General Theory of Qualia

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Abstract

The connection between the general theory of qualia and quantum measurement theory and thermodynamics turned out to be a breakthrough in the development of the ideas related to qualia. In TGD framework the contents of consciousness is determined as some kind of average over the sequence of very large number of quantum jump and this suggests strongly that non-geometric qualia allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last 'wake-up' of self.

a) There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or about increments of zero modes in quantum jump.

b) The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is a gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

c) Since subjective existence corresponds to quantum jumps, it is natural to assume that only the increments of zero modes and quantum numbers are experienced consciously. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number). A further working hypothesis analogous to functionalism is universality: kinesthetic qualia depending on the quantum number increments are universal. Thus the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia.

The thermodynanical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

1. Emotions as order-disorder qualia

$T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia qualia about the state of self. The fact that emotions correlate strongly with peptides which are also informational molecules, supports the identification of the qualia associated with various entropy growth rates as emotions. The entropy of sub-self in turn characterizes the sharpness of the mental image.

2. Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. Quite generally, the rates for the increase for a maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define what might be called kinesthetic qualia. Senses of force and torque, hearing, and intensity of color sensation can be regarded as examples of generalized kinesthetic qualia.

3. Generalized chemical qualia vm

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-canonical and quaternion conformal super algebras should define these kind

of qualia and the number of these qualia is very large. The particle numbers in question can be numbers of ions of Cooper pairs in various magnetic states, numbers of colored configuration space photons in various states of super-canonical representation, numbers of join along boundaries bonds, etc.. and one can understand chemical qualia, color vision, and sensations of pain and pleasure as generalized chemical qualia.

4. Boolean qualia

The transitions associated with the fermionic generators of super-canonical algebra can be identified as Boolean consciousness with intrinsic meaning ('This is true'). Boolean cognition without intrinsic meaning and/or conscious feeling of quantity can be understood as associated with temporal sequences of Z^0 mangnetization directions for cognitive antineutrinos.

There are two basic mechanisms generating sensory qualia.

a) Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. The magnetic quantum phase transitions at super-conducting magnetic flux tubes provide a basic example of this mechanism, and the quantum model of hearing relies on Z^0 magnetic quantum phase transitions.

b) The flow of particles with fixed quantum numbers between "electrodes" of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The "electrodes" carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and postsynaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The capacitor model applies to various chemical qualia and also to color vision and predicts that also cells should have senses.

1 Introduction

Macroscopic quantum phases are an essential element of most quantum theories of consciousness and Topological GeometroDynamics (TGD) is not an exception in this respect. TGD based theory of consciousness relies crucially on the notion of self hierarchy whose geometrical correlate is the hierarchy of space-time sheets realized as a 4-surface in certain 8-dimensional space. The notion of many-sheeted space-time indeed predicts new types of macroscopic quantum phases. This has led to guesses for the quantum correlates of sensory qualia (colors, tastes, odors,..) and conscious thought as various macroscopic quantum phases predicted by TGD but the the lack of direct experimental evidence for the macroscopic quantum phases has made more detailed models impossible. The breakthroughs in TGD and TGD inspired theory of consciousness inspired the first trials to construct a general theory qualia. Preliminary and incomplete versions of this theory are published in [16] and in [17]. During subsequent years the theory got a rather stable shape.

Dark matter hierarchy with levels labelled by the values of a dynamical quantized Planck constant have been the basic theme of the year 2005. TGD inspired theory of consciousness and TGD based view about quantum biology provide perhaps the most fascinating applications for this concept. It must be however added that condensed matter applications, say the models for the anomalous properties of water and for high T_c superconductivity, are of utmost relevance also for TGD based view about living matter. Dark matter hierarchy allows profound insights about the evolution of consciousness and life as the emergence of new levels of dark matter hierarchy, and deepens the view about the anatomy of quantum jump making it also possible to develop a more detailed view about qualia.

1.1 TGD in nutshell

Topological Geometro-Dynamics (TGD) is a unified theory of fundamental interactions. TGD involves a quite far-reaching generalization of the space-time concept and, apart from the notion of quantum jump, reduces quantum theory to infinite-dimensional geometry, which is highly unique from the mere requirement that it exists. Quantum TGD requires the introduction of several new mathematical tools and concepts, in particular p-adic numbers. p-Adic number fields R_p (one number field for each prime $p = 2, 3, 5, ...$) are analogous to real numbers but differ from them in that p-adic numbers are not well-ordered. p-Adic physics describes the physics of cognitive representations and matter-mind decomposition at space-time level corresponds to the decomposition of space-time surface to real and p-adic regions. The higher the value of p, the better the resolution of cognitive experience is, so that p serves as kind of intelligence quotient. The mappings of the real geometric structures to their p-adic counterparts interpreted as cognitive mappings plays also key role in TGD inspired theory of consciousness.

p-Adic length scale hypothesis states that the p-adic length scales $L_p = l\sqrt{p}$, $l \simeq 10^4$ Planck lengths, $p \simeq 2^k$, k prime or power of prime, are physically preferred. p-Adic length scale hypothesis provides quantitative realization for the hierarchy of space-time sheets and is in key role in TGD inspired theory of consciousness. The seven online books about TGD [1, 2, 4, 5, 3, 6, 7] and eight online books about TGD inspired theory of consciousness and quantum biology [10, 8, 9, 13, 11, 12, 14, 15] are warmly recommended for the reader willing to get overall view about what is involved.

1.2 TGD inspired theory of consciousness very briefly

TGD inspired theory of consciousness allows to construct a general model of conscious experiences based on some very general principles.

1. Quantum jump between quantum histories as moment of consciousness and the notion of self

The identification of quantum jump between quantum histories as moment of consciousness defines microscopic theory of consciousness whereas the notions of self and self hierarchy allow to understand macroscopic aspects of consciousness absolutely essential for brain consciousness [H1]. Self is identified as a sub-system effectively behaving like its own subuniverse quantum mechanically [H3]. Physically this means that self is a sub-system able to not generate bound state entanglement with environment during subsequent quantum jumps.

Simple assumptions about how the contents of consciousness of self is determined allow to understand the basic structure of conscious experience at general level. One can understand volition as closely related to the classical nondeterminism of the Kähler action; theory leads to a very general model of sensory experience and so called whole-body consciousness explaining basic characteristics of the mystic experiences is basic prediction of the theory [H4].

The localization in configuration space zero modes occurring in each quantum jump implies that the world of conscious experience is classical and standard quantum measurement theory follows as a consequence. Also self measurements are possible and each localization in zero modes is followed by a cascade of self measurements leading to a completely unentangled product state: this is nothing but TGD counterpart of the state preparation process which is also part of quantum measurement theory. Self measurements are governed by Negentropy Maximization Principle [H2]. Self measurements give rise to quantum level self repair mechanism. In p-adic context NMP is the basic variational principle of cognition.

In the absence of macro-temporal quantum coherence de-coherence times for quantum states would be or order 10^4 Planck times. Macro-temporal quantum coherence however effectively binds a sequence of quantum jumps to a single quantum jump, and the quantum jump at a given level

of hierarchy corresponds to a sequence of quantum jumps at lower levels, which also contributes to the experience of the higher level self.

1. Macro-temporal quantum coherence is made possible by the quantum spin glass degeneracy due to the fact that canonical transformations of CP_2 act like $U(1)$ gauge transformations but generate physically non-equivalent states having slightly different gravitational energies. Macro-temporal quantum coherence means the formation of bound states. The space-time correlate is the formation of join along boundaries bonds connecting corresponding space-time sheets to single space-time sheet. Bound state formation gives rise to the fusion of selves to a larger self implying what might be called stereo consciousness. During macro-temporal quantum coherence dissipation is absent in bound degrees of freedom so that the resulting mental image stays sharp. Neuronal synchrony is a signature of this phenomenon at brain level.

2. Quantum parallel dissipation is an essential aspect of the new view about quantum jump. Hadron as a quantum coherent system on one hand, and as a soup of quarks and gluons whose distribution functions obey kinetic equations on the other hand, provides a good example about quantum parallel dissipation. Self experiences this dissipation at lower levels of hierarchy as "thermal noise" except during "enlightened" moments of consciousness.

3. The hypothesis that bound state entanglement stable against state function reduction corresponds to algebraic entanglement coefficients gives a more precise quantitative content for what the fusion of quantum jumps could mean. For algebraic entanglement p-adic Shannon entropies obtained by replacing logarithms of probabilities with the logarithms of their p-adic norms are well-defined, and there is a prime p for which Shannon entropy is negative and minimum and identifiable as negentropy.

4. The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [J6, M3]. The hierarchy of dark matter levels is labelled by the values of Planck constant having quantized but arbitrarily large values. It seems that the basic hierarchy comes as $\hbar(k) = \lambda^k \hbar_0$, where $\lambda \simeq 2^k$ is integer. Also sub-harmonics and integer valued sub-harmonics of λ are possible [C6]. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \lambda^k$ of the quantum jump.

Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

2. p-Adic physics as physics of cognition and intention

TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, ...$ p-Adic regions obeys the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive pinary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination and intention is basically due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. In this vision real mind like space-time sheets are interpreted as geometric correlates of experience and corresponding p-adic space-time sheets correspond to imagined experience. The transformation of a p-adic region to a real one in quantum jump corresponds to a transformation of intention to action.

3. New view about time

The understanding of the relationship between subjective and geometric time leads to the notion of psychological time involving in an an essential manner the new view about space-time, in particular the idea about mind like space-time sheet (defined as space-time sheet having finite time-duration) as a geometric correlate of self [H5, K1]. One can understand psychological time as temporal center of mass coordinate for the cognitive space-time sheet. The arrow of psychological time can be understood as resulting from a drift towards the geometric future. Diffusion in future light-cone alone is probably not enough, also drifting force is needed and special relativity suggests that this force is the fourth component of four-force and could perhaps be identified as proportional to the dissipation rate for energy occurring during the self-organization. This suggests that the average increment of the geometric time per quantum jump is given by $\Delta t = (P/k)\tau$, where P is rate of energy dissipation, k is the coefficient of friction regarded as a Lorentz scalar, and τ some fundamental time scale, most naturally of the order of CP_2 time τ_{CP_2} is CP_2 time about 10^4 Planck times. P/k would determine the fraction of time spent in wake-up state if τ is the average increment of the geometric time in quantum jump.

The notion of psychological time forces to view the entire many-sheeted space-time surface as a living system so that the standard notion of linear time is illusory and reflects the restricted information content of our conscious experience rather than fundamental 4-dimensional reality. The paradigm of 4-dimensional brain provides completely new understanding of the long term memory: no memory storage mechanisms are needed and one avoids the basic difficulties of neural net models. There are two kinds of memories, geometric and subjective, as also two kinds of causalities. Massless extremals, whose light-like boundaries are identified as geometric correlates of selves, realize the paradigm of 4-dimensional brain concretely.

4. Selves self-organize

Subjective time development by quantum jumps implies quantum self-organization which can be regarded as a sequence of quantum jumps between quantum histories [I1]. This evolution corresponds to a sequence of macroscopic space-time surfaces associated with the final state quantum histories. Quantum jumps imply dissipation at fundamental level. Dissipation serves as a Darwinian selector of self-organization patterns, which can represent both genes and memes. In particular, one can understand how habits, skills and behavioral patterns are gradually learned.

5. Self hierarchy

The notion of self hierarchy, starting from elementary particle level and having entire Universe at the top, is a highly nontrivial prediction of TGD inspired theory of consciousness. Self hierarchy is very much analogous to the hierarchy of subprograms of a computer program and defines a

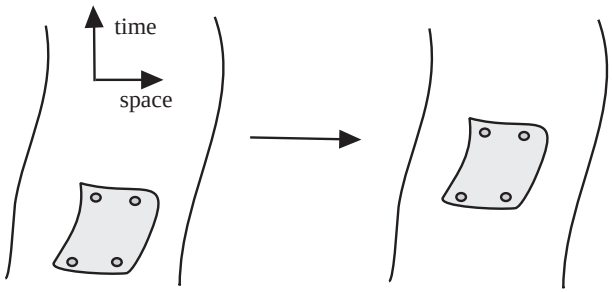

Figure 1: The mechanism giving rise to the arrow of psychological time. What happens is that mind like space-time sheet gradually drifts in direction of geometric future. Note that mind like space-time sheet has finite time duration.

hierarchy of increasingly abstract experiences. Self hierarchy allows to understand computational aspects of brain although connectionistic picture realized as quantum association network seems to work at various levels of the hierarchy [H7]. Topological field quanta of em fields are an part of self hierarchy and this force to give up the view that consciousness is brain centered phenomenon (wavelength of 10 Hz EEG photon has size scale of Earth). Self hierarchy is also crucial for the model of sensory qualia.

Dark matter hierarchy [C6, M3] leads to a detailed understanding of the correlates of our consciousness and its relation to lower and higher levels of the self hierarchy. There are good reasons to believe that the levels of the dark matter hierarchy correspond to the evolutionary hierarchy and that great leaps in evolution correspond to the emergence of a new level in the dark matter hierarchy [L2]. The hypothesis leads to precise quantitative predictions. For instance, a hierarchy of EEGs, ZEGs, WEGs, and GEGs (E, Z, E, and G correspond to photon, Z^0 boson, W boson and gluon) is predicted [M3], and the model predicts correctly the band structure and even individual resonances of ordinary EEG.

1.3 Biological realization of self hierarchy

Self hierarchy has as a geometric correlate the hierarchy of space-time sheets.

1. Space-time correlates of dark matter hierarchy

The scaling of $\hbar_0$ by λ^k means also scaling for various basic quantum scales like Compton length and - time and de Broglie wave length. Compton length correspond to a size of space-time sheet associated with the particle. The energy of dark photons with frequency f is scaled up by λ^k. For instance, EEG photons at $k_{em} = 4$ level of dark matter hierarchy have energy which is above thermal energy at room temperature: this is absolutely essential for understanding the role of EEG photons.

