)\frac{f}{f_0}\right]}{\left[1-exp(-\beta\frac{f}{f_0})\right]} \times \frac{1}{f} \quad . \tag{6.21}$$

Approximate $1/f$ spectrum is obtained in the frequency range

$$\frac{1}{\beta} \ll \frac{f}{f_0} \ll \frac{1}{|\beta-1|} \quad . \tag{6.22}$$

Clearly, $\beta \geq 1/2$ is required meaning that temperature is below $T = 2f_0$. For $\beta = 1$ $1/f$ spectrum becomes exact at sufficiently high frequencies and its normalization is fixed completely. It is important to notice that for reasonable cutoff frequencies, say of order $f_0 = 10$ Hz, the value of the temperature must be extremely low: or order $T \sim 10^{-10}$ Kelvin. Therefore new physics is necessarily involved.

$T \to \infty$ limit exist only in real context and gives

$$\frac{dN}{df} = \frac{f_0 exp(\frac{f}{f_0})}{\beta f^2} \quad . \tag{6.23}$$

Long range temporal correlations clearly disappear at this limit.

It is interesting to look how the situation changes when the allowed primes satisfy the constraint given by p-adic length scale hypothesis. The first observation is that for suitable unit of frequency frequencies are in good approximation prime-valued in this case, which is unique signature of the spectrum. The spectrum is given by

$$N(f) = \sum_{p \simeq 2^k} \frac{p^{-\beta}}{1-p^{-\beta}} \simeq \int dx \frac{2^{-x\beta}}{1-2^{-x\beta}} \times \frac{1}{log(x)} \quad . \tag{6.24}$$

$$\frac{dN}{df} = \frac{1}{f_0 log(\frac{f}{f_0})} \times \frac{2^{-\beta \frac{f}{f_0}}}{\left[1 - 2^{-\beta \frac{f}{f_0}}\right]} \quad . \tag{6.25}$$

Exponentially decaying spectrum is obtained for higher frequencies for finite values of the temperature reflecting very strong long range temporal correlations. For high temperatures the spectrum becomes

$$\frac{dN}{df} \simeq \frac{1}{log(2)\beta} \times \frac{1}{log(\frac{f}{f_0})f} \quad , \tag{6.26}$$

and differs from $1/f$ spectrum obtained in general case by different normalization factor and by logarithmic correction term. Thus the deviation of the normalization factor from unity could be interpreted as signature of the breaking of conformal symmetry implied by p-adic length scale hypothesis and the value of the temperature can be determined from cutoff frequency and normalization factor of $1/f$ spectrum. Note that in this case $1/f$ spectrum results for cutoff frequencies f_0 much smaller than room temperature, which corresponds to frequency of order 10^{13} Hz.

To sum up, thermalized arithmetic QFT implies $1/f$ spectrum and deviations from the precise $1/f$ spectrum reflect the properties of the distribution of primes since the dominating frequencies in the spectrum are essentially logarithms of primes in general case and primes in case that p-adic length scale hypothesis holds true. In p-adic thermodynamics $T/f_0 = 1/m$ are the only allowed temperatures and $T/f_0 = 1$ corresponds to the highest possible p-adic temperature: note that the calculation of the elementary particle masses using p-adic thermodynamics assumes also $T = 1$ [K24]. In its recent form TGD cannot predict the allowed values of f_0. Certainly transmutation of the fundamental p-adic length scale of order 10^4 Planck length is involved making possible small-p p-adicity at macroscopic length and time scales.

6.3.4 A possible connection between arithmetic quantum field theory, hydrodynamic turbulence, and chaos in excitable media

Turbulence in atmospheric hydrodynamics (flow is associated with a thin boundary layer of about 10 km) has fractal structure and is accompanied $1/f$ noise [K19]: both features associated with self-organized criticality and deterministic chaos. The mechanism giving rise to macroscopic coherent structures such like hurricanes and tornadoes has remained poorly understood in the framework of ordinary hydrodynamics [I4]. Typical structures involved are spiral vortices [I4]

$$\frac{r}{r_0} = \tau^{\frac{\theta}{\theta_0}} \quad , \quad \tau = \frac{1+\sqrt{5}}{2} \quad , \tag{6.27}$$

having the property that for large values of n the values of radii at $\theta_n = n\theta_0$ are proportional to Fibonacci numbers $F_n \simeq \tau^n$ (τ denotes Golden Mean). The favored value of θ_0 corresponds to $\theta_0 = 36$ degrees giving rise to Fibonacci spirals encountered widely in botany and associated with aperiodic Penrose tilings with five-fold rotation symmetry [A9].

In TGD hydrodynamic vortices are accompanied by Z^0 magnetic fields whose flux tubes are parallel to the spiral vortex cores. At the tip of the vortex the conserved Z^0 magnetic flux must go somewhere. The only possibility seems to be that it flows to another space-time sheet. This suggests that spiral vortices are associated with what I have called wormhole magnetic fields [K37]. These are double-sheeted structures carrying opposite magnetic fields created by rotating extremely tiny elementary particle sized wormhole contacts at the boundaries of second sheet of the double sheeted structure and feeding electric gauge fluxes between the two space-time sheets. If second sheet has negative time orientation, its energy is negative, and the structure can have finite time duration and be created spontaneously without any energy cost. Thus mind like space-time sheet is in question by definition. This in accordance with the idea that $1/f$ noise involves mind like space-time sheets in essential manner. Wormhole magnetic fields form a fractal hierarchy since space-time sheets can be glued to space-time sheets and this hierarchy can be identified as a fractal hierarchy of vortices containing smaller vortices inside them.

This picture inspires the following hypothesis: it is the excitations associated with wormhole magnetic fields, which are described by arithmetic quantum field theory. The mode with energy $log(p)$ corresponds to a definite structure, perhaps smaller space-time sheet carrying magnetic field glued to the larger sheet. These structures are labelled by primes and thus the distribution of primes is reflected in the dynamics of the system. Wormhole magnetic fields might provide general description of the spiral waves associated with various excitable systems. In particular, generation of chaos by the decay of spiral waves [A1] could correspond to the development of magnetic chaos. Since the phase increment of the order parameter of super-conductor over a closed circuit surrounding magnetic flux tube gives essentially magnetic flux [K22], magnetic chaos implies chaos for the phase of the order parameter of super conductor. Thus magnetic or Z^0 magnetic chaos at cellular level could spoil coherence of the macroscopic quantum phases crucial for bio-control in TGD inspired model of bio-control. For instance, this loss of quantum coherence could lead to heart failure known to involve the decay of spiral waves [A2, A4].

6.3.5 Connection with TGD inspired theory of conscious systems

For f_0 or order say 10 Hz, the temperature associated with $1/f$ noise is extremely low, something like 10^{-10} Kelvin. Standard physics does not certainly allow earthly systems with so low temperatures. In TGD Universe situation is different because the space-time is many-sheeted. In fact, TGD based theory of brain as a macroscopic quantum system relies crucially on the existence of cellular space-time sheets having ultra-low temperatures and allowing the presence of various types of Bose-Einstein condensates. It his view is correct, $1/f$ noise could be seen as a direct signature of consciousness. A natural TGD inspired interpretation for the arithmetic QFT could be as a statistical description of the dynamics at the mind like space-time sheets having by definition finite time duration $\tau = 1/f_0$. mind like space-time sheets are indeed suggested to give rise to $1/f$ noise which thus would become direct signature of consciousness [K6]. Around human brain τ could be even of the order of lifetime: mind like space-time sheets with this duration make possible long term episodal memories in the proposed general theory of qualia [K17]. Thus the standard formal trick of performing path integral over space-time of finite time duration to construct thermodynamical quantities [B7] seems to have deeper "psycho-physical" meaning in TGD framework.

In TGD inspired theory of bio-systems as macroscopic quantum systems so called association sequences [K25] provide geometric representation for thoughts and in fact are almost vacuum space-time surfaces with a possibly finite duration. Therefore one can consider seriously the possibility that $1/f$ noise is closely related to the basic mechanism with which brain and living matter control the behavior of the matter.

More concretely, "massless extremals" (MEs) are basic solutions of field equations of TGD and define an excellent candidate for an infinite hierarchy of life forms having huge information storage

capacities and expected to control lower level selves such as super-conducting magnetic flux tube structures. MEs are accompanied by non-vanishing light like vacuum gauge currents generating coherent states of gravitons and photons [K27]. Linear structures such as micro-tubuli and DNA molecules are excellent candidates for quantum antennae generating coherent light and perhaps also gravitons. In fact, infinite fractal hierarchy of MEs extending from elementary particle length scales to cosmological length scales is predicted.

That also gravitons might be important is suggested by the fact that it is the classical gravitational field (induced metric) which destroys the exact $U(1)$ gauge invariance (gauge transformations being represented by canonical transformations of CP_2) of the ordinary Maxwell action when the ordinary Maxwell field is replaced with the induced CP_2 Kähler form [K2]. This gives rise to spin glass type degeneracy due to the huge number of almost physically equivalent gauge-related 4-surfaces. Also the fact that the super-symplectic representations associated with MEs are genuinely quantum gravitational states supports this view.