The phase transition increasing k_{em} by one unit means that the sizes of space-time sheets are scaled up by λ. If the density of particles is high enough, the overlap criterion for the formation of a macroscopic quantum phase is satisfied in the resulting dark phase and Bose-Einstein condensates become possible. De-coherence phase transition for dark matter particle means that the size of the space-time sheet is scaled down by $1/\lambda$.

Poincare invariance requires that four-momentum and spin are invariant under the scaling of $\hbar$. Combined with number theoretical vision this requirement leads to a detailed picture about what the scaling corresponds at the level of configuration space of 3-surfaces [C6] The invariance of spin

leads to highly non-trivial predictions for what happens to the space-time sheet in the scaling: $\hbar(k)$ corresponds to λ^k-fold covering of M^4 analogous to Riemann surface. A possible interpretation is in terms of a transition to chaos, not via period doubling but via λ-folding.

2. The notion of magnetic body

The notion of magnetic body belongs to the key concepts of TGD inspired theory of consciousness. Magnetic body is the intentional agent, which uses biological body as a sensory receptor and motor instrument. The ideas about dark matter hierarchy lead to a concrete view about what magnetic bodies could look like. The basic observation is that the scaling of the unit $\hbar$ of magnetic flux by λ requires the scaling of the area of flux quantum or of field strength by λ or a more complex combination of these basic operations. For flux sheets with fixed thickness and fixed field strength the width of the flux quantum must be scaled up by λ. Applying this picture in the case of Earth's magnetic field leads to a concrete model for those parts of magnetic bodies which are in a direct contact with the biological body.

Magnetic body utilizes biological body as a sensory receptor most effectively if the flux quanta go through the receptor proteins at cell membranes. Motor instrument function is realized in an optimal manner if magnetic flux quanta connecting magnetic body to biological body are strongly folded thin flux sheets going through the DNA strands of cells which take the role of text lines at the pages of book formed by magnetic flux sheets. Flux quantization implies that sheets must traverse through quite a large number of genomes unless one assumes that the text lines are almost empty. This leads to a generalization of the notion of genome providing a powerful tool in attempts to build a concrete view about the higher levels of self hierarchy.

Super-genome means that sequences of genomes organize like lines of text on pages of a book formed by magnetic flux sheets. Super-genomes are responsible for the organization of cells to organs. Hyper-genome consists of super-genomes of different organisms organized in a similar manner. Mirror neurons could provide an example of this kind of organization at the level of neurons (it is known that autistic children possess much less mirror neurons than healthy ones). Hyper-genome (presumably involving introns and memetic code) is responsible for coding the collective levels of consciousness responsible for culture and social structures.

3. Massless extremals

The so called massless extremals (MEs) [J4, M2, M4, M5] are excellent candidates for correlates of dark photons at various levels of dark matter hierarchy. There the earlier term "mind like" space-time sheets is justified. MEs are ideal for control and communication purposes since the vacuum current associated with ME has arbitrary time dependence and is ideal for coding both the sensory data and control instructions. The fact that classical space-times are field theoretic counterparts of Bohr orbits, suggests that classical em field decomposes into MEs when classical de-coherence occurs. MEs provide a mechanism of long term memory and the notion of MEs leads to the idea about brain as a sensory and motor organ of higher level selves and to a rather detailed view about the general organization of brain.

By general coordinate invariance the light-like M^4_+ projections of the light-like boundaries of MEs act as quantum holograms and can be identified as universal (but probably not the only) geometric correlates of selves. The light-like vacuum currents are optimal for coding information and make MEs dynamical holograms in classical sense.

By Uncertainty Principle ELF MEs correspond to topological field quanta with size of Earth. It became clear already before the realization of super-canonical representations that MEs could be also seen as higher level selves [L1] living in symbiosis with biological life forms and responsible for the cultural aspects of human consciousness. This is in accordance with the idea that the flux tubes of Earth's magnetic and Z^0 fields serve as templates for the formation of bio-structures. Contrary to the Newtonian intuition, the only sensible view seems to be that we ourselves correspond to life

forms of electromagnetic size not smaller than Earth size: the illusory identification of 'me' with brain is created by the erratic identification of self with the contents of sensory experience. This view stimulates also rather concrete ideas about biological death and life after biological death.

MEs can carry besides classical em and Z^0 fields also W gluon fields and in general do so. These fields can be assigned to dark matter. The model for nerve pulse [M2] leads to a more detailed view about the division of labor between neutral and charged MEs. Neutral MEs are ideal for communication and coordination purposes. Charged W MEs can induce charge entanglement over macroscopic and even astrophysical length scales. This means a nonlocal mechanism inducing changes of charge equilibria in turn inducing the flow of ordinary em currents.

The model of nerve pulse assumes that magnetic body of neuron induces multiverse states in which no nerve pulse is present at the first branch and nerve pulse is generated at the second branch. In principle this makes possible dissipative quantum computation using nerve pulse patterns (the notion of quantum parallel dissipation justified by dark matter hierarchy is an essential conceptual prerequisite here). Color entanglement can in turn induce local color charging and in the capacitor model of sensory qualia this charging can lead to generation of color discharge giving rise to an experience of visual color.

4. Hierarchy of magnetic super-conductors

The empirical results [67, 68] about the effects of oscillating em fields on brain suggest that cyclotron frequencies, and more generally magnetic transition frequencies, of biologically important ions in the magnetic field of Earth correspond to important oscillation frequencies of Josephson currents and MEs. Also the magnetic transition frequencies of electronic Cooper pairs seem to be important as also Z^0 magnetic transition frequencies of neutrino and various Z^0 ions which at the same time are exotic ions in em sense (nuclear color bond containing quark and anti-quark at its ends can become charged as it transforms to $u\overline{d}$ of $d\overline{u}$ type bond).

Second empirical ingredient supporting the view about hierarchy of magnetic super-conductors are the puzzling observations of cell biology (for a summary see the first chapter of [32]) challenging the association of ionic channels and pumps to cell membrane. The paradoxes disappear if cell and its exterior are assumed to be in a many-sheeted ionic flow equilibrium with ionic currents flowing from super-conducting space-time sheets to atomic space-time sheets and back, so that the densities of ions at atomic space-time sheets are controlled by the the very small densities and quantized currents of the ions at super-conducting magnetic flux tube space-time sheets and coding the information about homeostasis of bio-matter [J1, J2, J3, M3]. Also a reason why for liquid crystal and electret properties of bio-matter emerges and one can understand the function of electric circuitry associated with body [Becker and Selden].

Dark matter hierarchy leads to a quantitative model for high T_c superconductivity predicting the basic length scales $L(149)$ and $L(151)$ associated with lipid layers of cell membrane and cell membrane itself. Also cell size emerges naturally. At higher levels of dark matter hierarchy scaled up versions of this basic structure appear. Cyclotron states at magnetic flux tubes are carriers of Bose-Einstein condensates of Cooper pairs and of bosonic ions. For instance, neurons correspond to $k_{em} = 3$ level of dark matter hierarchy whereas ordinary EEG correspond to $k_{em} = 4$: in this case Josephson junction corresponds to about 170 km thick double layered structure identifiable in terms of litosphere-ionosphere pair (this kind of identification would be of course non-sensible without dark matter and in single-sheeted space-time). A strong support for the model comes from the correct prediction of the band structure and resonance bands of EEG.

5. How MEs interact with magnetic super-conductors

One can imagine several mechanism for how MEs interact with magnetic superconductors.

1. Neural MEs can induce super currents in super-conducting magnetic circuits by magnetic induction mechanism, serve as temporary Josephson junctions between magnetic flux tubes,

and induce magnetic quantum phase transitions.

2. Neutral MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern and its phase conjugate could act as a control command and its time reversed version. Conjugate reference waves provide an extremely simple mechanism of healing by time reversal allowing the living matter to fight against second law. MEs can read DNA strand to the light-like vacuum current by moving along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. ELF MEs could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. Thus living matter could be regarded as a symbiosis in which MEs control super-conducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. DNA would represent the ROM of this system.

3. W MEs can induce charge entanglement over macroscopic and even astrophysical distances followed by a quantum jump reducing this entanglement. At the branch of the resulting multiverse for which charge density is affected by the exotic ionization of the cyclotron condensate (say Ca^{++} condensate), ordinary currents are generated in order to restore equilibrium. This mechanism could be behind Ca^{++} waves at various levels of dark matter hierarchy and the generation of nerve pulse would represent only a special instance of this mechanism. Many-sheeted version of the Faraday law is an essential element of this mechanism: it is the change of membrane potential at dark matter space-time sheet induced by the effective ionization which induces the change of potential at the space-time sheet containing ordinary matter or matter at a lower level of dark matter hierarchy. This mechanism means also that dark matter and visible matter can interact via classical fields.

6. MEs as carriers of super-canonical and Super Kac-Moody representations

TGD predicts two kinds of super-conformal symmetries [L4, C1]. Super-Kac Moody symmetries assignable to partonic 2-surfaces identifiable as time =constant sections of light-like causal determinants of 4-surfaces correspond to the gauge symmetries of fundamental interactions. Super-canonical symmetries act at imbedding space level, on $\delta M^4_{\pm} \times CP_2$, where $M^4_{\pm}$ is some future/past light-cone of M^4. The conformal weights of super-canonical representations are closely related to the complex zeros of Riemann Zeta and the net conformal weight of a physical state is always real: this implies conformal confinement. There is a fractal hierarchy of quantum holograms inside quantum holograms. One can identify the light-like boundaries of MEs as geometric correlates for selves.

Also space-like selves are very probably needed and magnetic flux tube structures could represent them. Indeed, the non-determinism of CP_2 type extremals representing elementary particles (their M^4_+ projections are random light-like curves) makes it impossible to characterize the quantum state completely by the data on the light-like boundaries of MEs.

Super-canonical degrees of freedom makes MEs ideal candidates for the correlates of higher level consciousness.

1. The states of super-canonical representations have gigantic almost-degeneracies broken only by non-commutativity of super-canonical and Poincare symmetries which means huge information storage capacities. Super-canonical representations can be realized in real context using Bose Einstein condensates of massless elementary particles on MEs. Super-canonical representations correspond to genuine quantum gravitational effects since wave functionals in the space of three-surfaces are involved: space-time ceases to be a passive arena of quantum dynamics. In fact, canonical transformations of CP_2 are approximate symmetries of

the theory broken only by classical gravitation. The notion of 'configuration space photon' having nontrivial dependence on configuration space degrees of freedom characterized by Hamiltonian suggests strongly itself and seems to be crucial for understanding of the visual colors.

2. Super-canonical representations associated with MEs have universal transition frequency spectrum given as multiples of the fundamental frequency determined by the length of ME. If one assumes that MEs have lengths given by p-adic length scale hypothesis, fundamental frequencies turn out to correspond to important resonance frequencies in EEG. For these reasons super-canonical representations are ideal candidates for an infinite hierarchy of life forms associated with MEs. The great vision is that MEs and magnetic super-conductors associated with the magnetic flux tube structures form a fractal hierarchy interacting with the ordinary bio-matter via the classical gauge fields associated with MEs [M3, M2, M4, M5, J7].

1.4 Qualia and thermodynamics

The connection between thermodynamics and qualia was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics. In TGD framework the contents of consciousness is determined as some kind of average over a sequence of very large number of quantum jump. Thus non-geometric qualia should allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps occurred after the last 'wake-up' of self. For instance, this picture allows to see the ageing of self with respect to subjective time as an approach to thermal equilibrium.

1. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or their increments in quantum jumps.

2. The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of the theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in the case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

3. Since subjective existence corresponds to quantum jumps, it is natural to assume that only the increments of zero modes and quantum numbers are experienced consciously. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration: this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number). A further working hypothesis analogous to functionalism is universality: the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia in the sense that quantum number increment is experienced in the same manner irrespective of context (other quantum number increments).

Spin is perhaps an exception since it does not change in the scaling of $\hbar$. If magnetic field strength remains invariant and the area of flux quantum scales up as λ in the scaling of $\hbar$, magnetic interaction energy $-\mu \cdot B$ remains invariant whereas cyclotron energy scales up. Hence spin would be thermalized and only cyclotron transitions would contribute to qualia. Spontaneous magnetization and spin flips of spontaneously magnetized regions of spin glass having very large magnetic moment might change the situation. One must also remember that the assignment of same temperature to all space-time sheets of the dark matter hierarchy is the most pessimistic working hypothesis.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

1.4.1 Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. Quite generally, the rates for the increase for a maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define what might be called kinesthetic qualia. Senses of force and torque, hearing, and intensity of color sensation can be regarded as examples of generalized kinesthetic qualia.

1.4.2 Generalized chemical qualia

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-canonical and Super Kac-Moody algebras should define these kind of qualia and the number of these qualia is very large. The particle numbers in question can be numbers of ions of Cooper pairs in various magnetic states, numbers of colored configuration space photons in various states of super-canonical representation, numbers of join along boundaries bonds, etc.. and one can understand chemical qualia, color vision, and sensations of pain and pleasure as generalized chemical qualia.

1.4.3 Boolean qualia

Boolean qualia would be naturally associated with fermion number or fermionic spin degrees of freedom. There are super-canonical and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-canonical algebra might give rise to Boolean consciousness with intrinsic meaning ('This is true'). The generation of sequences of zero energy cognitive neutrino pairs with neutrino and antineutrino quantum numbers at opposite light-like elementary particle horizons of a wormhole contact could correspond to Boolean cognition in which the presence/absence of fermion representing to 1/0. Boolean statements might be just bit sequences without consciously experienced intrinsic meaning (1/0 instead of true/false).

1.4.4 What kind of qualia could emotions correspond?

The identification of emotions as qualia is far from obvious. What looks clear is that emotions seem to relate closely to information (peptides are information molecules and their distributions also correlates strongly with the emotional state).

1. *Do emotional qualia reduce to gradients of entropy or negentropy?*

The first brave guess was that emotions reduce to the changes of a negentropy type variable. A more cautious assumption would be that these changes determine only a 2-valued emotional quale having values positive/negative.

1. The first candidate for the entropy type variable is the entropy for the ensemble determined by the quantum jumps of sub-self. More concretely, $T-S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing.

   The total entropy for the statistical ensemble defined by sub-self determines how sharp the the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state. Macro-temporal quantum coherence due to quantum spin glass degeneracy and dark matter hierarchy implying a hierarchy of increasing values of Planck constant is absolutely essential in guaranteing that the mental images stay non-entropic: otherwise 10^4 Planck times would be natural de-coherence time and define the duration of sharp mental images.

   The objection is that the entropy of sub-self is expected to increase as sub-self ages so that this kind of emotions would be always negatively colored. The notion of number theoretic negentropy based on p-adic variants of Shannon entropy is however non-negative in general and could increase of decrease as the size of the ensemble determined by quantum jumps increases. It is however not obvious whether it is sensible to assign this kind of entropy to ordinary statistical ensemble.

2. The color of emotion (positive/negative) could correlate with the increase/decrease of the number theoretic entanglement negentropy of the mental image, which characterizes the rational (or even algebraic) entanglement assignable to sub-self as a quantum mechanical bound state. The positive negentropy could be argued to be due to a conscious information due to the possibility to compare different states present in the multiverse state. Certainly the assignment of a non-negative quantum information to algebraically entangled bound state number theoretic entanglement entropy (!) is natural since this entropy does not describe lack of information about classical state. This makes possible the huge information processing capacity of quantum computers. Number theoretic negetropy can also increase in quantum jump and Negentropy Maximization Principle [H2] indeed postulates this increase as the fundamental variational principle of the dynamics of conscious experience.

2. Are emotions and cognition sensory qualia at higher levels of dark matter hierarchy?

Emotions and cognition could be higher level sensory qualia assignable to higher levels of dark matter hierarchy and cyclotron phase transitions at the magnetic bodies induced by EEG and its fractal generalizations would define this kind of qualia. Emotions and cognition represent in this picture two different kinds of communications of information from biological body to the magnetic body. This option is perhaps the most promising one but allows also the identification of the positive/negative attribute of emotion in terms of the sign of the negentropy gradient.

1.5 Spectroscopy of consciousness

The quantum correlates of sensory qualia suggest what might be called spectroscopy of consciousness. The original working hypothesis was that EEG frequencies correspond directly to various qualia but it seems that this assumption must be replaced with a less restrictive one.

The idea is that EEG (or ZEG, WEG, or GEG) MEs can be assigned with entanglement of a sub-self of magnetic body with sub-self of biological representing various mental images. That sub-selves can entangle with selves remaining themselves unentangled is one aspect of the generalized notion of sub-system and inspired by the hierarchy of space-time sheets allowing to identify the space-time correlate for this kind of entanglement as join along boundaries bonds connecting space-time sheets representing the sub-systems of disjoint space-time sheets. The entanglement in question could be in cyclotron degrees of freedom, charge entanglement, or color entanglement. An open question is whether this kind of entanglement is possible only for sub-selves characterized by a smaller value of $\hbar$ than self, or always when topologically condensed sub-system is characterized by a smaller value of p-adic prime and separated by a light-like causal horizon from the larger system.

Although EEG and its generalizations seem to serve communication and control purposes rather than representing qualia directly, the notion of spectroscopy of consciousness makes still sense. Furthermore, the identification of the fractal hierarchy of EWEGs and GEGs means a dramatic generalization of this notion making precise quantitative predictions in a huge range of frequency scales resulting by simple scaling from EEG [M3]. The model allows to assign the frequencies $nf_c \pm f_J$ (f_c is cyclotron frequency and f_J Josephson frequency) with the communications of sensory data to magnetic body and frequencies nf_c with the quantum control performed by the magnetic body. For ordinary EEG the harmonics of cyclotron frequencies of bosonic ions correspond to alpha band and its harmonics assignable to quantum control. Beta and theta bands and their analogs for the harmonics of alpha band correspond to the communication of sensory and cognitive data to the magnetic body. The rough correlations of EEG with the state of consciousness can be understood. The challenge would be to identify detailed EWEG and GEG correlates of sensory experience, emotion, cognition and memory and only the first partially misguided attempts in this direction have been made.

One of the first ideas was a possible connection of the theory of the various magnetic qualia with place and time coding with atomic and nuclear spectroscopy. The correspondence with nuclear spectroscopy is not promising since spin remains invariant in the phase transition to dark matter and if dark matter is at the same temperature as the ordinary matter, spin is thermalized and only cyclotron degrees of freedom are relevant. Spontaneous magnetization could of course change the situation.

Second idea was that the structure of the periodic table could reflect directly itself in the spectroscopy of consciousness. This would mean that various full electronic shells (He, Ne, Ar, Kr, Xe) would correspond to a hierarchy of magnetic qualia relating directly with the band structure of EEG. The periods also seemed to correlate with the five-layered structure of sensory cortex (primary, secondary, etc... areas). The objection against this vision is that biologically important ions must be bosons since only they can form Bose-Eistein condensates. Most of the biologically relevant bosonic ions have cyclotron frequencies in alpha band and this leads to a successful prediction of the band structure and of the narrow resonance bands. The correspondence with the periodic table must be given up unless exotic ions of bosonic atoms (also bosons) are allowed. Exotically ionized bosonic ions (say dark $Ca^{++,\pm}$) are necessary in the model of nerve pulse and result in the charge entanglement by W MEs, which suggests that they are indeed present.

Apart from scaling the spectrum of super-canonical transition frequencies is constant of Nature if MEs have preferred length scales given by p-adic length scale hypothesis. This leads to powerful predictions and theory is immediately testable. One can indeed identify the basic resonance frequencies associated with EEG as lowest frequencies of this kind. Furthermore, the lower bounds of EEG bands correspond to the fundamental frequencies of super-canonical transitions assuming p-adic length scale hypothesis. Dark matter hierarchy predicts scaled up variants of these frequencies.

Also now the representations associated with various p-adic length scales seem to correlate with

the hierarchy formed by the areas of the sensory cortex.

Without exaggeration, spectroscopy of consciousness could be for brain science what atomic spectroscopy has been for physics and chemistry. It is somewhat astonishing that this possibility has not been noticed before. After all, spectral lines provide extremely effective, reliable and universal manner to code information and brain is the most refined information processing system we know. Ironically, brain modelers busily mimicking EEG numerically know that EEG correlates strongly with mental state but do not still notice the enormous information storage potential of EEG spectrum. This is perhaps the most dramatic example of the power of the scientific prejudices ('there is no evidence for the importance of quantum effects in brain length scale') to hinder seeing the truth staring directly at our face in its full simplicity and beauty. It is also ironic that so many quantum consciousness theorists spend their time by speculating about quantum gravitational Planck length scale basis of consciousness without realizing that spectroscopy is the most important practical outcome of quantum theory and EEG is the most obvious place to search for this kind of spectroscopy.

2 General vision about the quantum correlates of qualia

In this section a general theory providing overall view about the identification of the quantum correlates of qualia is developed. Hard trial and error experimentation with concrete models for the identification of qualia has gradually led to a vision about fundamental physics and general principles behind qualia. Several questions remain still unanswered but it seems that following general vision deserves testing and further development.

1. Qualia can be divided into two classes: discrete, non-geometric, quantal qualia on one hand, and 'classical', geometric or what might be called zero mode qualia on the other hand and measured in the quantum jump. Discrete qualia correspond to quantum jumps defined by the non-diagonal generators of two super algebras. Super Kac-Moody algebra is responsible for the standard elementary particle quantum numbers and the super-canonical algebra defining the group of isometries for the configuration space of 3-surfaces. Thus quantum measurement theory dealing with the diagonal generators fuses with the theory of non-geometric qualia dealing with the non-diagonal generators.

2. Zero modes can represent various types of geometric information, say position, orientation or more general information about size or shape. Certain subspace of zero modes defines as a coset space a flag-manifold whose points characterize the possible choices of the quantization axes. Flag-manifold coordinates are naturally mapped into magnetic and Z^0 magnetic field configurations which in turn determine magnetic and Z^0 magnetic transitions frequencies. Averages of the increment of the zero modes are experienced but sub-selves make possible to have temporally structured experiences especially important for hearing.

3. Place and time coding is important part of the theory. When EEG frequency (note that there is hierarchy of EEGs and its weak and colored generalizations involved) corresponds to a particular magnetic transition frequency, magnetic transitions in corresponding part of the linear cortical structure occur and induce quantum phase transition waking up mental image giving rise to a sensation that something exist in that particular spatio-temporal position. The sensation about movement of an object of perceptive field and perhaps even the sensation about the rate of time flow result automatically when the mental image moves along the linear spatiotemporal structure.

4. Each quale corresponds to some quantum jump serving as a seed of quantum phase transition for macroscopic quantum phases in quantum critical spin glass state. The assumption

that primary sensory organs are the seats of the sensory qualia has turned out to provide the simplest view about sensory experience, imagination, and dreams. Assuming quantum entanglement between sensory organs, brain, and magnetic bodies one can avoid various objections against this scenario. This leaves a lot of room for more detailed identifications. The magnetic and Z^0 magnetic transitions for ions in Earth's magnetic and particles in Z^0 magnetic fields are good candidates for quantum transitions associated with the sensory qualia. Visual colors could correspond to increments of color quantum numbers.

5. Music metaphor in its recent form states that primary sensory organs contain the music (also neurons are probably sensory experiencers but these experiences would not be ours) and nerve pulse patterns and membrane oscillations are the notes. Thus brain would construct symbolic and cognitive representations rather than direct sensory experiences.

   EEG MEs would entangle the mental images at magnetic body and in brain and sensory organs. EEG patterns could be also seen as providing a representations for the notes of the music produced by sensory instrument. The function of nerve pulse patterns is to resonantly excite EEG frequencies entangling brain with the magnetic body and to induce magnetic transitions amplified into quantum phase transitions. The frequencies of many of these transitions can be predicted. Essential prerequisite is quantum criticality of the quantum spin glass phases associated with supra phases.

6. The observation that quantum TGD implies quantum measurement theory meant also a breakthrough in the theory of qualia. The localization in so called zero modes is equivalent with the quantum measurement. The cascade of self measurements whose non-deterministic dynamics is governed by Negentropy Maximization Principle [H2] gives rise to the state preparation process leading to a completely unentangled state serving as the initial state of the next quantum jump. Self defines a statistical ensemble as the set of unentangled prepared states resulting in quantum jumps. The statistical description of this ensemble is assumed to provide the description of qualia. It seems that statistical description applies also to the geometric qualia determined by the increments of zero modes. The quantum correlates of the qualia are assumed to correspond very closely to the primary causes of the qualia (for instance, the sensation of force corresponds to the gradient of momentum of some sub-self with respect to subjective time).

Conscious experience is assumed to depend on the increments of zero modes and quantum numbers are assumed to be experienced consciously but to not contain information about the transition to which these increments are associated. One could argue that this is too strong an idealization since quantum jump has complex anatomy and there is also an infinite variety of quantum jump anatomies with no change in quantum numbers.

Qualia can be divided into three basic types: the kinesthetic qualia (determined by increments of Poincare, color and other basic quantum numbers) in quantum jumps; the qualia corresponding to the increments of various kinds of particle numbers (say chemical qualia) and topological quantum numbers; and the entropic qualia relating to information flows associated with the sequence of quantum jumps. The connection with the statistical physics suggests that the average over the increments of the quantum numbers for the sequence of quantum jumps defining the self is experienced consciously. Sequences of sub-selves (mental images) however are experienced separately and this makes possible a temporally structured experience, so that the words of a sentence are experienced separately rather than as an average.

2.1 What qualia are?

Before going to a detailed model it is useful to pose the question what qualia are. The final answer (as it seems at this moment) to this question provided by the statistical physics analogy

has emerged only gradually and in the following this development of ideas is summarized.

2.1.1 Qualia as quantum phase transitions and as discharges of quantum capacitor

In TGD framework the meaning of the primary quale is associated with the mental images created by the self-organization process. If the quale corresponds to an average increment of quantum numbers or zero modes in a long quantum jump sequence, the quantum jump with same increment must occur repeatedly. One can imagine at least two mechanism inducing qualia.

1. Quantum phase transition produce qualia

Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. Transition frequencies themselves as such serve as symbols initiating this process, much like sub-program call initiates subprogram. They act like the name of dog: when dog hears its own name, dramatic self-organization process is initiated.

Music metaphor suggests that only the ratios of transition frequency to, say, cyclotron frequency can code for qualia. Only the ratios of Larmor and cyclotron frequencies and Super Virasoro frequencies and the intensities of the Fourier components for various harmonics can affect self-organization process. Furthermore, quale together with its emotional aspects depend on a simultaneous occurrence of several quantum phase transitions induced by the EEG pattern containing several magnetic transition frequencies. For instance, sensation of pain probably involves both the fundamental Super Virasoro transition frequency inducing primary quale and harmonics of this frequency at least partially responsible for the emotional aspects of pain.

2. Discharge of quantum capacitor produces qualia

The flow of particles with fixed quantum numbers between "electrodes" of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The "electrodes" carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and postsynaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The model of sensory receptor as a quantum capacitor will be discussed later. The model applies to various chemical qualia and also to color vision and predicts that also cells should have senses. Ordinary cells would sense only the nearby chemical environment whereas neurons would experience via synapses also representations of external world chemically: at our level of conscious experience these representations could give rise to emotions. The strange behavior of ionic currents leads to the view that even ionic channels and pumps are actually ionic and voltage receptors.