To sum up, this picture suggest that $1/f$ fluctuations could be even regarded as a physical signature for the presence life and cognitive consciousness: if this is true then the universality of $1/f$ noise could mean that even cognitive consciousness is everywhere.

7 The Role Of ELFFields In Bio-Control AndCoordination

In this section the evidence that higher levels of the biological self hierarchy control biological body using fields at ELF frequencies (EEG frequencies are in ELF range) is discussed. The basic inputs are topological field quantization, the idea of memetic code and the observations about the effects of ELF em fields to brain suggesting that the higher levels of our self hierarchy correspond to em selves with sizes of order wavelength of photons generated by EEG currents and thus realized as topological field quanta having size of order of Earth.

A very important and rather recent input (I am writing this towards the end of year 2005) is the model of high T_c superconductivity inspired by the notions of dark matter hierarchy based on the dynamic and quantized $\hbar$ having arbitrarily large values. Detailed models are not discussed here but are left to the chapters [K4, K5] of [K28] devoted to superconductivity in bio-systems.

7.1 Electromagnetic Selves

Rather remarkably, the time scale of.1 seconds predicted by the model of the memetic code and also the time scales of the photons associated with the cyclotron frequencies of ions correspond to the time scale of EEG. The currents generating EEG certainly create weak electromagnetic radiation fields which in TGD framework correspond to topological field quanta of size of Earth. The lowest Schumann frequency is roughly $f = c/2\pi R$, R radius of Earth, and equal to $f \simeq 7.8$ Hz. It is known that EEG frequencies are in the same frequency range as so called Schumann frequencies 7.8, 14, 20, 28, 33, 39, ... Hz [F1] associated with the resonances of the electromagnetic fields in the 80 km thick wave cavity between Earth surface and ionosphere. The higher EEG frequencies seem to correlate with higher Schumann resonance frequencies: in particular, the frequencies 13 and 39 Hz which are also cyclotron resonance frequencies of Na_+, are very near to Schumann frequencies. Schumann frequencies vary in time and it has been found that also the variations of EEG frequencies correlate with this variation. Magnetic perturbations near Schumann frequencies are known to have profound effects on human brain inducing altered states of consciousness and cortical instabilities such micro-seizures and epilepsies [J18, J21].

The photons generated in cyclotron transition associated with macroscopic ionic BE condensates in Earth's magnetic field have wavelengths of order Earth size and the topological field quanta representing classically the radiation field have size of Earth. A possible mechanism generating EEG waves would be the dropping of ions or their Cooper pairs from smaller space-time sheets to high n cyclotron states at the magnetic flux tubes of Earth and the decay of the cyclotron states via emission of radiation at harmonics of cyclotron frequency.

In many-sheeted space-time particles (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries

of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. In this case the process would occur coherently for all particles. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

EEG could be also generated as coherent photons generated by Josephson current varying at ELF frequency [K5]. Dark matter hierarchy indeed predicts a hierarchy of Josephson junctions and that ELF photons at sufficiently high level of dark matter hierarchy correspond to photon energies above thermal threshold. This model leads also to a new view about genetic code and to a model how cell membrane and nucleus co-operate to achieve bio-control. It is quite possible that both mechanisms are involved. In fact, Josephson radiation model generalizes so that Josephson energy is dominated by the difference of cyclotron energies of ion at flux tube portions at different sides of cell membrane [K29].

The fact that classical ELF em fields are represented by topological field quanta with size of order Earth size (by Uncertainty Principle alone) raises the question whether our "physical" body is only a dip of an iceberg and formed by the topological condensation of the bio-matter around electromagnetic topological field quanta serving as templates for the bio-structures.

These observations and arguments suggest the identification of the relevant selves in our self-hierarchy are electromagnetic selves having the size of Earth and correspond to EEG frequencies, and raises the idea that our magnetic body (or hierarchy of magnetic bodies) corresponds to "me" as intentional agent, and that also the magnetic bodies of other systems, in particular Earth itself, are conscious entities and intentional agents. Dark matter hierarchy discussed in [K4, K5] gives a precise quantitative content to this vision.

7.2 Neuro-Psychological Evidence For The Importance Of ElfFields

There is quite a lot of neuro-psychological evidence for the importance of ELF fields.

7.2.1 The work of Michael Persinger

Neuroscientist Michael Persinger [J19, J17, J22] from Laurentian University in Canada believes that temporal lobes are electrically unstable and may also be involved in sensing these fluctuations in the Earth's magnetic field. In-stability results in micro-seizures in sensitive individuals [1]. Persinger proposes that his tectonic strain theory [J19, J22] explains UFO experiences as natural phenomena generated by stresses and strains within Earth's crust. The anomalous luminous phenomena, UFO experiences and earthquake would be caused by the same process: earth stress causing local strains and eventually leading to sudden release of seismic energy. These phenomena are also reflected in geomagnetic field and most notable perturbation occurs at electromagnetic resonance frequency of 8 Hz of Earth for the propagation of electromagnetic fields in the spherical cavity below ionosphere This resonant frequency interacts with human brain and generates what would have been interpreted as spirit in Indian culture and is interpreted as UFO in our culture.

Altered states of consciousness can be also induced using patterns of magnetic fields with basic frequency of 8 Hz and Persinger suggests that these patterns could have something to do with the "fundamental algorithms" of brain [J17]. One example of the induced experiences is the experience about presence of something. If left brain half is stimulated, this something is experienced as friendly, when right half is stimulated it is experience as scary. Women experience this something as a man and vice versa. Persinger claims that also mystic and religious experiences can be induced using magnetic fields [J17]. The frequency range producing the claimed effects is around 10 Hz with accuracy of 1 Hz. Persinger has gone so far as to design a magnetic helmet that pulses the temporal lobes with earth resonance frequencies producing mystical experiences in student volunteers.

What is remarkable that Persinger uses magnetic pulses rather than smooth sine waves. This encourages to think that magnetic pulses induce scalar wave pulses, which accelerate charges particles at the space-time sheets of scalar wave pulses and generate negative energy "acceleration radiation" in turn inducing time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/`

[1] On basis of my personal experiences I have reasons to believe that I belong to those sensitive individuals

timemirror.jpg or **Fig. ??** in the appendix of this book) at the harmonics of frequency defined by the duration of the scalar wave pulse presumably equal to the rising time of the pulse.

It should be emphasized that Persinger is hard nosed neuro scientist and materialist and uses his findings as a support for the reduction of religious experiences to neuronal level and to geophysical phenomena. Persinger also claims that surprisingly many religious people have suffered some brain injury during some state of their life. Persinger bases his explanation of religious experiences to the instability of the frontal lobes against micro-seizures (invisible epilepsies) induced by the magnetic perturbations with certain resonance frequencies, which happens to be resonant frequency of the perturbations of Earth's magnetic field.

Even forgetting Persinger's materialistic starting assumptions, one can criticize Persinger's conclusions in several respects. Why brain would have developed this kind of instability if it produces only hallucinations? Why just the resonance frequency of Earth's magetic field? The content of these hallucinations is the experience about the existence of some higher level consciousness. On the other hand, these hallucinations are produced by interaction with Earth: could this be an accident?

Consider now the situation in which an oscillatory magnetic field varying with certain frequency is generated by Earth quake or artificially.

1. The interaction of brain with the nearby magnetic field must reduce to the interaction of magnetic flux tubes with some parts of brain. It is known that this interaction can lead to electric in-stability of frontal lobe leading to micro-seizures.

2. The coupling of the frontal lobes with Earth's magnetic field can be understood if the flux tubes of the magnetic and Z^0 magnetic fields of Earth serve as templates for the formation of bio-structures. This implies that the biological network of the magnetic flux tubes associated with axons is part of the much larger flux tube network characterizing Earth's magnetic field. The order of magnitude estimate for the thickness d of the magnetic flux tubes associated with Earth's magnetic field is obtained by assuming quantization of magnetization flux. This $d \sim \sqrt{2/eB}$ giving $d \sim 4 \times 10^{-6}$ meters for $B \sim .5 \times 10^{-4}$ Tesla. The diameter of flux tube is very near to the p-adic length scale L_p, $p \simeq 2^k$, $k = 169$: $L(169) \simeq 4.4 \times 10^{-4}$ meters. This length scale is the p-adic length scale associated with cells. Indeed, the quantitative TGD based models for nerve pulse and EEG, for cognition, and for the quantum correlates of sensory qualia, rely crucially on the magnetic transition frequencies of various super conducting charged particles in Earth's magnetic field.

3. The mechanism generating altered states of consciousness could be following. The perturbations of Earth's magnetic field with resonance frequencies cause oscillatory perturbations of the magnetic flux tubes. The interaction of these perturbations with the two-layered structures of brain glued to magnetic flux tubes makes possible resonant coupling with the "Indra's net" formed by the magnetic flux tubes and massless extremals describing the classical em field of Earth.