2.1.2 Non-geometric and geometric qualia

Various types of quantum phase transitions are natural candidates for qualia. In accordance with *'Where-What'* decomposition of brain information processing, one can decompose qualia into geometric ('Where' and 'When': position, orientation,...) and non-geometric ('What': colors, tastes,..) qualia.

Geometric qualia correspond to the zero modes of configuration space in which a localization takes place in each quantum jump. An objection against the notion of geometric qualia is that the choice of the quantization axes changes in each quantum jump and it is not therefore sensible to speak about the change of quantum numbers. For a given change of quantization axes one can however assign to the final state of the quantum jump unique color and spin quantum numbers so

that the increment is also unique although the 'coordinate frame' can change. Perhaps one should interpret the change of the quantization axes as a discrete quantum version of parallel translation. For the asymptotic states of self-organization the values of the zero modes are expected to approach to the values associated with a maximum of Kähler function so that the choice of the quantization axes becomes stationary.

Non-geometric qualia correspond to non-zero modes and hence to quantum jumps between states of super-canonical and Super Kac-Moody representations. This suggests that non-geometric sensory qualia can be classified at brain level into super-canonical qualia and Super-Kac Moody qualia.

1. Super-canonical qualia are higher level qualia in the sense that quantum jump occurs at the level of the entire configuration space rather than at the level of space-time only. The quantum number increments (spin and color quantum numbers) associated with BE-condensing super-canonical boson characterize the quale. BE-condensation occurs for 'configuration space photons' rather than ordinary photons whose configuration space dependence is characterize by color $SU(3)$ and spin quantum numbers.

2. Magnetic qualia could be much more primitive (perhaps kinesthetic qualia). Endogenous NMR or its generalizations could give rise to entire spectrum of magnetic qualia. Geometric data from external can be coded to zero modes of MEs, in particular the position and other geometric characteristics of sub-self (ME) representing an object of the perceptive field. Most naturally the portion of a magnetic flux tube at which ME is glued to the magnetic flux tube codes the information classically to the properties of ME, especially the light-like vacuum current and classical gauge fields associated with it. Note that this picture leaves open the identification of emotional qualia which seem to something different from sensory qualia.

The entire isometry algebra consists the function algebra of $E^2 \times CP_2$ associated with ME localized with respect to the light-like coordinate of the light-like M^4_+ projection X^3 of the light-like boundary of ME and having well defined conformal weights. This algebra is essentially the function algebra of boundary' $X^3 \times CP_2$. Each element of this algebra defines Hamiltonian depending parametrically on the radial coordinate. This algebra must extended by the CP_2-localized radial Virasoro algebra of the light-cone boundary to achieve Lorentz invariance. Hamiltonians have conformal weight which is integer valued. Odd integer valued Hamiltonians correspond to non-zero modes whereas even-integer valued Hamiltonians correspond to zero modes. In particular, the Hamiltonians which do not depend on the radial coordinate of the light-cone boundary and have thus vanishing conformal weight correspond to zero modes [B2, B3]. These canonical transformations specify a very general set of choices of quantization axes.

The most general choices of the quantization axes for the canonical $E^2 \times CP_2$ sub-algebra of zero modes are parameterized by the infinite-dimensional flag-manifold defined as the coset space of the canonical group of zero modes and Cartan group of $O(2) \times SU(3)$. Thus the localization in zero modes means also a choice of the quantization axes. Since zero modes characterize macroscopic geometry of the space-time surface, this localization makes the world of the conscious experience classical.

The monomials in the enveloping algebras of the super-canonical and Super Kac-Moody algebras defined by the configuration space isometries is the most general candidate for the algebra defining the possible increments of quantum numbers. Primary discrete qualia would correspond to non-diagonal generators of this algebra. Super algebras have decomposition into bosonic and fermionic parts and the first thing coming into mind is that bosonic generators correspond to generalized sensory qualia and fermionic generators to Boolean qualia. This algebra decomposes into zero mode and non-zero mode parts and one should decide which parts give rise to which qualia.

1. The algebra of non-zero modes is obtained by localizing zero mode super-canonical algebra with respect to the light-like coordinate coordinate of the light-like boundary of ME so that the generators are labelled by super-canonical conformal weight n which does not contribute to mass squared. This supports super-symmetric option: ordinary Lie-algebra generators which act like creation and annihilation operators correspond to complementary pairs of sensory qualia. The pairs of the fermionic generators correspond naturally to Boolean qualia with opposite truth values. The meaning and content of the Boolean statement should be determined by the non-geometric sensory quale associated with the corresponding bosonic generator.

2. Fermionic counterparts of the canonical zero norm generators in zero mode degrees of freedom have zero norm since gamma matrices have vanishing anti-commutators in these degrees of freedom. One might think that also the bosonic generators generate zero norm states. This is however not the case: infinitesimal isometries of the imbedding space do not correspond to pure gauge degrees of freedom. This is in fact the property that distinguishes zero mode symmetries from pure gauge transformations.

3. The interaction of super-canonical algebra states with the classical gauge fields associated with ME induces quantum jumps. In the lowest order of perturbation theory the interaction must be linear in the generators of SCA. As higher order terms of perturbation theory become significant, also transitions generated by the higher powers of Lie-algebra generators occur with a considerable rate and enhance the experienced intensity of the quale and give rise to transitions not possible in the lowest order.

2.1.3 Comparison with ideas of Noe and Regan

Quite generally, discrete non-geometric sensory qualia (such as colors) must correspond to the changes of the quantum numbers in quantum jumps serving as seeds of quantum phase transitions of the quantum critical macroscopic quantum phases combining to form quantum spin glass phase. This allows to interpret the sequence of quantum jumps giving rise to a quale as a process analogous to what we do when we explore room in total darkness or what physicist does when she studies an unknown system by perturbing it slightly again and again and finding the reaction. The 'world of classical worlds' character of super-canonical states corresponds to this idea at the level of physical states.

Lie-algebras mathematize the notion of infinitesimal change (small perturbation) induced by symmetry transformation and thus they are expected to characterize fundamental qualia. The reduction of non-geometric qualia to the representations of Super Kac-Moody and super-canonical algebras [1], the latter being related to the isometries of the configuration space of 3-surfaces and acting at the light-like boundaries of MEs, seems indeed possible. What is nice that super generators of the algebra could correspond to Boolean 'this is true' qualia in one-one correspondence with sensory qualia.

Poincare algebra is closely related to the Super Kac-Moody algebra. A natural expectation is that the increment of momentum should basically characterize the qualia induced by forces and torques (pressure sense, and sensations caused by ordinary and angular acceleration).

This interpretation is extremely general and implies that quantum TGD and also super Lie-algebra theory at basic level is theory of the fundamental discrete qualia. The unexpected feature is the assignment of qualia to non-diagonal generators rather than diagonal ones as quantum measurement theory would suggest. The notion of quantum jump between quantum histories

[1] Super-conformal and related super algebras are generalized Lie-algebras introduced in seventies and are encountered in both super string models and TGD.

however provides full support for this interpretation. The realization of the importance of the non-diagonal creation and annihilation operator like generators of Lie-algebra took surprisingly long time although the moment of consciousness is basically nothing but creation of something new and annnihilation of something pre-existing. The possibility to understand the special features of color vision, such as the phenomenon of complementary colors and color contrast supports the general idea.

This view is in some aspects consistent with the view represented in the article of Regan and Noe [52]. The authors do not believe in qualia as properties of the external world and speak about sensory modalities only. To avoid confusions, it is important to make clear that in TGD qualia and sensory modalities are used interchangeably: qualia are not properties of single quantum history but are identified as mental images generated by self-organization processes involving huge number of quantum jumps between quantum histories.

The approach adopted in [52] relies on experimental data about vision and states that sensory modalities can be characterized, not as properties of the world, but as modes of exploration of the world that is mediated by knowledge of what the authors call sensorimotor contingencies. More concretely, sensory experience can be identified as exploratory activity, much like feeling by fingers what the object of the tactile field is like. The structure of this exploratory activity determines the quale. What happens is that object of external world, or rather, the system consisting of observer and object of the external world, is perturbed slightly in very manner manners and this gives rise to the sensation about shape of object. The study of the responses generated by small perturbations is very much what physicist does when studying unknown physical system. The fact, that is possible to 'see' external world by signals by hearing or as vibratory stimulation of skin, supports this view.

For tactile senses and for macro-geometric aspects of all modalities this picture seems to make sense. It is however not at all obvious whether one can realize this vision at macroscopic level in the case of, say, color vision. In TGD framework entire physics reduces to configuration space geometry and classically the system representing perceiver and external world corresponds to 3-surface X^3 which can be regarded as a point like object moving in infinite-dimensional configuration space of 3-surfaces. The metaphor for active tactile sensing process could make sense at more abstract level as deduction of the position of system + perceiver 3-surface X^3 in configuration space. This process is deducing the shape of a stone by giving it small kicks. X^3 corresponds in good approximation minimum for the negative of Kähler function and sensory experience is determined by the depth and shape of the bottom of the valley of the spin glass energy landscape. In this self-organization process consisting typically of $N \sim 10^{39}$ kicks per second, the experiences created by kicks would be summed up to average experience giving a conscious view what the surroundings of object look like. This metaphor applies to the sensing of the internal state of observer itself and could involve active perturbation of parts of CNS and receiving of the response.

It is interesting to see how this picture relates to the capacitor model of sensory receptor and to the model of nerve pulse [M2].

1. The capacitor model for sensory receptor assumes that a generalized discharge results as the charge of the other "capacitor plate" changes and crosses the threshold for the occurrence of discharge.

2. In the case of cell membrane a reduction of the magnitude of membrane voltage below criticality would be in question. W ME induces charge entanglement between magnetic body and neuron interior (second plate of the capacitor) and a quantum superposition of states "no nerve pulses" and "nerve pulses" at $k_{em} = 3$ level of dark matter hierarchy.

3. Magnetic body shares the mental images created in brain via entanglement of subselves. From the point of view of magnetic body $k_{em} = 4$ level the $k_{em} = 3$ sub-self represented

by the entangled state experience is superposition of "no nerve pulses" and "nerve pulses" states so that conscious experience could in principle involve also the comparison aspect. This comparison aspect could explain why rational entanglement can carry positive information (recall that the p-adic variants of Shannon entropy can be negative). It must be emphasized that the comparison aspect would be due to the sharing of mental images.

4. Multiverse state would be the quantum counterpart of the small perturbation created by the magnetic body curious to get information about the state of biological body by perturbing and comparing. The remote modification of the charge density inside neuron at the "nerve pulse" branch of multiverse could be seen as a (remote) motor action in an abstract sense. Whether qualia quite generally involve generalized motor action creating multiverse making possible comparison remains an open question.

2.1.4 What about emotions?

What seems essential is that qualia involve meaning. In some cases this meaning is emotionally stronger (pain, pleasure), in some cases it is emotionally weaker (colors): in fact, it would seem that one could permute colors without changing much of the overall emotional meaning (actually colors can be distinguished by the behavior they induce [49]). It seems that emotions give this meaning.

The previous ideas do not however give a slightest hint about how emotional content of the quale emerges. As a matter fact, the first guess was that emotions are generalized sensory qualia about the state of body and averaging over sub-selves of sub-selves could explain their single pixel nature and low information content but not the emotional quale itself. This might be part of the story since the neuronal sensory experiences created by nerve pulses at synapses at level of neuronal bodies ($k_{em} = 3$) could determine the emotions. Also cellular qualia about nearby chemical environment (presumably $k_{em} = 2$ level) could contribute to emotions. The realization of the connection with statistical physics led to more concrete ideas about how emotional content of conscious experience might emerge.

Second guess is that emotions and also cognitions correspond to sensory qualia of magnetic body and perhaps correspond to higher level of dark matter hierarchy than ordinary sensory qualia. This leads to a rather concrete view about emotions and cognitions as patterns of cyclotron phase transitions induced at the magnetic body by EEG radiation consisting of dark photons. Entire fractal hierarchy of EEGs, ZEGs, WEGs, and GEGs corresponding to photons, Z^0 bosons, W bosons, and gluons and labelled by p-adic length scales and values of the Planck constant is predicted. Charged bosons could correspond in this framework to sensory qualia in the standard sense of the word whereas neutral bosons could correspond to cognitive and emotional qualia.

2.1.5 General classification of qualia inspired by the connection with quantum measurement theory and statistical physics

The connection between qualia and quantum measurement theory and statistical physics was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics and quantum measurement theory involves in essential manner consciousness. First of all, millenium had to change before I realized that quantum TGD predicts standard quantum measurement theory. Each quantum jump can be regarded as an ordinary quantum measurement involving a localization in zero modes representing geometric information following by a state preparation procedure realized as a sequence of self measurements whose dynamics is dictated by Negentropy Maximization Principle (NMP). This suggests strongly the division of qualia to

geometric qualia associated with quantum measurement part of quantum jump and non-geometric qualia associated with the state preparation stage.

In TGD framework the contents of consciousness is determined as some kind of average over the sequence of a very large number of quantum jumps defining self. This suggests that qualia allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last 'wake-up' of self. This ensemble is dynamical since each quantum jump generates a new member in the ensemble. In standard statistical physics the notion of ensemble is only a fictive concept but in the ensemble defined by self would be the fundamental statistical ensemble realized at the level of subjective existence. Therefore consciousness theory would provide foundations of both quantum measurement theory and of statistical physics. Before continuing, notice that this picture allows to see the ageing of self with respect to subjective time as a universal phenomenon resulting from an approach to thermal equilibrium. Getting tired would be only one aspect of the same phenomenon. Also mental images should age and this would correspond to gradual loss of the sharpness of the mental image.

Quite generally, one can divide qualia to the geometric qualia characterized by the increments of the zero modes, to the generalized kinesthetic qualia characterized by the increments of Poincare, color and electro-weak quantum numbers, to the generalized chemical qualia labelled by the increments of various particle numbers, such as the numbers of ions or Cooper pairs in various magnetic states and the topological quantum numbers characterizing the topology of the many-sheeted space-time surface, and to the information theoretic qualia characterized by entropy gradients. Besides the gradients of the state variables with respect to subjective time for the statistical ensemble determined by the quantum jumps, also the values of the state variables themselves contribute to the contents of conscious experience. It would thus seem that the theory of qualia reduces to statistical physics and one can expect rather concrete correspondences between sensory inputs and their quantum correlates. In particular various physical metaphors for conscious experience might find a justification in this approach.

2.2 Classification of qualia in thermodynamical framework

Consider now the general classification of qualia in this conceptual framework.

2.2.1 Do qualia depend on the averages of quantum number increments only?

Functionalism, which has been one of the dominating views in neuroscience, states roughly that the contents of consciousness of system is determined solely by its functional structure. The analog of this hypothesis in TGD framework states that the contents of consciousness are determined completely by the increments of zero modes, quantum numbers and particle numbers in various quantum jumps in context independent manner. This hypothesis has very strong implications and internal consistency requirements make possible to test it. For instance, kinesthetic qualia characterized by the increments of Poincare, color and electro-weak quantum numbers would be universal and would not depend on the system to which they are associated.

1. All quantum phase transitions involve frequency increments. Therefore, if hearing is frequency quale and if energy and frequency increments are equivalent, some kind of auditory sensation should be involved with all sensory experiences. The fact that EEG frequencies cover only a small part of the range of audible frequencies, the weakness for the intensity of this sensation could explain why visual and other experiences do not involve sensation of hearing something. One could also argue that the background noise always present in auditory experience actually corresponds to the contribution from other senses.

   Also deaf persons should experience some kind of auditory sensation, kind of background noise, if this view is correct. Interesting question is whether this sensation is present if

person is made cortically deaf in an artificial manner. One must of course be very cautious here: it might be that this sensation relates only to the dynamical nature of hearing: several qualia, such as pain, have similar time-like nature.

2. The increments of various quantum numbers in magnetic and Z^0 magnetic quantum phase transitions would yield similar sensory experiences, generally kinesthetic experiences.

The connection of the theory of qualia with the statistical physics suggests that self experiences some kind of average over the experiences associated with the quantum jumps of subself but self itself at highest dark matter level corresponds to single moment of consciousness. Thus averages of the increments of zero modes and various quantum numbers would dictate the contents of mental images. This would in general mean that the approach to a thermal equilibrium would make conscious experience increasingly diffuse when sub-self (mental image) ages unless sub-self is able to fight against second law. Macro-temporal quantum coherence allows to circumvent the pessimistic conclusion that every mental images in the human time scale of order .1 second consists of about 10^{38} quantum jumps and should be completely fuzzy as a statistical average. Note also that dark matter hierarchy implies hierarchy of average geometric durations of moments of consciousness.

If averages over the increments of zero modes are experienced this implies that kind of a zigzag curve defined by the averages of the increments of the zero modes formed by sub-selves is experienced consciously but not the initial point of this curve. Kind of a principle of relativity at the level of conscious experience would be in question. In fact, it is very difficult to imagine, how zero modes as such could be experienced. For instance, the huge symmetries involved would make it impossible to experience differently symmetry related points. Note that also in physics one can measure only changes of the observables, rather than observables themselves. The fact that conscious observation of visual textures (say lines) is not possible without saccadic motion is consistent with the assumption that only the increments of the zero modes are experienced consciously. The assumption that intersections of the line sight with lines of figure are time coded is consistent with the assumption that short time averages of zero mode increments are coded to sub-selves.

The fact that position and momentum are quantum incompatible qualia seems to be incompatible with the belief that we experience these geometric qualia simultaneously. One could think that it could be possible to circumvent Uncertainty Principle at the level of conscious experience by using the fact that the velocities that we observe are not velocities with respect to geometric time but with respect to subjective time. This is not the case if we experience only the increments of the zero modes which are analogous to momentum variables. The presence of sub-selves each representing some average value of a zero mode increment make it possible to have an idea about continuous path in zero modes which, in accordance with Uncertainty Principle, is however determined apart from a shift in the space of zero modes.

2.2.2 Various types of non-geometric qualia

As found, one can classify qualia into geometric and non-geometric qualia. Geometric qualia correspond to the increments of zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information increments of zero modes in the quantum jump. Non-geometric qualia correspond to the preparation of state stage of the quantum jump during which zero modes remain constant.

The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics, which like quantum measurement theory is a black sheet

of fundamental physics, forms basically a part of the theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in the case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone boundary of ME, which for super-canonical representations need not annihilate the physical states. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

1. Emotions as order-disorder qualia

$T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing. Also zero modes define a statistical ensemble and these geometric emotional qualia might be about external world: perhaps aesthetic experiences and other 'non-self-centered' emotions could be in question. The total entropy for the statistical ensemble defined by self determines how sharp the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state. Fighting against the second law is an essential part in the martial art of having sharp conscious experiences.

2. Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. The increments of maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define this kind of qualia. The increments of four-momentum code for the sensation of force whereas the increments of orbital angular momentum code for the sensation of torque.

Tactile senses such as pressure sense and their generalizations involve kinesthetic qualia. The increment of energy or equivalently, increment of frequency, can be identified as a correlate for hearing in generalized sense responsible for the essentially dynamical nature of the auditory experience (hearing is time-like version of force sense). Whether spin flip codes something different from torque, and what this something different might be, is not obvious. In TGD based model of auditory experience hearing relates to Z^0 magnetic spin flip phase transitions for cognitive neutrino pairs [M3, M5, M6] but angular momentum increment is also involved in this case.

The rate for the increase of the two diagonal color quantum numbers should code intensity type variables associated with color sensation. At least the intensity of color is this kind of variable. The rate for the increase of electric charge of sub-self should code for electric sense possessed by, say, fishes. Also $B - M$, $\phi\rho$ and $E - P$ pairs correspond to generalized forces since electromagnetic fields are reduced to space-time geometry in TGD framework.

3. Generalized chemical qualia

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories with N being generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. That is the particle number of sub-self increases or decreases. Quite generally, super-canonical and Super Kac-Moody algebras

should define these qualia and the number of these qualia is very large.

1. One can assign particle numbers to super-conducting phases with various magnetic quantum numbers and these could define generalized chemical qualia. They could perhaps be regarded as qualia and subqualia of chemical qualia defined by a particular ion and chemical qualia could actually reduce to magnetic qualia. Since the changes of the magnetic field induce these quantum phase transition, it would seem that magnetic and Z^0 magnetic quantum phase transitions at super-conducting magnetic flux tubes could induce this kind of qualia besides kinesthetic qualia. In principle, endogenous NMR and its generalizations induced by the interaction of magnetic and Z^0 magnetic fields of MEs with magnetic and Z^0 magnetic flux tube structures are possible.

   Our chemical qualia could correspond to the Bose-Einstein condensation of ions to the super-conducting magnetic flux tubes. The paradigm of four-dimensional brain allows even the possibility that these ions are ions of the tastant or odorant. Also secondary representations at the level of cortex in terms of super-conducting light ions are possible and would give rise to a classification of primary tastes and odors. Magnetic qualia are characterized by definite transition frequencies and this makes possible place (time) coding by magnetic transition frequencies if magnetic or Z^0 magnetic field varies along magnetic flux tube (is a function of time). The activation of a point of the living sensory map would generate some quale at that point.

2. For super canonical qualia the number of Bose-Einstein condensed possibly colored 'configuration space photons' having nontrivial dependence on configuration space degrees of freedom replaces number of molecules. The condensation rates for the numbers of the configuration space photons with non-vanishing color quantum numbers could be interpreted as correlates of color qualia, whereas the condensation rates for color singlet configuration space photons could relate to the intensity of color sensation. If the rates for the transfer of color quantum numbers define intensity type variables associated with the color sensation, then BE condensation to color singlet states does not give rise to experienced quale so that only non-diagonal color generators correspond to visual colors. Also the BE condensation of the ordinary coherent light should give rise to some kind of quale: perhaps vibratory sense which can be developed to effective vision, could correspond to non-colored vision. Configuration space Hamiltonians are also labelled by 2-dimensional orbital spin quantum number and longitudinal momentum. Polarization sense and sensation about motion of the object of visual field would naturally relate to spin and longitudinal momentum.

3. Tactile senses involve topological phase transitions involving the creation of join along boundaries contacts between object and skin whose number would thus be the relevant variable. The purely sensory aspect of physical pain could correspond to a topological phase transition involving the splitting of join-along boundaries bonds between space-time sheets (MEs could even define these bonds) so that N would be now the number of join along boundaries bonds. The simplest picture requires that the MEs associated with sensory organs are connected to the MEs responsible for our experience. Of course, splitting and generation of join along boundaries contacts could occur also at the level of sensory representations.

4. Boolean qualia

Boolean qualia would be naturally associated with fermion number or fermionic spin degrees of freedom. There are super-canonical and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-canonical algebra might give rise to Boolean consciousness with intrinsic meaning ('This is true/false').

Fermion number 1/0 can also represent truth value when wormhole contacts with fermion and antifermion at causal horizons of the wormhole contact (having interpretation as partons) are used. The assumption that only fermions/antifermions are associated with the "upper" space-time sheet would select automatically a maximal set of independent statements. Boolean statements could be seen as particle-antiparticle pairs living simultaneously at two space-time sheets and one might speak about 'Boolean matter'.

The generation of sequences of zero energy cognitive neutrino pairs with neutrino and antineutrino quantum numbers at opposite light-like elementary particle horizons of a wormhole contact could correspond to Boolean cognition in which the presence/absence of fermion representing to 1/0 (the model is discussed in [M6]). One can wonder whether these Boolean statements might be just bit sequences without consciously experienced intrinsic meaning (1/0 instead of true/false). Of course, the meaning of truth value need not correlate with how truth value is represented and be related to the emotional content represented by say neurotransmitters at neuronal level.

One can argue that the experience of true/false involves always comparison. As proposed, during sharing of mental images the entanglement of two states could also involve comparison which would explain the positive information content of the rational (algebraic) entanglement in p-adic sense. If indeed so, one might think that the conscious experience that statement is true involves a comparison of the statement with a collection of the true reference statements, one half of all possible statements for a given Boolean algebra constructed from N elementary statements and having 2^{N-1} mutually consistent true statements. If true statements are represented as their negation in comparison process based on entanglement, 'false' would mean that for one comparison the statement and reference statement area identical and entanglement is not possible and no shared mental image is formed. For 'true' the entanglement is possible for all comparisons.

A general model for abstraction process not only explains the basic numbers of the genetic code but also suggests an entire hierarchy of codes [L1] in accordance with fractality of TGD Universe. The next code in the hierarchy is very attractive candidate for 'memetic code'. The hypothesis predicts correctly the .1 second time scale for the duration of 'our' self (immediate short term memory, duration of psychological moment). Codewords corresponds to sequences of 126 bits with duration of one millisecond: this is indeed the time scale of nerve pulse. Temporal sequences of cognitive neutrino pairs having duration of order millisecond realize memetic code and cognition. The frequency of about 10 Hz is in EEG frequency range and also corresponds to ELF topological field quanta with size of Earth representing our cognitive sub-self. Dark matter hierarchy represents a hierarchy of durations of memetic codon coming as $T = \lambda^k T_0$, $T_0 = .1$ seconds and λ is integer valued. $\lambda \simeq 2^{11}$ seems to define an important hierarchy of this kind [M3].

2.2.3 About quantum correlates of alertness and attention

It is a matter of definition whether one can regard alertness, attention, the level of arousal, and other similar attributes of conscious experience as qualia. What is clear that they are not geometric, sensory or emotional qualia. A possible identification for the quantum correlates of this kind of aspects of conscious experience might be based on the entropy type variables associated with the statistical ensemble defined by self. Thus also entropy rather than only its gradient with subjective time would characterize the conscious experience. Very high/low entropy would obviously mean correlate with diffuse/sharp conscious experience. Obviously macro-temporal quantum coherence would be absolutely essential for having sharp mental images. In this picture alertness would correspond to low entropy state, possibly very few mental images which would have very low entropy. Directing attention to some object of perceptive field could also be regarded as purposeful reduction of the entropy of the sub-self representing the attended mental image. For instance, the diffuse background of my computer screen would correspond to high entropy sub-self and the icon to which I am concentrating my attention corresponds to the low entropy sub-self.

Directing attention to an object of the perceptive field involves amplification type phenomenon

and is seen directly as neural activity. This activity would make possible to fight successfully against second law so that the entropy of the attended sub-self would be reduced rather than increase. 7 ± 2 rule might be interpreted as stating that 7 ± 2 is the maximum number of mental images (sub-selves) which can be kept in a low-entropy state simultaneously. Meditative practices often involve concentration of the attention to some object of perceptive field: the number of mental images would be thus minimized to achieve low entropy state of pure alertness. It is interesting to compare the notions of attention and arousal. Arousal wakes-up several mental images. Highly alert state can be even empty of mental images (sub-selves). High level of arousal necessarily involves entropy growth ofthe mental images by 7 ± 2 rule. One form of attention deficit disorder would involve generation of too many mental images so that mental images necessary become entropic.

Getting tired and fatigue would mean the inability to keep mental images in a low entropy state. The connection with the level of metabolism is thus obvious. One function of sleep might be to 'kill' mental images with long wake-up period so that they can reincarnate in a low entropy state. Without this these mental images would become more and more entropic. Sleep would be a fractal phenomenon having counterpart at all time scales: for instance, the wake-up time for sensory mental images would be of order .1 seconds.