   More concretely, the resonant oscillations of Earth's magnetic field "wake-up" some higher level sub-selves (mental images) in the self-hierarchy of a sensitive person so that the higher level component to our experiences becomes exceptionally intensive. The mechanism wake-up is resonance: some Schumann frequencies are very near to the magnetic transition frequencies of ions crucial for the function of brain. Indeed, both K_+ (7.5 Hz) and Cl_- (8.5 Hz) cyclotron frequencies are very near to the lowest Schumann frequency of about 7.8 Hz and $n = 1$ and $n = 3$ multiples Na_+ cyclotron frequency (13 Hz) are also very near to Schumann frequencies.

4. One can wonder why the coupling (possibly entanglement) with the higher level selves is not permanent, why strong oscillatory perturbations are required to achieve this. Perhaps this has to do with the dimensions. Two 4-surfaces in 8-dimensional space (now "Indra's web" and 4-surface associated with cell layers) have generically discrete set of stable intersection points. These must give rise to topological sum contacts giving rise to interaction of material space-time sheets with classical radiation fields. For magnetic flux tubes which are perturbed so that they oscillate with large amplitude one can expect that the number of intersections with the 4-surface describing cell layers, is proportional to the frequency of oscillation and to the amplitude of oscillation. Note that this picture realizes Feynman diagrammatics topologically

and that the realization is possible only in dimension 8 since in higher dimensions two 4-surfaces have no intersections in the generic case.

Dark matter hierarchy with levels characterized by the values $\hbar = \lambda^{k_d}\hbar_0$, $\lambda \simeq 2^{11}$, allows to develop much more concrete ideas about the interaction of human brain with the Earth's magnetic field [K5]. Later a more general hypothesis allowing all powers of 2 emerged and corresponds for the hierarchy of Planck constants the hypothesis $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. In this model $k_d = 4$ level of the dark matter hierarchy corresponds to the space-time sheets of Earth's magnetic field to which brain is connected by magnetic flux sheets traversing through DNA. $k_d = 4$ flux sheets act as Josephson junctions of thickness ~ 180 km connecting the region of Earth below litosphere to the magnetic flux quanta of Earth's magnetic field above ionosphere. In this picture organisms in biosphere can be seen as scaled up variants of proteins in the cell membrane acting also as Josephson junctions. The highly folded magnetic flux sheets mediate the perturbations of the flux quanta of Earth's magnetic field to brain and explain the strong effects of Schuman resonances and perturbations of Earth's magnetic field on consciousness.

7.2.2 Other evidence

There are also "mind machines" which anyone can buy (see for instance [J16]), which produce meditative states through entrainment of brain waves, using light and sound at ELF frequencies. For instance, by feeding in ears two audible frequencies differing by about 8-10 Hz, it is possible to generate mystic experiences. Also light and sound oscillating with these frequencies can be used to generate altered states of consciousness. Indeed, important cyclotron frequencies are in this range. That the alpha frequency of the brain as determined by electroencephalograph is in the range of 8 to 10 Hertz, may not be a coincidence. Perhaps when yogis and adepts are modulating their brain wave frequencies during meditation, they really are achieving altered states of consciousness by tuning in to the Earth. Resonant coupling would be the classical correlate of strong entanglement.

It has been also observed that magnetic pulses of duration of order millisecond and with frequencies between 1 and 50 Hz have profound effects on brain [J6]. For instance, depression can be cured in some cases by transcranial magnetic simulation (TMS) [J6]. Depression correlated with anomalously low neural activity of some parts of left frontal lobe (anterior cingulate cortex belonging to limbic system). During sadness this region is very active. This would suggest that depression is not about feeling sad but about not being able feeling sad. It might be that too much sadness causes numbness to sadness, depression. A prosaic explanation for the effect of 1 millisecond pulse sequence is that the pulses act like a sequence of kicks to broken household machine. Electro-convulsive therapy (ECT), which also stimulates brain act like a single big kick and causes micro-seizures and convulsions avoided in TMS.

It has been proposed that hauntings could be explained acoustically. On basis of his personal experiences Vic Tandy [J24] has proposed that resonant sound waves at frequency of about 19 Hz can cause experiences like cold chills, sense of paranoia and distress and visual hallucinations. Laboratory research has indeed shown that very low frequency infra sounds can cause unpleasant physiological effects like shivering, anxiety and breathlessness. The resonance frequency of eye is known to be about 18 Hz and this the resulting smearing of vision could explain hallucinations. On the other hand, second harmonic for Schumann resonance is roughly 20 Hz. Of course, one can ask whether there is some deeper reason for why the resonance frequency of eye is near to Schumann resonance and whether this frequency is closely related to some Z^0 magnetic Larmor frequency, which are of order 20 Hz for the "emotional" $k = 173$ space-time sheet carrying Z^0 magnetic field having minimal field strength about $g_Z B_Z = eB/16$ by flux quantization.

More generally, one can also ask why various biorhythms are in Hz [E1] [F1]: one could indeed identify geophysical frequencies which are near to various frequencies of body. One can also aks why the effect of music to human brain is so deep. Could it be that also music wakes up higher level selves in our self-hierarchy? In fact, the quantum model for auditory experience leads to just this conclusion.

7.3 Effects Of Elf- And ELFModulated EM Fields On Living Matter

The work by pioneers of of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and others) which began already at sixties led to amazing discoveries about ELF fields on brain. The review article of Blackman provides a detailed summary of these developments [J5].

1. Already at sixties Hamer discovered that ELF em fields in EEG frequency range had effects on the reaction times of human volunteers [J15]. At seventies Bawin and Adey [J3] discovered the effects of ELF em fields on calcium release in brain tissue. Maximum effect on Ca release was found at 16 Hz.

2. Blackman found 1979 that 50 MHz field modulated by 15 Hz ELF field increased Calcium ion release in chick brain tissue [J9]. Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized the importance of Earth's magnetic field [J10, J11, J12]. The results and speculations of Blackman led Liboff to propose ionic cyclotron resonance model [J1]. This model was classical and subject to grave objections at the level of principle [K5]. Obviously cyclotron and Larmor frequencies in Earth's magnetic field are in the frequency range of EEG.

3. Also the Schumann resonances associated with Earth's em field are in EEG frequency range and it is known that geomagnetic fields interact strongly with brain and Persinger [J19, J17] has done valuable work related to this.

7.4 Summary About Effects Of ELFEM Fields On Brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [J5] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [J3, J10, J12]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

7.4.1 Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [J20].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in Ca^{2+} homeostasis: Ca^{2+} it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, Ca^{2+} is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - c$AMP signal transduction process.

Change in Ca^{2+} homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alternations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In case of immune system an example is provided by the change of functioning of lymphosytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

7.4.2 Amplitude windows

Two main amplitude windows have been seen. For the first window ELF em fields have values of electric field in tissue around 10^{-7} V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1-10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that cell membrane electric field has a strength about 10^7 V/m whereas EEG electric fields in the range $5-10$ V/m. The fact that the second intensity window corresponds to $1-10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [J14]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

7.4.3 The effects occur at harmonics of cyclotron resonance frequencies

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized the role of Earth's magnetic field [J11]. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [J1] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of Ca^{2+} ion in Earth's magnetic field. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [J4]. This phenomenological model combines ICR model with ideas about atomic physics. There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [J5]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time. On the other hand, the fact that that effects at spin flip frequencies proportional have not been reported suggests that the effects are classical. Large $\hbar$ hierarchy however predicts that spin flip energies behave like $1/hbar$ whereas cyclotron energy do not depend on the value of $\hbar$ so that only cyclotron transitions are predicted to be important.

7.4.4 Are quantal effects in question?

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca^{2+} ion. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing

the transitions in question has non-vanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [B6]. Odd and even values of n for cyclotron states have opposite parities so that Δn odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

There are however also objections.

1. The cyclotron energy scale is about 10^{-14} eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. These have not been reported.

3. The wave functions of ions in Earth's magnetic field are confined in a region of size of order

$$r_n \sim \sqrt{2n/eB} \ ,$$

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2e$. If one requires quantum classical correspondence, very large values of n are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with B scaling like $1/hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Since spin is invariant under scalings of $\hbar$ spin flip energy scales down as $1/\hbar$ so that its contribution to magnetic energy is very small as compared to the cyclotron contribution and spin degrees of freedom are thermalized. Hence the system behaves classically in spin degrees of freedom. By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar = \lambda^k \hbar_0$, $\lambda \simeq 2^{11}$.

7.4.5 A brief summary of the model

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control.

1. Ions with charge Z, mass m and spin S in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \ , \quad E_c = (n + \tfrac{1}{2})\hbar\omega_c \ , \quad E_L = S_z \tfrac{g\omega_c}{2} \ , \quad \omega_c = \tfrac{ZeB}{m} \ \ (c = 1) \ . \tag{7.1}$$

The first contribution corresponds to cyclotron contribution. For a given value of n the component of angular momentum in the direction of B has $n + 1$ values $n, n - 2, ..., -n$. E_L denotes spin (Larmor) contribution. g is so called Lande factor which for free elementary fermions equals to $g = 2$. Since S_z is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. The model for high T_c superconductivity involving competition of two superconductivities, one associated with cell interior and second with cell membrane is the starting point. These phases coexist in a narrow range around critical temperature and 36-37 C range where the effects are observed is a good candidate for this range.

3. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. For $k = 4$ level of dark matter hierarchy cyclotron energy scale turns out to be above the thermal energy $2.88T$ of photons at maximum intensity of black body radiation at room temperature for $A \leq 223Z$. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. The scale of cyclotron energies for $k = 4$ level of dark matter hierarchy is indeed turns out to be consistent with this assumption.

4. The ELF em field used in the experiments have electric fields strengths in two windows: one around 10^{-7} V/m and second corresponding to $1 - 10$ V/m. Even in the latter case the field is by a factor of order million weaker than membrane potential: the notion of many-sheeted space-time allows to understand why so weak fields can have effects on biomatter. Amplitude windows are a further mystery related with the interaction of ELF em fields with brain tissue: if ELF em field defines potential difference eV associated with a Josephson junction, one might understand this effect in terms of quantum jumps induced by Josephson current with frequency $f = ZeV/2\pi$.

5. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ..., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

6. Josephson current is of form $J \propto sin(2eVt + 2e \int V_1 dt)$ and its amplitude does not depend on the strength of the perturbation V_1. V_1 is same for all values of $\hbar$ but scales like $L(k)$ as function of p-adic length scale for given value of $\hbar$. Perturbation is represent as EEG pattern communicated to the magnetic body of fractally scaled up variant of cell or cell nucleus, which reacts appropriately. At the limit when the Josephson frequency $f_J^1 = 2eV_1/2\pi\hbar$ of perturbation satisfies $f_J^1 \gg f_c$, the amplitude of perturbation is coded to frequencies $f_\pm = f_J^1 \pm f_J$ in the EEG in a good approximation.

7. The response of the system is that of AND gate. V_1 induces in the neuronal nucleus or its scaled up counterpart cyclotron transitions if the frequency is correct. If this the case, cell nucleus opens up communication line receiving possible control signals from the magnetic body at higher level of hierarchy. V_1 induces in Josephson junctions effects if the amplitude is in the amplitude window guaranteeing that the frequencies $f_\pm$ belong to EEG resonance bands (or their scaled up variants. In this case magnetic body receives representation of V_1 as coherent photons and responds. If communication line is open the response induces in the cell nucleus gene translation and other activities necessary for the biological response. The model implies that cyclotron frequencies code for the biologically relevant information carried out by classical electric fields so that noise is eliminated very effectively. A detailed discussion of the model is left to [K5], where also the implications for the understanding of genetic code are discussed.

7.4.6 What about Z^0 magnetic transitions?

The idea that Z^0 magnetic magnetic transitions might be relevant for biomatter have been discussed already earlier. The identification of the sources of long ranged classical weak fields as dark matter

forces however a profound modification of the earlier picture.

The TGD based models for atomic nuclei [K32] and condensed matter [K11] suggest strongly that the dark variant of $k = 113$ copy of $k = 89$ electro-weak physics is essential for understanding of not only the anomalies of water but also the basic properties of condensed matter. Also other copies of electro-weak physics with arbitrarily small weak mass scale are implied by the fact that long ranged classical weak fields are unavoidable in TGD Universe. Also the scaled down copies of color physics with arbitrarily low mass scales for quarks are a basic prediction of TGD.

If classical Z^0 magnetic field is present and if nuclei possess anomalous weak charges due to the presence of color bonds with quark and antiquark at their ends carrying non-vanishing net weak charges coupling to $k = 113$ dark weak bosons, one must consider also Z^0 cyclotron frequencies given by

$$\begin{aligned} \Omega &= \frac{N(u\bar{d})}{A} \times Q_Z(u\bar{d}) \times \frac{g_Z B_Z}{eB} \times \Omega_p \ , \quad \Omega_p = \frac{eB}{m_p} \ , \\ Q_Z(u\bar{d}) &= \frac{1}{2} - sin^2(\theta_W) \ . \end{aligned} \tag{7.2}$$

Here $N(u\bar{d})$ is anomalous Z^0 charge of the nucleus due to weakly charged color bonds connecting nucleons with quark and antiquark at their ends using $u\bar{d}$ Z^0 charge $Q(u\bar{d})$ as unit. Ω_p is proton cyclotron frequency, which is about 300 Hz for $B = B_E = .5$ Gauss. The dependence on the Z^0 magnetic transition frequencies on the mass of nucleus is same as in the electromagnetic case.

The doubly dark weak bosons with weak length scale $L_w = 2^{22} L_w(113) = .2$ μm should be key actors in TGD based model of living matter. Since the quantization of magnetic flux uses $\hbar$ as unit the quantum of Z^0 flux over a given area is multiplied by a factor 2^{22} for doubly dark weak bosons. Also the energy $\hbar\omega_c$ associated with the cyclotron frequency is multiplied by a factor 2^{22} so that energies are by a factor 2^{44} higher for cyclotron transitions in flux quantized Z^0 magnetic field than one might expect. In the case of dark quarks it would be natural to use $2(Q_Z(u\bar{d})$ as unit of charge in the quantization of magnetic flux so that the flux quantization reads $2Q_Z(u\bar{d}) \int B_Z dA = n2^{22}\hbar 2\pi$.

Z^0 flux quanta with radius $L_w = .2$ μm are expected to be of special interest. Consider the field corresponding to single flux quantum in this case. Using the fact that Earth's magnetic field taken to have nominal value.4742 Tesla corresponds to a single quantum of flux through a disk of radius $L(k = 169)$, one obtains that the Z^0 cyclotron frequency and energy in this case are given by

$$\begin{aligned} \Omega_c(2^{22}\hbar) &= 2^{22}\Omega_c(\hbar)2^{22}\frac{N(u\bar{d})}{A} \times Q_Z(u\bar{d}) \times (\frac{L(169)}{L_w})^2 \omega_p(B_{end}) \\ &\simeq \frac{N(u\bar{d})}{A} \times 750 \ \ GHz \ , \\ E_c(2^{22}\hbar) &= 2^{44} E_c(\hbar) \simeq \frac{N(u\bar{d})}{A} \times 10^4 \ \ eV \ . \end{aligned} \tag{7.3}$$

Here $B_{end} = .2$ Gauss corresponds to the endogenous magnetic field explaining the effects of ELF em fields on vertebrate brain: the value of B_{end} differs from the nominal value $B_E = .5$ Gauss for the Earth's magnetic field. Note that Ω_c and E_c do not depend on the unit of flux quantization. Cyclotron frequencies are in 10^{12} GHz range but energies in 10^4 eV range and corresponds to ordinary photon wavelength of about atomic length scale. In the earlier picture frequencies were in 10 Hz range. The energies involved are well above the thermal energy in room temperature. For the first level of dark matter hierarchy the frequency scale would be.375 GHz and energy scale 25 meV which is below thermal energy at room temperature.

Also ordinary nuclei containing charged color bonds would couple to dark weak bosons with weak length scale having nominal value $L_w = 2^{11} L_w(113) = 1$ Angstrom. In this case Z^0 magnetic fields would have 2^{11} stronger strength that in previous case and cyclotron energies would be same.

7.5 A General View About The Role Of Classical Fields In Quantum Control, Coordination And Communication

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K10].

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

5. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Besides neutral massless extremals (MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The second non-local quantum control mechanism is based on em charge entanglement involving a superposition of ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. Charged massless extremals could be seen as correlates for non-local quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K17].

6. These non-local quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

8 Dark Matter And Living Matter As Quantum Phases With Large Value Of Planck Constant

The TGD based model for topological quantum computation [B5] inspired the proposal that Planck constant might be dynamical and quantized in terms of logarithms of so called Beraha numbers $B_n = 4cos^2(\pi/n)$, $n \geq 3$ [K35]. Some recent discoveries in astrophysics [E2] and hadron physics

[C6, C3], cold fusion anomaly [C2], etc. suggest that this might be the case. In particular, dark matter could correspond to quantum coherent phase with a large value of Planck constant [K31, K9]. The theoretical background for the quantization of Planck constant is discussed in [K36].

One implication is that living systems would correspond to a large value of Planck constant. This would mean that elementary quantum units correspond to systems consisting of very many elementary particles and that characteristic time and length scales are scaled up from those predicted by ordinary quantum theory so that macroscopic and macro-temporal quantum coherence become possible in the simplest manner one can imagine: indeed, the characteristic time and length scales are proportional to $\hbar$. This vision is discussed in detail in the [K9]. Here only a brief summary about basic ideas is given

8.1 Quantum Criticality, Hierarchy Of Dark Matters, And Dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

8.1.1 Quantization of Planck constants and the generalization of the notion of imbedding space

The recent geometric interpretation for the quantization of Planck constants is based on Jones inclusions of hyper-finite factors of type II_1 [K13].

1. Different values of Planck constant correspond to imbedding space metrics involving scalings of M^4 *resp.* CP_2 parts of the metric deduced from the requirement that distances scale as $\hbar(M^4)$ *resp.* $\hbar(M^4)$. Denoting the Planck constants by $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$, one has that covariant metric of M^4 is proportional to n_b^2 and covariant metric of CP_2 to n_a^2. In Kähler action only the effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M^4)/\hbar(CP_2)$ appears and by quantum classical correspondence same is true for Schödinger equation. Elementary particle mass spectrum is also invariant. Same applies to gravitational constant. The alternative assumption that M^4 Planck constant is proportional to n_b would imply invariance of Schrödinger equation but would not allow to explain Bohr quantization of planetary orbits and would to certain degree trivialize the theory.