2.3 Critical questions and open problems

The identification of qualia involves several open questions and the best manner to proceed is to make the unclear aspects of the model as explicit as possible.

2.3.1 Does the brain construct meta-stable sensory maps?

Several highly interesting questions relate to sensory maps. For instance, does brain construct quasi-static sensory maps for the visual world updated continually? The view represented in [52] is that this need not be the case, and is motivated by several empirical facts, in particular by the observations that there seems to be no visual memory besides the memory of duration of order .1 seconds. It is further argued in [52] that external world provides the fundamental representation.

Also TGD framework suggests the possibility that the MEs connecting retinas to the object of the perceptive field might be essential for our ability to experience the object of perceptive field as a part of external world. TGD predicts that objects of perceptive field are represented as mind like space-time sheets. Where these mental images are located is a difficult question to answer but the most elegant option is that they reside at the level of sensory organs [M1]. Sensory organs have also magnetic bodies, which can serve as seats for the fundamental sensory representations. Brain would in turn construct symbolic and cognitive representations entangled with these fundamental sensory representations. These representations would entangle with mental images at magnetic bodies associated with various parts of brain so that the resulting structure would have astrophysical size.

If this is the case then the experienced position of the object of perceptive field corresponds to the position of this mind like sheet at the sensory magnetic canvas associated with eyes. Brain would somehow deduce the distances and sizes of the objective of the perceptive field and by back-projection mechanism construct the sensory representation at the level of sensory organs. Remote tactile sensing and the ability to 'see' external world by vibratory sense [52] support the view that it is orientation-position quale which determines whether an object of perceptive field is experienced as belonging to external world or to body. Also the illusions associated with tactile senses, such as the experienced location of sensation to even dead material object of perceptive field, suggest the same. Perhaps one must make here a careful distinction between sensations about external world on one hand, and about body and body-external world boundary on the other hand.

In TGD view our eyes can be visualized as tubes connecting brain to external world and changing their orientation all the time. Through these tubes light enters to a screen representing visual cortex in a room representing head. Also head is moving and changing its orientation with respect to the external world all the time. The mind like space-time sheets representing objects of perceptive field are certainly present, but they are not static but short-lived objects, having lifetimes not longer than .1 seconds and are recreated all the time and in general in new position of the visual cortex. There is no homunculus inside this room; the experience is not computed nor do 40 Hz EEG waves in some mysterious manner give rise to experience. It is self-organization processes generated by nerve pulse patterns coming from sensory organs and generated by brain itself which give rise to qualia and magnetic transition frequencies serve as names for these processes.

2.3.2 Are super-canonical qualia associated with vision only?

Super-canonical qualia are labelled by the increments of color and 2-dimensional spin quantum numbers which for 8-dimensional basic representation correspond naturally to 3+3 basic colors and to polarization sense.

The idea that qualia should correspond very closely to the physical phenomena what qualia suggests that super-canonical qualia are associated with vision. Light-like 3-surfaces associated with MEs provide indeed classical model for a light front and MEs themselves model geometrical optics in a well-defined sense. MEs inside MEs represent naturally light rays. Also the two-dimensionality of light-like coordinate constant section of the light-like boundary conforms with the two-dimensional nature of the visual experience. In the case of other qualia (except perhaps tactile senses) the two-dimensionality of the objects of the perceptive field is not obvious.

One cannot exclude the possibility that color Lie-algebra, as opposed to higher representations of color group, could correspond to colors, tastes and basic tactile qualia (warm, cold, pain,..). In the case of odors, and perhaps also in the case of tactile qualia, CP_2 Hamiltonians in higher-dimensional representations of the color group would be needed to account for the large number of these qualia. One could even ask whether some emotional qualia could involve super-canonical BE condensation type phase transitions or possible phase transition changing the direction of spin polarization of the BE condensate of configuration space photons. Although the connection with thermodynamics excludes this possibility, pros and cons of this kind of identification are still worth of a detailed consideration.

1. MEs seem to correspond to the most abstract level in the control hierarchy formed by MEs, super-conducting magnetic flux tubes and ordinary matter. More precisely, super-canonical states are state functionals in the space of three-surfaces, 'world of classical worlds' and thus correspond to a higher level of abstraction. This would suggest that our qualia should correspond to what happens on the light-like boundaries of MEs. One could however identify super-canonical-magnetic dichotomy with spirit-flesh dichotomy so that visual experience would represent higher level sense in comparison to other senses.

2. Colors, tastes, odors and tactile qualia like cold, warm and pain allow dichotomic pairs supports the identification as discrete qualia. These good-bad dichotomies are analogous to color-complementary, which supports the view that they could correspond super-canonical qualia. On the other hand, all sensory qualia can be accompanied by strong entropy gradients explaining positive/negative emotional aspects for qualia such as odors. For reasons of survival organism might even amplify these entropic gradients.

3. One could argue that also emotions could regarded as generalized sensory qualia and the interpretation of pure emotions coming as dichotomic pairs of complementary emotional colors

does not exclude the identification in terms of SCA. Emotions involve however often also comparison aspect and this could be reduced to the geometric aspect of the generalized sensory experience represented as a flag-manifold quale representing information about the space-time surface describing the state of body and CNS geometrically. Therefore, if emotions are accompanied by super-canonical qualia, they represent pure emotion without any comparison aspect. Does it make sense to speak about, say, pure rage, is difficult philosophical problem.

4. Zero modes involve infinite hierarchy of CP_2 Hamiltonians grouped into representations of color group and odors should correspond to Lie-algebra generators belonging to higher representations of color group instead of octet representation. The simplest vision is that the only difference between colors and, say, odors and tastes is that the Hamiltonians belong to different representations of the color group. The prediction would be that the phenomenon of color contrast and perhaps even color constancy should have counterparts at the level of other qualia. One can argue that this kind of close structural relationship should have been observed if it is really there and tables organizing various sensory qualia neatly to the representations of color group could be found in the text books of neuroscience.

5. One can also wonder why higher representations of color algebra should be experienced so differently from the 8-dimensional representations assumed to be responsible for visual colors. This picture also requires that configuration space photons belonging to only single color representation are produced in sensory pathway. It is difficult to imagine a mechanism producing configuration space photons belonging to only single color representation unless it is octet representation. One could also argue that only configuration space photons in octet representation are produced abundantly and that this is due to the classical color gauge fields accompanying classical electromagnetic fields: if so then higher colors would be rarely realized as conscious qualia.

The assumption that only color octets qualia are possible, allows in principle the identification of colors, tastes and tactile qualia as generalized colors cannot be excluded. Thus a more detailed analysis of this option is motivated.

1. The simplest hypothesis is that 6 basic colors, tastes and basic tactile qualia could all correspond to color flips. This hypothesis is very strong since it suggests that the basic phenomena of color perception such as complementary colors, color contrast, color constancy and possibly even color summation (this phenomenon involves also neural circuitry in essential manner) could have tactile and gustatory counterparts.

2. In the case of tactile senses the very fact that cool resp. warm serves as metaphor for black, blue and green resp. white, yellow and red, encourages the view that tactile qualia correspond to color algebra. In this spirit one could identify the dichotomic pairs cold-warm, pain-pleasant touch and touch-sensation of numbness as counterparts of 3 pairs of color generators of with opposite quantum numbers. Numbness is indeed quale in itself and analogous to sensation of black since it is experienced in absence of sensory input from skin. Proprioception could perhaps be understood as a mixture of sensations of touch and pain-pleasure sensation with geometric qualia. If this view is correct, then superficial touch and pressure sensation are analogous to sensation of color white at different values of brightness.

3. Model predicts six basic tastes. There is evidence for five basic tastes [42] but situation has not been resolved. Dichotomies suggest that the triplet of bitter, sour and salty corresponds to the triplet of cool colors whereas the sweet, the fifth taste and some sixth taste. One possibility is that different variants of sweet are in question: for instance, sugar and salt and sweet-sour could correspond to different variants of sweet. The sixth taste complementary

to bitter could be analogous to color black or sensation of numbness. Very strongly flavored food or bitter food could perhaps induce experience of sixth taste in the same manner as very bright light dazzles.

The basic objection against this kind of assignments is that the tactile and gustatory counterparts of color complementarity and color contrast need not make sense: to my best unprofessional knowledge these phenomena are not observed. One must be however very cautious: these phenomena might be masked by the emotional reactions accompanying these sensations, by the complexity of the phenomena involved and by the non-topographical character of odor and taste perception. For instance, color contrast phenomenon requires precise object-background separation not possible in the case of odors and tastes. Summation of colors red and green to yellow involves also neural circuitry and does not generalized to the case of tactile senses, tastes and odors.

2.3.3 How qualia are compared?

An interesting question is how geometric qualia are compared consciously. Velocities might be regarded as basic types of qualia for which this kind of comparison occurs. It however seems that velocity type qualia reduce to experience of self about genuine motion of sub-selves inside it if geometric coordinates are mapped to spatial arrays of neurons such that given neuron (or large structure) is sensitive to particular EEG frequency and represents point of map which becomes 'alive' when it is activated. Self could also automatically compare the sub-selves representing qualia of same type so that not specific mechanism would be needed. Concerning the comparison of qualia, an interesting idea is that the simultaneous experience of these slightly different qualia gives rise to the simultaneous wake-up of nearby points of the sensory map. This mechanism might be the same as involved with the binaural beat[38]. This beat mechanism makes it possible, not only to discriminate between slightly different frequencies but also to 'hear' very low frequencies not otherwise audible to us. For instance, when one feeds sligthly different audible frequencies to ears, difference frequency is heard consciously. Of course, one can argue that this anomalous hearing has nothing to do with comparison in the fundamental sense.

2.3.4 Association problem

How different type qualia are associated with each other? Is spatial and temporal association in the geometric sense always necessary or could it be enough to associate the qualia in subjective time so that they would be associated with same quantum jump and same sub-self always? It would seem that geometric association with same sub-self is the most natural option. Topographical association by the topology of neural circuits is the simplest manner to achieve this and should be involved with vision. The coding of qualia by EEG frequencies is second option. In the case of magnetic transition frequencies continuous spectrum of positions can be coded. Of p-adic lengths define preferred lengths for MEs then the frequency spectrum would be discrete given by integer multiples of basic length: discretization of positional qualia would result if the fundamental frequencies of MEs code for position.

3 About the identification of the non-geometric qualia

Non-geometric qualia by definition correspond to the quale associated with the state preparation part of quantum jump whereas geometric qualia are understood as characterized by the increments of the zero modes fixed in quantum measurement part of quantum jump. This terminology is somewhat clumsy since one could argue that qualia like pressure and force sense are in a very general sense geometrical.

3.1 Color vision and super-canonical algebra

Super-canonical algebra contains infinite number of Hamiltonians in representations of color group and possessing definite two-dimensional spin. For color octet representations, which is the lowest one, there are 3+3 non-diagonal oscillator operator like color generators with opposite quantum numbers. Perhaps the discovers of color symmetry had some precognition about the possible role of this symmetry when they jokingly choose to call it color symmetry. The 3+3 color generators carrying opposite quantum numbers indeed can be related to the six primary colors forming complementary pairs (with black and white included). This identification, originally stimulated by the observations of mathematician Barbara Shipman [29] about the dance of honeybee, makes sense.

TGD predicts that classical em field are accompanied by classical long range color fields and super canonical representation can give rise to colored states. Of course, quantum jumps of any color system could give rise to color qualia and one cannot even exclude copies of QCD in the length scales of living matter in TGD framework: if this is the case then even the generation of color charged gluons quantum coherently could give rise to color quale. A very strong support for the correctness of the prediction is that it nicely explains the basic characteristics of color vision (color contrast, color opponency, color constancy) besides reducing the existence of six primary colors to the symmetries of the 8-dimensional imbedding space (the structure of which can thus be deduced from the basic properties of color vision!). Perhaps the most realistic interpretation of the higher color representations is as higher level colors. One cannot however exclude the possibility that these representations could act as correlates for other qualia, such as odors and tastes.

3.1.1 Basic facts about color vision

Color space provides a multidimensional representation for different color experiences and satisfying the requirement that colors producing nearly same experience are represented by nearby points of color space. Color circle deviced by Newton is the simplest example of color space and provides very economical manner to represent huge amount of information about experience of color (say the fact that blue is more similar to purple than it is to yellow). One can classify colors into spectral colors present in rainbow and non-spectral colors, including many reds, all magentas and most purples and also brown. The famous 'inverted spectrum argument' of Locke states that other people might have the same overall set of color experiences as you but differently connected to objects in the external world. For instance, you might experience the colors of rainbow as inverted: your 'red' might be my 'blue'. This is clearly about possible symmetries of the color space and the very emergence of symmetries is consistent with the idea that qualia correspond at the fundamental level to Lie-algebra generators.

Colors can be represented as composites of primary colors defined as colors which have no other 'colorishness' in them: for instance, orange has some yellowishness and redness in it. Red, green, blue and yellow are the primary colors and correspond to diametrically opposite points along the two orthogonal axes of color plane. Complete model of color experience must explain the existence of the primary colors and why some colors are experienced as composite of them. It is clear that the existence of fundamental colors breaks complete color symmetry and leaves only discrete set of symmetries consisting of rotations by multiples of $\pi/2$ and reflections with respect to two color axes and two axes forming angle $\pi/4$ with respect to them. Also these symmetries are broken as detailed study of behavior correlates of color experience has demonstrated [49]. Color circle is not a complete model of color experience since it leaves out the vast majority of color experiences, including white and black, all their mixtures with each other (grays) and their mixtures with chromatic colors.