2. M^4 and CP_2 Planck constants do not fully characterize a given sector $M^4_{\pm} \times CP_2$. Rather, the scaling factors of Planck constant given by the integer n characterizing the quantum phase $q = exp(i\pi/n)$ corresponds to the order of the maximal cyclic subgroup for the group $G \subset SU(2)$ characterizing the Jones inclusion $\mathcal{N} \subset \mathcal{M}$ of hyper-finite factors realized as subalgebras of the Clifford algebra of the "world of the classical worlds". This means that subfactor $\mathcal{N}$ gives rise to G-invariant WCW spinor s having interpretation as G-invariant fermionic states.

3. $G_b \subset SU(2) \subset SU(3)$ defines a covering of M^4_+ by CP_2 points and $G_a \subset SU(2) \subset SL(2,C)$ covering of CP_2 by M^4_+ points with fixed points defining orbifold singularities. Different sectors are glued together along CP_2 if G_b is same for them and along M^4_+ if G_a is same for them. The degrees of freedom lost by G-invariance in fermionic degrees of freedom are gained back since the discrete degrees of freedom provided by covering allow many-particle states formed from single particle states realized in G group algebra.

4. Phases with different values of scalings of M^4 and CP_2 Planck constants behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality corresponding to a leakage between different sectors of imbedding space glued together along M^4 or CP_2 factors. In large $\hbar(M^4)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence. In particular, quantum energies associated with classical frequencies are scaled up by a factor n_a/n_b which is of special relevance for cyclotron energies and phonon energies (superconductivity). For large $\hbar(CP_2)$ the value of $\hbar_{eff}$ is small: this leads to interesting physics: in particular the binding energy scale of hydrogen atom increases by the factor n_b/n_a^2.

8.1.2 Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and the powers of 2^{11} seem to be especially favored as values of n_a in living matter [K10].

8.1.3 How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation relations of various super-conformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [K13]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

8.1.4 Phase transitions changing the level in dark matter hierarchy

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constant and more precisely, definite groups G_a and G_b characterizing dark matter hierarchy. Particles of different phases could not appear in the same vertex and a phase transition changing the particles to each other analogous to a de-coherence would be necessary.

2. If transition amplitudes involve only a discrete set of common orbifold points of 2-surface belonging to different sectors then the phase transition between relatively dark matters can be described in terms of S-matrix. It seems that this option is the correct one. In fact, also propagators are essential for the interactions of visible and dark matter and since virtual elementary particles correspond at space-time level CP_2 type extremals with 4-dimensional CP_2 projection, they cannot leak between different sectors of imbedding space and therefore cannot mediate interactions between different levels of the dark matter hierarchy. This would suggest that the direct interactions between dark and ordinary matter are very weak.

If the matrix elements for real-real partonic transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [K7], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Of course, the fact that the points which correspond to zero of Riemann Zeta form only a small subset of points common to real partonic 2-surface and corresponding p-adic 2-surface, implies that the rate for phase transition is in general small. On the other hand, for the non-diagonal S-matrix elements for

ordinary transitions would become very small by almost randomness caused by strong fluctuations and the rate for phase transition could begin to dominate.

8.1.5 Transition to large $\hbar$ phase and failure of perturbation theory

A further idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling strength α so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

A justification for this picture would be that in non-perturbative phase large quantum fluctuations are present (as functional integral formalism suggests). At space-time level this would mean that space-time sheet is near to a non-deterministic vacuum extremal. At parton level this would mean that partonic surface contains large number of CP_2 orbifold points so that S-matrix elements for the phase transition becomes large. At certain critical value of coupling constant strength one expects that the transition amplitude for phase transition becomes very large.

8.1.6 Dark matter and standard physics

The hierarchy of phases behaving like dark or partially dark matter with respect to the ordinary matter [K16] seem to be essential for the understanding of even ordinary hadronic, nuclear and condensed matter physics [K16, K32, K11]. This strengthens the motivations for finding whether dark matter might be involved with quantum critical super-conductivity.

8.2 Hadronic Black Holes And New View About Dark Matter

Important steps in the development of ideas were stimulated by the findings made during period 2002-2005 in Relativist Heavy Ion Collider (RHIC) in Brookhaven compared with the discovery of America and for full reason [C6, C3]. In particular, the observed production of black-hole like object in heavy ion collisions support the view that in non-perturbative phase of QCD matter possesses large value of $\hbar$ and becomes thus analogous to dark matter. Surprisingly precise analogies with black hole formation and evaporation or equivalently with big crush followed by big bang describable as scaled down version of TGD inspired cosmology, emerge.

8.3 Dark Atoms And Dark Cyclotron States

The development of the notion of dark atom involves many side tracks which make me blush. The first naive guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of imbedding space at space-time.

The rules are very simple when one takes the singular coverings assigned to the many-valuedness of the time-derivatives of imbedding space coordinates as functions of canonical momentum densities as a starting point.

1. The mass and charge of electron are fractionized as is also the reduced mass in Schrödinger equation. This implies the replacements $e \to e/r$, $m \to m/r$, and $\hbar \to r\hbar_0$, $r = n_a n_b$, in the general formula for the binding energy assigned with single sheet of the covering. If maximal number $n_a n_b$ are present corresponding to a full "Fermi sphere", the total binding energy is r times the binding energy associated with single sheet.

2. In the case of hydrogen atom the proportionality $E \propto m/\hbar^2$ implies that the binding energy for single sheet of the covering scales as $E \to E/(n_a n_b)^3$ and maximal binding energy scales as $E \to E/(n_a n_b)^2$. This conforms with the naive guess. For high values of the nuclear charge Z it can happen that the binding energy is larger than the rest mass and fractionization might take place when binding energy is above critical fraction of the rest mass.

3. In the case of cyclotron energies one must must decide what happens to the magnetic flux. Magnetic flux quantization states that the flux is proportional to $\hbar$ for each sheet separately. Hence one has $\Phi \to r\Phi$ for each sheet and the total flux scales as r^2. Since the dimensions of the flux quantum are scaled up by r the natural scaling of the size of flux quantum is by r^2. Therefore the quantization of the magnetic flux requires the scaling $B \to B/r$. The cyclotron energy for single sheet satisfies $E \propto \hbar qB/m$ and since both mass m and charge q become fractional, the energy E for single sheet remains invariant whereas total cyclotron energy is scaled up by r in accordance with the original guess and the assumption used in applications.

4. Dark cyclotron states are expected to be stable up to temperatures which are r times higher than for ordinary cyclotron states. The states of dark hydrogen atoms and its generalizations are expected to be stable at temperatures scaled down by $1/r^2$ in the first approximation.

5. Similar arguments allow to deduce the values of binding energies in the general case once the formula of the binding energy given by standard quantum theory is known.

The most general option option allows fractional atoms with proton and electron numbers varying from $1/r$ to 1. One can imagine also the possibility of fractional molecules. The analogs of chemical bonds between fractional hydrogen atoms with $N-k$ and k fractional electrons and protons can be considered and would give rise to a full shell of fractional electrons possessing an exceptional stability. These states would have proton and electron numbers equal to one.

Catalytic sites are one possible candidate for fractal electrons and catalyst activity might be perhaps understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron.

8.4 How Dark Matter And Visible Matter Interact?

The hypothesis that the value of $\hbar$ is dynamical, quantized and becomes large at the verge of a transition to a non-perturbative phase in the ordinary sense of the word has fascinating implications. In particular, dark matter, would correspond to a large value of $\hbar$ and could be responsible for the properties of the living matter. In order to test the idea experimentally, a more concrete model for the interaction of ordinary matter and dark matter must be developed and here of course experimental input and the consistency with the earlier quantum model of living matter is of considerable help.

8.4.1 How dark photons transform to ordinary photons?

The transitions of dark atoms naturally correspond to coherent transitions of the entire dark electron BE condensate and thus generate N_{cr} dark photons and behave thus like laser beams. Dark photons do not interact directly with the visible matter. An open question is whether even ordinary laser beams could be identified as beams of dark photons: the multiple covering property at the level of imbedding space and the fact that MEs are possible in all sectors suggests that this is not the case. Note that the transition from dark to ordinary photons implies the scaling of wave length and thus also of coherence length by a factor n_b/n_a.

Dark $\leftrightarrow$ visible transition should have also a space-time correlate. The so called topological light rays or MEs ("massless extremals") represent a crucial deviation of TGD from Maxwell's ED and have all the properties characterizing macroscopic classical coherence. Therefore MEs are excellent candidates for the space-time correlate of BE condensate of dark photons.

MEs carry in general a superposition of harmonics of some basic frequency determined by the length of ME. A natural expectation is that the frequency of classical field corresponds to the generalized de Broglie frequency of dark photon and is thus $\hbar/\hbar_s$ times lower than for ordinary photons. In completely analogous manner de Broglie wave length is scaled up by $k = \hbar_s/\hbar$. Classically the decay of dark photons to visible photons would mean that an oscillation with frequency f inside topological light ray transforms to an oscillation of frequency f/k such that the intensity of the oscillation is scaled up by a factor k. Furthermore, the ME in question could naturally decompose into $1 < N_{cr} \leq 137$ ordinary photons in case that dark atoms are in question. Of course also MEs could decay to lower level MEs and this has an interpretation in terms of hierarchy of dark matters to be discussed next.