One can however generalize color circle to 3-dimensional color space by introducing white-black axis orthogonal to green-red and yellow-blue axis. The three cylindrical coordinates of color space are called hue, saturation and lightness (or brightness). Hue is the azimuthal angle along color

circle and corresponds to the basic 'color' of surface. Saturation represents the vividness of color experience and corresponds to the perpendicular distance from the central axis for the position of the color experience in color space. For instance, the vivid colors of rainbow lie along the outside edge. All the grays lie along the central axis because they have zero saturation. The 'muted', 'muddy' and 'pastel' in between have intermediate levels of saturation. The third dimension of surface color is lightness and refers to the height of color's position. The color circle corresponds to the perimeter of an oblique section through this color solid. This section is oblique because the most saturated yellows are quite light and therefore higher in color spaces whereas the most saturated blues and purples are quite dark and therefore lower in color space.

The phenomena of color constancy, color summation and color contrast are further phenomena related to color vision. Color constancy means that completely homogenous lighting of the visual field by monochromatic light gives rise to no color experiences. This is as it should be since in natural conditions the lighting conditions change all the time. Color summation says that basic colors red, green and blue in suitable proportions sum up to white color. Color contrast means that the region around objects having primary color inherit slight complementary colorishness. For instance, grey object in a red background looks somewhat greenish. The phenomena of color constancy, color contrast and color summation can be satisfactorily understood in terms of experimentally established neural mechanisms [42]. This does not of course eliminate the need for deeper explanation: the neural mechanisms involved might only reflect the more fundamental facts about color vision.

3.1.2 Can one understand colors Lie-algebraically?

Could one understand these basic facts about color vision in terms of color Lie-algebra? The first question is whether to assign to visual colors the color quantum numbers of states or the color numbers characterizing the changes of states. One could indeed consider the association of three primary chromatic colors and their complementary colors with quark triplet and antiquark triplet, with antitriplet perhaps resulting in tensor product of operation for two triplets. The however implies that color rotation changing the quantization axes should change also the color experience and replace primary colors with new ones: it is however an experimental fact that primary colors are something unique. If they correspond to changes of color quantum numbers induced by specific Lie-algebra generators this is true independently of the particular quantization axes used.

Taking seriously the idea that color Lie-algebra might represent basic facts about color experience, the next question concerns the detailed identification of colors with Lie-algebra generators of color algebra.

1. What seems obvious is that complementary colors must correspond to Lie-algebra generators with opposite sign of quantum numbers. With this assumption 3-dimensional color space could be understood as a space spanned by three diagonal color generators for which there are no linear dependences between color quantum numbers.

2. Primary colors correspond to the six non-diagonal Lie-algebra generators consisting of 3 creation operator like and 3 annihilation operator like generators. There are six primary colors red-green, yellow-blue and white-black.

   This leaves only one possibility: the six non-diagonal generators of color algebra correspond to all the primary colors with white and black included. This conclusion came as a little surprise since the identification of white-black pair as associated with spin flips was competing hypothesis.

3. All color pairs are dichotomic pairs providing metaphorical representation for cool-warm dichotomy such that red, yellow and white correspond to warm colors and green, blue and

black correspond to cool colors. What could distinguish between white-black pair and non-chromatic colors is color hypercharge: white and black would have vanishing hyper charge. Thus the following identification of quantum number increments (hypercharge and isospin represented as column vector) associated with various colors suggests itself:

$$\begin{array}{ll} \begin{pmatrix} 0 \\ 1 \end{pmatrix} \leftrightarrow white & \begin{pmatrix} 0 \\ -1 \end{pmatrix} \leftrightarrow black \\ \begin{pmatrix} 1 \\ 1/2 \end{pmatrix} \leftrightarrow red & \begin{pmatrix} -1 \\ -1/2 \end{pmatrix} \leftrightarrow green \\ \begin{pmatrix} 1 \\ -1/2 \end{pmatrix} \leftrightarrow blue & \begin{pmatrix} -1 \\ +1/2 \end{pmatrix} \leftrightarrow yellow \end{array} \tag{1}$$

It seems that one can indeed reduce color opponency, color contrast and color constancy to deeper level in this framework.

1. Opponent process theory of Ewald Hering [42] explains basic facts about color summation (for example, summation of red and green to yellow which cannot be understood as summation of color quantum numbers). Color opponent processing means that the members of each pair of complementary colors (red, green), (blue, yellow) and (white, black) tend to compete in the sense that receptors give excitatory response for color and inhibitory response for complementary color, or vice versa.

   Therefore no sensory experience results for suitably balanced intensities of light for complementary colors. For instance, in the case of red and green the sensation of yellow which represents a wavelength between these two remains as a result of this competition. Color opponency can be understood as reflecting the competition between quantum jump and its reversal induced by two Lie-algebra generators acting like creation and annihilation operators with same color quantum numbers. Note that the sensation of darkness after closing eyes could correlate with quantum jumps in which the ions or Cooper pairs of macroscopic quantum phase generated by quantum jumps 'white' gradually decays back to ground state by quantum jumps 'black'. This suggest that same phenomenon should be associated also with other colors. This would mean that immediate after images should tend to have complementary color. Dazzling phenomenon could result from the depletion of the macroscopic quantum phase from which quantum jumps 'white' occur.

2. Color contrast is apparently just the opposite of color opponency: region of given color creates the illusion that background has tinge of complementary color. Thus the complementary colors seem to facilitate each other across boundaries whereas inside the boundaries they tend to cancel each. The called double-opponent cells located in the visual cortex can explain at least partially color contrast phenomenon [42].

   A more fundamental explanation is based on the properties of color-charged macroscopic quantum phase and on the properties of the classical color field accompanying ELF em field associated with EEG and inducing the color quantum jumps. Color confinement requires that color charge density of the macroscopic quantum phase formed by exotic super-canonical representations is such that net color vanishes. Thus a region containing exotic particles with given color quantum numbers would be surrounded by a region of opposite color quantum numbers. Only the second sign for the increment of color quantum numbers is possible for a given colored state of lowest-dimensional representations of color group as one finds easily by studying color triplet and octet representations. Color contrast would thus result from the

fact that classical color gauge field does not approach zero sufficiently fast at the boundary of colored region and as a real field necessarily contains with the same intensity the Lie-algebra components stimulating color and its complementary color.

3. Color constancy can be reduced to the phenomenon of color contrast. If the net color charge of a color charged Super Virasoro quantum phase vanishes, there must be also a region of complementary color charge. Since this is not possible for a constant illumination by monochromatic light, no sensory experience results. Color constancy is not absolute law: the exceptional cases could correspond to situations in which the entire perceptive field is not actually perceived and this effectively leads to the situation in which constant illumination covers only part of the visual field. In this case complementary colors should be seen on the boundaries.

   The neurology-inspired manner to understand color constancy is that color vision involves comparison in an essential manner. One might say that conscious experience is generated as an integral of the derivative of the intensity of the sensory input such that the initial values at the boundaries of the perceptive field vanishes (this corresponds to the vanishing of the net color charge). If entire perceptive field is illuminated by monochromatic light of constant intensity, there is no sensory experience. A concrete realization of this would be in terms of a saccadic motion. Saccadic motion would translate spatial gradients of the illumination with a given wavelength to increments of color quantum numbers in quantum jump.

3.2 Chemical qualia

Chemical qualia (tastes and odors) are in a well defined sense more primitive than visual qualia. Unless one takes statistical physics connection as an axiom, there are several options concerning the identification of the quantum correlates of chemical qualia.

1. Thermodynamical analogy suggests that basic chemical qualia can be assigned with the Bose-Einstein condensation of super-conducting ions (possibly tastant or odorant), or, less plausibly, to various magnetic transitions of super-conducting ions amplified to macroscopic quantum phase transitions.

2. An alternative identification is in terms of super-canonical qualia labelled by color and spin quantum numbers. The general objections against assigning other than visual colors and polarization sense to super-canonical representations have been already discussed.

3. The third option is motivated by the observation that entire hierarchy of experiencers is involved. Thus chemical stimuli, such as odors, could be literally seen at some levels of the self hierarchy. There is indeed empirical evidence for infrared vision based on odor molecules which is however not conscious-to-us.

3.2.1 Quantum correlates of 'our' chemical qualia

The naivest identification of chemical qualia is as correlates of BE condensation of tastants and odorants to the super-conducting space-time magnetic flux tubes. This would predict that the primary chemical sensory experience occurs at the level of sensory organ. The paradigm of four-dimensional brain allows to explain also chemical sensory hallucinations as olfactory memories. The fact that olfactory organs can be regarded as part of brain also supports the view that our primary odor sensation can be localized to primary sensory organ. Quite generally, if super-conducting magnetic flux tube circuits run along sensory pathways to cortex, the events at the level of primary sensory organ can correspond to 'our' qualia. This is however not the only option as the following considerations demonstrate.

The energy involved with the BE condensation of single molecule should be extremely small if EEG frequencies are assumed to be able to induce or amplify this process, of order $E - 14$ eV for 10 Hz frequency. If BE condensation occurs by the transfer along join along boundaries bonds carrying electric field, this is indeed the case since the BE-condensation energy of BE condensation per molecule is just the change of potential energy when molecule traverses through the join along boundaries bond. It must be emphasized that this kind of mechanism allows also the generation of the BE condensate of ions giving rise to emotion at cortical level. In this case the BE condensation by this mechanism would occur for ions representing large classes of odorants and it would make sense to speak about finite number of chemical qualia. It would not be too surprising if cortex would have developed this kind of classification chemical senses.

3.2.2 Some facts about odors

There are hundreds of receptors for different odorants and this forces to question the idea about primitivity of olfaction. Olfaction is often regarded as the most primitive modality being the only sense involving projections from sensory organs to paleobrain: all other sensory organs project directly via thalamus to cortex. There are two olfactory pathways. The first leads directly to amygdala whereas second leads via the thalamus to cortex as also other sensory pathways. Also entorhinal cortex receives direct projections from olfactory bulb.

Olfactory memories are most emotional and most stable, which is perhaps related with the fact that amygdala which is often regarded as emotional brain, receives direct projections from olfactory bulb but not from other primary sensory organs. The fact that strong odorants are bio-chemically active and induce strong entropy gradients would explain why odors are so emotional. Evolution might have even developed mechanisms amplifying the entropic gradients and thus also emotional responses to odors. The large number of odors is consistent with the idea that each molecule generates its own odor quale in BE condensation on super-conducting magnetic flux tubes. The finite number of odor receptors would not imply that the number of basic odors is finite, but only that there is classification of odors at the cognitive level determining the accuracy of the odor discrimination.

3.2.3 Evidence for infrared vision based on odor molecules?

Callahan has studied the sense of smell of insects [69]. Many insects, such as moths and ants, are known to be attracted by light, say candles and electric lamps and Callahan took as his challenge to understand what is involved. Callahan discovered that insect's olfaction is not based on chemistry but to a maser like emission of infrared light generated by various molecules such as pheromones, scent molecules and many other bio-molecules. Insects would see rather than sense chemically the sources of the infrared light. The sensillae of the insects serve as receiving antennas and amplify the incoming maser like infrared emissions. Callahan also observed that the oscillation of insect antennae induce maser like emission from scent/etc. molecules by creating an oscillating emf. Thus sensory experiencing seems to involve active participation from the part of insect. The work of Callahan demonstrates that ELF modulation of IR light is an essential element of the perception mechanism [69].

In the case of insects infrared light emissions from pheromones mediate sexual messages. Pheromones are known to mediate sexual and social signals also in the case of many mammals. For instance, certain chemical messages from female mouse can make male mouse to mate immediately while certain chemical messages from other males make him agressive. Many mammals, for instance rodents, are known to possess vomeronasal organs, small cigar like sacks containing neurons and having length of order few millimeters [65], giving rise to an accessory olfactory system, which is known to have much more primitive structure and to work in different way than the ordinary olfactory system. It is also known that this systems bypasses cerebral cortex in rodents. There is

evidence that even humans have the ability to sniff certain chemicals mediating social and sexual signals without being aware of it and there is already now flourishing perfume industry based on this evidence. The chemicals responsible for sexual attraction are probably pheromones. The fact that pheromones mediate sexual signals in the case of both insects and mammals, is hardly an accident and suggests that the sensory mechanism must be the same and be based on the infrared emissions by pheromones. If the response is at neuronal level and if the cortex is not involved, one could understand why these messages are not experienced consciously. One could test this hypothesis by finding whether coherent infrared radiation at frequencies emitted by pheromones can affect the behavior of higher mammals including humans.

There is a further peculiar co-incidence: the cascade of the transduction events occurring in the absorption of photon in retina is repeated in a remarkably similar way in olfactory receptor cells, which respond to odors whereas the receptor cells that respond to sound use a very different system [65].

3.2.4 Odor perception as IR vision at the level of odor receptors?

The facts described above suggest that also in the case of mammals the experience of odor involves the, possibly un-conscious, detection of infrared light so that humans would not basically differ from insects and that olfactory system has evolved from the receptor neurons sensing infrared light. The proposed identification means that IR odors are like colors and large number of odors means high acuity with respect to the IR wavelength: this is natural if large number of odorants must be distinguished from each other. Furthermore, odor perception at the level of primary sensory organs could involve exotic super-canonical representations associated p-adic length scales $L(173) = .02$ mm, $L_3(59) = .08$ mm, $L_2(89) = .11$ mm, $L(179) = .16$ mm, $L(181) = .32$ mm and perhaps even shorter length scales corresponding to $k = 167$ and 169.

If incoming IR photons indeed induce super-canonical transitions, integer multiples of the fundamental frequency generate maximum response. Good sensory acuity requires that fundamental frequency of the super-canonical representation is small enough and that the resonant frequencies coded to our conscious experience correspond to relatively high multiples of the fundamental frequency (this conclusion depends crucially on assumption that super-canonical transition frequencies are multiples of the fundamental frequency). This would suggest that olfactory receptors can perceive consciously very low IR frequencies not conscious-to-us. Similar argument in the case of color vision would suggest that photoreceptors perceive consciously IR frequencies not conscious-to-us. The structures responsible for primary color vision could be cilia containing micro-tubuli with length distribution covering besides visible wavelengths also UV and IR wavelengths. Also in the case of odor perception micro-tubuli are good candidate for the primary detectors of odors: the longest axonal micro-tubuli have length of order .1 mm.