8.4.2 About the criterion for the transition increasing the value of Planck constant

An attractive assumption is that the transition to dark matter phase occurs when the interaction strength satisfies the criticality condition $Q_1Q_2\alpha \simeq 1$. A special case corresponds to self interaction with $Q_1 = Q_2$. This condition applies only to gauge interactions so that particles can be characterized by gauge charges. A more general characterization would be that transition occurs when perturbation theory ceases to converge. The criterion cannot be applied to phenomenological QFT description of strong force in terms of, say, pion exchange.

Some examples are in order to test this view.

1. Transition from perturbative phase in QCD to hadronic phase is the most obvious application. The identification of valence quarks and gluons as dark matter would predict for them QCD size ($k = 107$ space-time sheet) of about electron Compton length. This does not change the QCD cross sections in the lowest order perturbation theory but makes them excellent predictions. It also provides completely new view about how color force determines the nuclear strong force indeed manifesting itself as long ranged harmonic oscillator potential, the long range of which becomes manifest in case of neutron halos of size of 2.5×10^{-14} m [C7]. One can also understand tetraneutron in this framework. This criterion applies also in QCD plasma and explains the formation of liquid like color glass condensate detected in RHIC [C6]. A possible interpretation for QCD size would be as a length of the cylindrical magnetic walls defining the magnetic body associated with u and d type valence quarks, nucleons, and nuclei. There is no need to assume that conformal weights are complex in this phase.

2. QCD size of quark must be distinguished from the electromagnetic size of quark associated with $k = 113$ space-time sheets of u and d quarks and assignable to the height of the magnetic body and defining the length scale of flux tubes feeding quark charges to $k = 113$ space-time sheets.

3. In the case of atomic nuclei the criterion would naturally apply to the electromagnetic interaction energy of two nucleon clusters inside nucleus or to to self energy ($Q^2\alpha_{em} = 1$). Quite generally, the size of the electromagnetic $k = 113$ space-time sheet would increase by a $n_F = 2^k \prod_s F_s$, where F_s are different Fermat primes (the known ones being $3, 5, 17, 257, 2^{16} + 1$), in the transition to large $\hbar$ phase. Especially interesting values of n_F seem to be of form $n_F = 2^{k11}$ and possibly also $n_F = 2^{k11} \prod_s F_s$. Similar criterion would apply in the plasma phase. Note that many free energy anomalies involve the formation of cold plasma [K33].

The criterion would give in the case of single nucleus and plasma $Z \geq 12$ if the charges are within single space-time sheet. This is consistent with cold fusion involving Palladium nuclei [C2]. Since u and d quarks have $k = 113$, they both and thus both neutrons and protons could make a transition to large $\hbar$ phase. This is consistent with the selection rules of cold fusion since the production of ^3He involves a phase transition $\mathrm{pnp}_d \rightarrow$ pnp and the contraction of p_d to p is made un-probable by the Coulomb wall whereas the transition $\mathrm{nnp}_d \rightarrow$nnp producing tritium does not suffer from this restriction.

Strong and weak physics of nuclei would not be affected in the phase transition. Electromagnetic perturbative physics of nuclei would not be affected in the process in the lowest order in $\hbar$ (classical approximation) but the height of the Coulomb wall would be reduced by a factor $1/n_F$ by the increase in the electromagnetic size of the nucleus. Also Pd nuclei could make the transition and Pd nuclei could catalyze the transition in the case the deuterium nuclei.

8.5 Dark Matter And Exotic Color And Electro-Weak Interactions

The presence of classical electro-weak and color gauge fields in all length scales is an unavoidable prediction of TGD and the interpretation in terms of hierarchy of dark matters in some sense is also more or less unavoidable.

8.5.1 Does dark matter provide a correct interpretation of long ranged classical electro-weak gauge fields?

For two decades one of the basic interpretational challenges of TGD has been to understand how the un-avoidable presence of long range classical electro-weak gauge fields can be consistent with the small parity breaking effects in atomic and nuclear length scales. Also classical color gauge fields are predicted, and I have proposed that color qualia correspond to increments of color quantum numbers [K17] . The proposed model for screening cannot banish the unpleasant feeling that the screening cannot be complete enough to eliminate large parity breaking effects in atomic length scales so that one one must keep mind open for alternatives.

p-Adic length scale hypothesis suggests the possibility that both electro-weak gauge bosons and gluons can appear as effectively massless particles in several length scales and there indeed exists evidence that neutrinos appear in several scaled variants [C5] (for TGD based model see [K24]).

This inspires the working hypothesis that long range classical electro-weak gauge and gluon fields are correlates for light or massless dark electro-weak gauge bosons and gluons.

1. In this kind of scenario ordinary quarks and leptons could be essentially identical with their standard counterparts with electro-weak charges screened in electro-weak length scale so that the problems related to the smallness of atomic parity breaking would be trivially resolved.

2. In condensed matter blobs of size larger than neutrino Compton length (about 5 μm if $k = 169$ determines the p-adic length scale of condensed matter neutrinos) the situation could be different. Also the presence of dark matter phases with sizes and neutrino Compton lengths corresponding to the length scales defined as scaled up electronic Compton lengths $L_e(k)$, $k = 151, 157, 163, 167$ in the range 10 nm-2.5 μm are suggested by the number theoretic considerations (these values of k correspond to so called Gaussian Mersennes [K20]). Only a fraction of the condensed matter consisting of regions of size $L_e(k)$ need to be in the dark phase.

3. Dark quarks and leptons would have masses essentially identical to their standard model counterparts. Only the electro-weak boson masses which are determined by a different mechanism than the dominating contribution to fermion masses [K24, K24] would be small or vanishing.

4. The large parity breaking effects in living matter would be due to the presence of dark nuclei and leptons. Later the idea that super-fluidity corresponds to Z^0 super-conductivity will be discussed: it might be that also super-fluid phase corresponds to dark neutron phase.

The basic prediction of TGD based model of dark matter as a phase with a large value of Planck constant is the scaling up of various quantal length and time scales. A simple quantitative model for condensed matter with large value of $\hbar$ predicts that $\hbar$ is by a factor $\sim 2^{11}$ determined by the ratio of CP_2 length to Planck length larger than in ordinary phase meaning that the size of dark neutrons would be of order atomic size. In this kind of situation single order parameter would characterize the behavior of dark neutrinos and neutrons and the proposed model could apply as such also in this case.

Dark photon many particle states behave like laser beams decaying to ordinary photons by de-coherence meaning a transformation of dark photons to ordinary ones. Also dark electro-weak bosons and gluons would be massless or have small masses determined by the p-adic length scale in question. The decay products of dark electro-weak gauge bosons would be ordinary electro-weak bosons decaying rapidly via virtual electro-weak gauge boson states to ordinary leptons. Topological light rays ("massless extremals") for which all classical gauge fields are massless are natural space-time correlates for the dark boson laser beams. Obviously this means that the basic difference between the chemistries of living and non-living matter would be the absence of electro-weak symmetry breaking in living matter (which does not mean that elementary fermions would be massless). If both nuclear neutrons and neutrinos are in dark phase, it is possible to achieve a rather complete local cancelation of Z^0 charge density.

The model for neutrino screening was developed years before the ideas about the identification of the dark matter emerged. The generalization of the discussion to the case of dark matter option should be rather trivial and is left to the reader as well as generalization of the discussion of the effects of long range Z^0 force on bio-chemistry.

8.5.2 Criterion for the presence of exotic electro-weak bosons and gluons

Classical gauge fields directly are space-time correlates of quantum states. The gauge fields associated with massless extremals ("topological light rays") decompose to free part and a part having non-vanishing divergence giving rise to a light-like Abelian gauge current. Free part would correspond to Bose-Einstein condensates and current would define a coherent state of dark photons.

The dimension D of the CP_2 projection of the space-time sheet serves as a criterion for the presence of long ranged classical electro-weak and gluon fields. D also classifies the (possibly asymptotic) solutions of field equations [K2].

1. For $D = 2$ induced gauge fields are Abelian and induced Kähler form vanishes for vacuum extremals: in this case classical em and Z^0 fields are proportional to each other. The non-vanishing Kähler field implies that induced gluon fields are non-vanishing in general. This raises the question whether long ranged color fields and by quantum classical correspondence also long ranged QCD accompany non-vacuum extremals in all length scales. This makes one wonder whether color confinement is possible at all and whether scaled down variants of QCD appear in all length scales.

   The possibility to add constants to color Hamiltonians appearing in the expression of the classical color gauge fields allows to have vanishing color charges in the case of an arbitrary space-time sheet. The requirement that color quantum numbers of the generator vanish allows to add the constant only to the Hamiltonians of color hyper charge and isospin so that for $D = 2$ extremals color charges can be made vanishing. This might allow to understand how color confinement is consistent with long ranged induced Kähler field.

2. For $D \geq 3$ all classical long ranged electro-weak fields and non-Abelian color fields are present. This condition is satisfied when electric and magnetic fields are not orthogonal and the instanton density $A \wedge J$ for induced Kähler form is non-vanishing. The rather strong conclusion is that in length scales in which exotic electro-weak bosons are not present, one has $D = 2$ and gauge fields are Abelian and correspond trivially to fixed points of renormalization group realized as a hydrodynamic flow at space-time sheets [K1].

Quantum classical correspondence suggests the existence of electro-weak gauge bosons with mass scale determined by the size of the space-time sheets carrying classical long range electro-weak fields. This would mean the existence of new kind of gauge bosons.

The obvious objection is that the existence of these gauge bosons would be reflected in the decay widths of intermediate gauge bosons. The remedy of the problem is based on the notion of space-time democracy suggested strongly by the fact that the interactions between space-time sheets possessing different p-adic topologies proceed with very slow rates simply because the number of common rational (algebraic points of partonic 2-surfaces appearing in the vertex is small.

For light exotic electro-weak bosons also the corresponding leptons and quarks would possess a large weak space-time sheet but lack the ordinary weak partonic 2-surface so that there would be no direct coupling to electro-weak gauge bosons. These space-time sheets are dark in weak sense but need not have a large value of $\hbar$. This picture implies the notion of partial darkness since any space-time sheets with different ordinary of Gaussian primes are dark with respect to each other.

8.5.3 Do Gaussian Mersennes define a hierarchy of dark electro-weak physics?

Gaussian Mersennes are defined as Gaussian primes of form $g_n = (1+i)^n - 1$, where n must be prime. They have norm squared $g\overline{g} = 2^n - 1$. The list of the first Gaussian Mersennes corresponds to the following values of n.

2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283, 353, 367, 379, 457, 997, 1367, 3041, 10141, 14699, 27529, 49207, 77291, 85237, 106693, 160423 and 203789.

The Gaussian primes $k = 113, 151, 157, 163, 167$ correspond to length scales which are of most obvious interest but in TGD framework one cannot exclude the twin prime $239, 241$ corresponds to length scales $L_e(k) \simeq 160$ km and 320 km. Also larger primes could be of relevant for bio-systems and consciousness. Also the secondary and higher length scales associated with $k < 113$ could be of importance and their are several length scales of this kind in the range of biologically interesting

length scales. Physics and biology inspired considerations suggests that particular Gaussian primes correspond to a particular kind of exotic matter, possibly also to large $\hbar$ phase.

$k = 113$ corresponds to the electromagnetic length scale of u and d quarks and nuclear p-adic length scale. For dark matter these length scales are scaled up by a factor $\sim 2^{11}n$, where n is an integer. For $k = 113$ one obtains atomic length scale.8 A for $n = 1$. $k = 151, 153, 163, 167$ correspond to biologically important p-adic length scales for which electron Compton lengths vary in the range 10 nm-2.5 μm with the scaled up Compton lengths varying in the range 2 μm- 5 mm.

On basis of biological considerations (large parity breaking in living matter) there is a temptation to assign to these length scales a scaled down copy of electro-weak physics and perhaps also of color physics. The mechanism giving rise to these states would be a phase transition transforming the ordinary $k = 89$ Mersenne of weak space-time sheets to a Gaussian Mersenne and thus increasing its size dramatically.

If given space-time sheet couples considerably only to space-time sheets characterized by same prime or Gaussian prime, the bosons of these physics do not couple directly to ordinary particles, and one avoids consistency problems due to the presence of new light particles (consider only the decay widths of intermediate gauge bosons [K26]) even in the case that the loss of asymptotic freedom is not assumed.

A question arises about the interpretation of structures of the predicted size. The strong interaction size of u and d quarks, hadrons, and nuclei is smaller than $L(k = 113) \simeq 2 \times 10^{-4}$ m for even heaviest nuclei if one accepts the formula $R \sim A^{1/3} \times 1.5 \times 10^{-15}$ m. A natural interpretation for this length scale would be as the size of the field body/magnetic body of system defined by its topologically quantized gauge fields/magnetic parts of gauge fields. The (possibly dark) p-adic length scale characterizes also the lengths of flux tubes feeding gauge fluxes from elementary particle to the space-time sheet in question. The de-localization due these flux tubes in p-adic length scale in question would determine the scale of the contribution to the mass squared of the system as predicted by p-adic thermodynamics.

8.6 Dark Matter And Living Matter

The hypothesis that the value of $\hbar$ is dynamical, quantized and becomes large at the verge of a transition to a non-perturbative phase in the ordinary sense of the word has fascinating implications. In particular, dark matter, would correspond to a large value of $\hbar$ and could be responsible for the properties of the living matter. In order to test the idea experimentally, a more concrete model for the interaction of ordinary matter and dark matter must be developed and here of course experimental input and the consistency with the earlier quantum model of living matter is of considerable help.

8.6.1 Hierarchy of dark matters and hierarchy of minds

The notion of dark matter is only relative concept in the sense that dark matter is invisible from the point of view of the ordinary matter. One can imagine an entire hierarchy of dark matter structures corresponding to the hierarchy of space-time sheets for which p-adic length scales differ by a factor $1/v_0 \sim 2^{11}$. The BE condensates of N_{cr} ordinary matter particles would serve as dynamical units for "dark dark matter" invisible to the dark matter. The above discussed criticality criterion can be applied at all levels of the hierarchy to determine the value of the dynamical interaction strength for which BE condensates of BE condensates are formed.

This hierarchy would give rise to a hierarchy of the values of $\hbar_n/\hbar$ coming as powers of v_0^{-n} as well as a hierarchy of wavelengths with same energy coming as powers or v_0^n. For zero point kinetic energies proportional to $\hbar^2$ this hierarchy would come in powers of v_0^{-2n}, for magnetic interaction energies proportional to $\hbar$ the hierarchy would come in powers v_0^{-n} whereas for atomics energy levels the hierarchy would come in powers of v_0^{2n} (assuming that this hierarchy makes sense).

The most interesting new physics would emerge from the interaction between length scales differing by powers of v_0 made possible by the decay of BE condensates of dark photons to ordinary photons having wavelength shorter by a factor $\sim v_0$. This interaction could provide the royal road to the quantitative understanding how living matter manages to build up extremely complex coherent interactions between different length and time scales.

In the time domain dark matter hierarchy could allow to understand how moments of consciousness organize to a hierarchy with respect to the time scales of moment of consciousness coming as 2^{11k} multiples of CP_2 time scale. Even human life span could be seen as single moment of consciousness at $k = 14^{th}$ level of the dark matter hierarchy whereas single day in human life would correspond to $k = 12$.

8.6.2 Realization of intentional action and hierarchy of dark matters

How long length scales are able to control the dynamics in short length scales so that the extremely complex process extending down to atomic length scales realizing my intention to write this word is possible. This question has remained without a convincing answer in the recent day biology and there strong objections against the idea that this process is planned and initiated at neuronal level.

I have proposed a concrete mechanism for the realization of intentional action in terms of time mirror mechanism involving the emission of negative energy photons and proceeding as a cascade in a reversed direction of geometric time from long to short length scales [K34]. This cascade would induce as a reaction analogous processes proceeding in the normal direction of geometric time as a response and would correspond to the neural correlates of intentional action in very general sense of the word.

The counterparts for the negative energy signals propagating to the geometric past would be phase conjugate (negative energy) laser beams identifiable as Bose-Einstein condensates of dark photons. In the time reflection these beams would transform to positive energy dark matter photons eventually decaying to ordinary photons. The space-time correlate would be MEs decaying into MEs and eventually to CP_2 type extremals representing ordinary photons.

The realization of intentional action as desires of boss expressed to lower level boss would naturally represented the decay of the phase conjugate dark laser beam to lower level laser beams decaying to lower level laser beams decaying to.... This would represent the desire for action whereas the time reflection at some level would represent the realization desire as stepwise decay to lower level laser beams and eventually to ordinary photons. The strong quantitative prediction would be that these levels correspond to a length and time scale hierarchies coming in powers of $1/v_0 \sim 2^{11}$.

8.6.3 Wave-length hierarchy, coherent metabolism, and proton-electron mass ratio

The fact that a given wavelength length corresponds to energies related to each other by a scaling with powers of v_0 provides a mechanism allowing to transfer energy from long to short long scales by a de-coherence occurring either in the standard or reversed direction of geometric time. De-coherence in the reversed direction of time would be associated with mysterious looking processes like self-assembly allowing thus an interpretation as a normal decay process in reversed time direction.

It is perhaps not an accident that the value of $v_0 \simeq 4.6 \times 10^{-4}$ is not too far from the ratio of $m_e/m_p \simeq 5.3 \times 10^{-4}$ giving the ratio of zero point kinetic energies of proton and electron for a given space-time sheet. This co-incidence could in principle make possible a metabolic mechanism in which dark protons and ordinary electrons co-operate in the sense that dark protons generate dark photon BE condensates with wave length λ transforming to ordinary photons with wavelength $v_0\lambda$ absorbed by ordinary electrons.

Some examples are in order to illustrate these ideas.

1. As already found, in the case of dark atoms the scaling of binding energies as $1/\hbar^2$ allows the coupling of ~ 9 cm scale of brain hemisphere with the length scale ~ 50 μm of large neuron. $N_{cr} \leq 137$ ordinary IR photons would be emitted in single burst and interacting with neuron.

2. For a non-relativistic particle in a box of size L the energy scale is given by $E_1 = \hbar^2\pi^2/2mL^2$ so that the visible photons emitted would have energy scaled up by a factor $(\hbar_s/\hbar)^2 \simeq 4\times 10^6$. The collective dropping of N_{cr} dark protons to larger space-time sheet would liberate a laser beam of dark photons with energy equal to the liberated zero point kinetic energy. For instance, for the p-adic length scale $L(k = 159 = 3 \times 53) \simeq .63$ μm this process would generate laser beam of IR dark photons with energy $\sim .5$ eV also generated by the dropping

of ordinary protons from $k = 137$ atomic space-time sheet. There would thus be an interaction between dark protons in cell length scale and ordinary protons in atomic length scale. For instance, the dropping of dark protons in cell length scale could induce driving of protons back to the atomic space-time sheet essential for the metabolism [K21]. Similar argument applies to electrons with the scale of the zero point kinetic energy about 1 keV.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. In this case the process would occur coherently for all particles. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

In the sequel the early version of the model assigning metabolic energy quantum to the dropping of protons is only considered. In [K29] a model of metabolism associating the metabolic energy quantum to the change of cyclotron energy is discussed.

3. If the energy spectrum associated with the conformational degrees of freedom of proteins, which corresponds roughly to a frequency scale of 10 GHz remains also invariant in the phase transition to dark protein state, coherent emissions of dark photons with microwave wave lengths would generate ordinary infrared photons. For instance, metabolic energy quanta of $\sim .5$ eV could result from macroscopic Bose-Einstein condensates of 58 GHz dark photons resulting from the oscillations in the conformational degrees of freedom of dark proteins. A second option is that the conformal energies are scaled by $\hbar_s/\hbar$ (ω would remain invariant). In this case these coherent excitations would generate ordinary photons with energy of about 1 keV able to drive electrons back to the atomic $k = 137$ space-time sheet.

4. Since magnetic flux tubes have a profound role in TGD inspired theory of consciousness, it is interesting to look also for the behavior of effective magnetic transition energies in the phase transition to the dark matter phase. This transition increases the scale of the magnetic interaction energy so that anomalously large magnetic spin splitting $\hbar_s eB/m$ in the external magnetic field could serve as a signature of dark atoms. The dark transition energies relate by a factor $\hbar_s/\hbar$ to the ordinary magnetic transition energies.

For instance, in the magnetic field of Earth with a nominal value $.5 \times 10^{-4}$ Tesla dark electron cyclotron frequency is 6×10^5 Hz and corresponds to ordinary microwave photon with frequency ~ 1.2 GHz and wavelength $\lambda \simeq 25$ cm. For proton the cyclotron frequency of 300 Hz would correspond to energy of ordinary photon with frequency of 6×10^5 Hz and could induce electronic cyclotron transitions and spin flips in turn generating for instance magneto-static waves.

It is easy to imagine a few step dark matter hierarchy connecting EEG frequencies of dark matter with frequencies of visible light for ordinary photons. This kind of hierarchy would give considerable concreteness for the notion of magnetic body having size scale of Earth.

8.6.4 A connection with the scaling law of homeopathy

The value of the parameter $1/v_0 \simeq 2083$ is essentially the ratio of CP_2 radius and Planck length scale (as also the ratio of Compton lengths of electron and proton) and rather near to $2^{11} = 2048$. Interestingly, much larger number $2 \times 10^{11} \simeq 25 \times 2^{33}$ appears in the simplest form for what I have christened the scaling law of homeopathy [K18]. This rule has been proposed on basis of experimental findings [I2] but has no convincing theoretical justification. The scaling law of homeopathy states that high frequency em radiation transforms to a low frequency radiation and vice versa preferably with the frequency ratio $f_{high}/f_{low} \simeq 2 \times 10^{11}$.

In [K18] I have discussed some mechanisms for the transformation of high energy photons to low energy photons consistent with the rule and proposed a generalization of the rule based on p-adic length scale hypothesis. For instance, high energy visible photons of frequency f could induce an excitation of the receiving system having same frequency, propagating with velocity $\beta = v/c \simeq 10^{-11}/2$, and having wave length equal $\lambda_0 = f/v = \lambda/\beta$. This excitation would in turn couple to photons of wavelength λ_0 and frequency $f_0 = \beta f$.

A much deeper explanation for the scaling law of homeopathy is based on the quantization of Planck constant. Number theoretical arguments suggest a general formula for the allowed values of λ [K13] as $\lambda = n$ where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [K36]. The values of n for which quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17, F_3 = 257, F_4 = 2^{16} + 1$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales.

The scaling factor 2×10^{11} corresponds with 1.5 per cent accuracy to the integer $n_F = 2^{36} \times 3 \simeq 2.03 \times 10^{11}$ defining a Fermat polygon. This suggests an interpretation in terms of a decay of dark photon with a given wave-length to a bundle of n_F ordinary photons with the same wavelength. The energy of the dark photon would be by a factor n_F higher. This process could serve as an effective tool of bio-control. Dark photon could also transform to an ordinary photon with wavelength shorter by factor $1/n_F$. There is a lot of evidence that the powers of $n = 2^{11}$ define preferred scalings of $\hbar$: n_F corresponds to $n_F = 2^{3\times 11} \times 24$ which suggests that also the scale factors $n_F = 2^{k\times 11} \times 24$ could be favored. Quite generally, integers n_F defining Fermat polygons are a reasonable guess for the generalization of the scaling law of homeopathy and the search for these scaling factors could provide an experimental means of identifying the values of Planck constant relevant for living matter.

The time units of everyday life could reflect the properties of the dark matter hierarchy responsible for the control of living matter, in particular those of the sub-hierarchy defined by Fermat polygons. Indeed, one year corresponds to $n_F = 4 \times 3$ months, one month to $n_F = 2 \times 3 \times 5$ days, one day to $n_F = 8 \times 3$ hours, one hour to $n_F = 60 = 4 \times 3 \times 5$ minutes, and one minute to $n_F = 60$ seconds.

8.6.5 A connection with bio-photons

The biologically active radiation at UV energies was first discovered by Russian researcher Gurwitz using a very elegant experimental arrangement [I1]. Gurwitz christened this radiation mitogenetic radiation since it was especially intense during the division of cell.

A direct proof for the biological activity of mitogenetic radiation consisted of a simple experiment in which either quartz or glass plate was put between two samples. The first sample contained already growing onion roots whereas the second sample contained roots which did not yet grow. In the case of quartz plate no stimulation of growth occurred unlike for glass plate. Since quartz is not transparent to UV light whereas the ordinary glass is, the conclusion was that the stimulation of growth is due to UV light.

The phenomenon was condemned by skeptics as a pseudo science and only the modern detection technologies demonstrated its existence [I7], and mitogenetic radiation became also known as bio-photons (the TGD based model for bio-photons is discussed in [K21]). Bio-photons form a relatively featureless continuum at visible wavelengths continuing also to UV energies, and are believed to be generated by DNA or at least to couple with DNA. The emission of bio-photons is most intense from biologically active organisms and the irradiation by UV light induces an emission of mitogenetic radiation by a some kind of amplification mechanism. It has been suggested that bio-photons represent some kind of leakage of a coherent light emitted by living matter.

According to Russian researcher V. M. Injushin [I9] , mitochondrios emit red light at wavelengths 620 nm and 680 nm corresponding to energies 2 eV and 1.82 eV. According to the same source, the nucleus of cell sends UV light at wavelengths 190, 280 and 330 nm corresponding to the energies 6.5, 4.4 and 3.8 eV. The interpretation as a kind of leakage of coherent light would conform with the identification in terms of BE condensates of dark photons with $\hbar_s/\hbar \simeq 2^{11}$ emitted at wavelengths varying in the range $.3 - 1.25$ mm and decaying to photons with energies visible and UV range. For instance, 1.82 eV radiation corresponds to a dark photon wave length of 1.4 mm for $v_0(eff) = 2^{-11}$. A bio-control of ordinary bio-matter at sub-cellular level performed by dark matter from the millimeter length scale could be in question. This proposal conforms with the fact that 1 mm defines the scale of the blobs of neurons serving as structural units in cortex.

The analysis of Kirlian photographs has shown that the pattern of visible light emitted by various body parts, for instance ear, code information about other body parts [I12]. These bio-

holograms for which a general model is discussed in [K3] could be realized as dark photon laser beams.

In phantom DNA effect [I5] a chamber containing DNA is irradiated with a visible laser light and the DNA generates as a response coherent visible radiation at same wavelength. Strangely enough, the chamber continues to emit weak laser light even after the removal of DNA. This effect could be due to the decay of a dark photon BE condensate remaining in the chamber. Also the findings of Peter Gariaev [I6] about the effects of visible laser light on DNA, in particular the stimulated emission of radio waves in kHz-MHz frequency range might also relate to dark photons somehow.

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