3.2.5 Frequency coding of odors

It is known that odor discrimination relies on spatiotemporal patterns of nerve pulse patterns [63]. This spike pattern could be however interpreted as coding information about EEG and/or ZEG frequencies which must be excited in order to generate quantum phase transitions generating the sensation of a particular odor which in general involves several primary components. Also geometric information about, say, the direction of source of odor must be coded into magnetic transition frequencies. A good metaphor is provided by color vision but which much larger number of basic colors and therefore counterparts of cones. The higher harmonics of the transition frequencies might also code emotional reaction to odor discrimination. The importance of ELF modulation in the case of odor perception of insects [69] suggests that this modulation basically codes for the odor experienced by the insect and is thus in the same role as EEG rhythm coding for odor in

human brain. The testing of whether infrared light can affect the behavior of mammals would be also a test of TGD based theory of consciousness.

3.3 Magnetic qualia as generalized chemical qualia

Magnetic quantum phase transitions are characterized not only by the increments of the Poincare quantum numbers perhaps giving rise to kinesthetic qualia but also by increments of the particle numbers in various macroscopic quantum phase labelled by magnetic quantum numbers. This would suggest the interpretation as generalized chemical qualia. The BE condensation of particle numbers to given magnetic phase could give rise to a sub-quale of a chemical quale.

The model for the interaction between sensory organ and its magnetic body [M4] leads to the conclusion that the spatio-temporal patterns of cyclotron phase transitions at the magnetic bodies must be fundamental from the point of view of our consciousness. Varying cyclotron frequencies are ideal for the coding of various perceived geometric variables like frequencies and distances as positions at the magnetic body, and cyclotron frequency patterns generated by biological body would define kind of somatosensory sensations at the level of magnetic body. The representations of the sensory input constructed as temporal sequences of phoneme and note type basic units modulating cyclotron frequencies could be interpreted as cognitive and emotional representations (left brain talks, right brain sings). The chemical qualia of the magnetic body would be cognitive and emotional qualia of ours and correspond to higher level of dark matter hierarchy that our sensory qualia.

Spin flips are problematic since spin does not change in the scaling of $\hbar$. If magnetic field strength remains invariant and the area of flux quantum scales up as λ in the scaling of $\hbar$, magnetic interaction energy $-\mu \cdot B$ remains invariant whereas cyclotron energy scales up. If dark space-time sheets are at same temperature as ordinary ones, spin would be thermalized and only cyclotron transitions would contribute to qualia. Spontaneous magnetization and spin flips of spontaneously magnetized regions of spin glass having very large magnetic moment might change the situation. One must also remember that the assignment of same temperature to all space-time sheets of the dark matter hierarchy is the most pessimistic working hypothesis. Note also that for cognitive neutrino pairs the thermalization does not occur since the pairs have vanishing inertial energy.

For instance, magnetic spin flip phase transitions changing the direction of spontaneous magnetization inside figure could induce conscious figure-background splitting. The repeated occurrence of this phase transition and its reversal induced by an oscillating ELF em field would make figure analogous to a twinkling star. This is like superposing to a harmonic background a tone shifted by constant amount so that dissonance distinguishes the superposed tone from background. The Fourier dual of this representation is by phase shift and there is evidence that hippocampal neurons of rat apply this method to represent the position of rat with respect to surroundings as a temporal phase shift of spike patterns with respect to EEG rhythm with hippocampal theta frequency [62]. Figure-background separation involves decomposition of the perceptive field to objects which means that higher level representation is indeed in question.

3.3.1 Endogenous NMR spectroscopy?

MEs could induce the rotating part of the magnetic field associated with flux tube inducing magnetic transitions. This could make possible an endogenous NMR spectroscopy in which purely magnetic qualia besides force and torque accompanying magnetic transitions would code the points of a living chemical map. Conscious NMR spectroscopy need not however correspond to *our* experiences directly. Rather, it could contribute to proprioception after several averageings implied by the lower position of the cell-sized selves in the self hierarchy. Note however that the BE condensation of coherent photons generated in the magnetic phase transitions on MEs could induce experiences of force and torque at super-canonical level. Vibrational sense might involve Z^0

magnetic quantum phase transitions.

If p-adic length scales define preferred lengths for MEs, then there is a difference between magnetic and super-canonical transitions. The tunability of the magnetic transition frequencies makes possible the mapping of the geometric information to flag-manifold coordinates mapped to the magnetic transition frequencies mapped to an excitation of certain neuron or neuron group of 4-dimensional brain and thus waking-up the point of cognitive map of the external world or of body.

3.3.2 Z^0 and em fields are not independent degrees of freedom

Before continuing it is important to make clear that due the special features of the induced gauge field concept, it is in general not possible to regard Z^0 and ordinary magnetic fields as independent degrees of freedom.

It is possible to have space-time surfaces with 2-D CP_2 projection with vanishing em field and non-vanishing Z^0 field but these surfaces are very probably not extremals of Kähler action. Vanishing Z^0 field and non-vanishing em field is possible only for vacuum extremals when Weinberg angle vanishes.

Ordinary ions couple only to the ordinary magnetic field so that Z^0 magnetic field does not affect directly the dynamics. Exotic ions obtained by generating charged nuclear color bonds have both anomalous nuclear em and Z^0 charge. If nuclear exotic charge compensates the charge resulting from electronic ionization, the system possesses only Z^0 charge and one speak about pure Z^0 cyclotron transitions (for instance, tetraneutron is a doubly ionized Z^0 ion resulting via a double exotic and electronic ionization of ^{4}He atom [F8]). Em neutral bosonic Z^0 ions are of special interest and correspond to bosonic ions for which nuclear ionization compensates the electronic ionization: examples are $Ca^{+2,-2}$ and $Mg^{+2,-2}$. For $Q_Z g_Z B_Z = Q_{em} eB$, where Q_Z/Q_{em} denotes the charge unit used in the quantization condition for the magnetic flux, Z^0 cyclotron frequencies are identical with their em counterparts and the contributions to ZEG and EEG are identical.

Charged particle can feed its em and Z^0 charges to different space-time sheets via wormhole contacts which can be regarded as parton-antiparton pairs with quantum numbers of "upper parton" identical to those feeded to the "lower" space-time sheet. In this case Z^0 and em fields can be regarded as more or less independent degrees of freedom and cyclotron frequencies are superpositions of em and Z^0 parts.

3.3.3 Do magnetic and Z^0 magnetic kinesthetic qualia differ from each other?

The universality of the kinesthetic qualia would mean that there is in principle no difference between magnetic and Z^0 magnetic kinesthetic qualia. Since $k_W = k_e + 2$ at given scale, one might think that Z^0 magnetic representation of the geometric qualia is more symbolic representation. This encourages to consider the possibility that Z^0 magnetic qualia quite generally represent symbolic higher level representations of geometric qualia involving decomposition of perceptive field into objects.

1. Z^0 magnetic qualia could be related with long term memory providing symbolic representations of remembered qualia. 'Hippocampal theta frequencies' vary in the range 4-12 Hz whereas Z^0 magnetic cyclotron frequencies are of order 10 Hz but could vary in a considerable range if Z^0 magnetic homeostasis is possible. This might mean that declarative memories which are one aspect of cognition are realized Z^0 magnetically.

2. For $Q_Z g_Z B_Z = Q_{em} eB$ the Z^0 magnetic cyclotron frequencies are identical with their em counterparts and in alpha band in the case for ordinary EEG for bosonic em neutral Z^0 ions. The multiples of Z^0 magnetic frequencies might provide a realization of the memetic code

as amplitude modulation of high frequency carrier wave by the multiples of Z^0 magnetic cyclotron frequency [M5].

3. Thermal constraint need not apply to the Z^0 $\Delta n = 1$ spin-flips of cognitive neutrino pairs with the value of spin increment representing truth value are indeed an excellent candidate for representing also Boolean consciousness: the sign of spin increment would represent Boolean truth value. Second manner to represent Boolean statements would be as temporal sequences of cognitive neutrino pairs such that the presence/absence of the pair in millisecond time interval would represent 1/0. 1 kHz neuronal synchronization would define the temporal lattice needed.

   Z^0 spin flips are relevant for consciousness only if the notion of nuclear Z^0 magnetization make sense and corresponding transitions would correspond to magnetic spin flips with net change of the magnetic energy above thermal energy. Exotic Z^0 magnetization would due to the spins of exotic quark-antiquark pairs.

3.4 Kinesthetic qualia

The connection with statistical physics allows very nice understanding of kinesthetic qualia and tight connections with basic physics.

3.4.1 Are kinesthetic qualia universal?

TGD version of functionalism would state that kinesthetic qualia are completely universal in the sense that the quale is determined completely by the increments of the Poincare, color, and electroweak quantum numbers in the quantum jumps. Thus both magnetic and Z^0 magnetic quantum phase transitions as well as super-canonical transitions could give rise to similar kinesthetic qualia. Since super-canonical qualia seem to correspond to higher level qualia in a well-defined sense, there are good motivations to consider the possibility that our kinesthetic qualia correspond to magnetic quantum phase transitions.

The quantum numbers which change in the magnetic quantum phase transitions are spin, orbital angular momentum, momentum in the direction of the magnetic flux tube, and the energy of the single particle state. The kinesthetic qualia associated with the magnetic quantum phase transitions could basically correspond to the experiences of torque in the case of angular momentum increment and force in the case of increment of longitudinal momentum. Also the increment of the integer n characterizing the radial dependence of the harmonic oscillator wave function could give rise to some kind of quale. Kinesthetic interpretation would encourage to assign a sensation of radial force to this kind of transition. Since the eigenvalues of the harmonic oscillator Hamiltonian are integers, one could consider also the possibility that elementary arithmetic quale could be in question. Generalized hearing as time-like force sense seems however to provide the most convincing identification.

Momenta correspond to spatial translations whereas energy corresponds to time translations and in spirit of special relativity one expects that sensation of energy flow is the counterpart of sensation of force. Sense of force involves always some spatial direction and sense of torque direction of rotation besides the intensity of the force of torque. Auditory experience involves duration and direction of time in an essential manner and the increment of energy, or equivalently of frequency, relates closely with hearing which is basically frequency sense. Thus the unification of hearing and force senses to generalized four-force sense suggests itself.

An objection against this identification is that energy increments are involved with all quantum transitions so that also vision would involve some kind of auditory aspect. Most audible frequencies are however above EEG range makes hearing especially makes possible to store a lot of information to auditory sensation whereas for other senses the content of dynamical information is so small that

the auditory information of these senses remains un-noticed. Alternatively, the net energy flow in the direction of subjective time in turn could correspond to the intensity of the quale for all qualia. This would be in nice accordance with the universality of the kinesthetic qualia. The intensity of quale could however have other identifications: for instance, very entropic mental images should give rise to dim qualia.

One can wonder what the interpretation of Lorentz boosts, do they correspond to independent qualia or not? Very probably not: what is needed to characterize the basic qualia is quantum number increments for a maximum number of mutually commuting observables. Boosts induce increments of four-momentum and thus force and energy qualia.

3.4.2 Linear and angular acceleration

Magnetic states have well defined momentum and angular momentum component in the direction of the magnetic field and the sensation of acceleration or force in the direction of the magnetic field and angular acceleration around this direction naturally correspond to a quantum phase transition changing the momentum and angular momentum of charged particles of the macroscopic quantum phase. For instance, sensations of falling in gravitational field and sensation of dizziness when the world rotates around could be related correspond to primitive angular acceleration quale.

Note that it is also possible to have state basis for which two momentum components are well defined quantum numbers with suitable choice of gauge. In TGD framework the choice of gauge is not however completely free since classical fields are induced from CP_2 spinor connection. For instance, canonical transformations of CP_2 acting formally as $U(1)$ gauge symmetries of the Kähler potential do not act as ordinary gauge symmetries but isometries of the configuration space and deform space-time surface and affect classical gravitational fields.

Identification as linear and angular acceleration probably makes sense when the experience is about body. If spin flip and increment of momentum are associated with an object of perceptive field they might give rise to figure-background separation in magnetic case. Object of perceptive field effectively 'pops up' from the background or makes small twists with respect to the background. In this case the net changes of these quantum numbers vanish in the long run and kind of 'twinkling' results. A classical example about the the flipping of the figure-background identification between two alternatives is the figure in which Freud's head and naked woman is seen alternately but never simultaneously.

Increment of orbital angular momentum and color flip are in general associated with the same Hamiltonian which can be chosen to be a product of functions in E^2 *resp.* CP_2. Hamiltonians associated with E^2 can be chosen to be eigen states of the angular momentum in the direction determined by the point of flag-manifold. Functions are most naturally localized around point of E^2 and thus only angular momentum component J_z is good quantum number. The transitions are thus characterized by the increment $\Delta M = J_z$ of angular momentum and by the increments of color quantum numbers and for given color representation D infinite series of qualia or variants of same quale labelled by ΔM are possible. The identification of spin increment as related to polarization sense is very natural if color corresponds to the visual color. Polarization would be experienced as some kind of a torque of universality holds true.

3.4.3 Hearing as time-like counterpart of force sense

As already found, a natural identification for the energy increment is as being related to hearing which would be thus time component of sense of four-force. This identification is elegant but one must compare it with alternative possibilities.

1. Does the increment of cyclotron frequency define a generalized auditory quale?

Also Z^0 magnetic quantum phase transitions are possible and the model of hearing and memetic

code based on cognitive neutrino pairs was the first decisive step of progress in the modelling qualia. The upper bound of audible frequencies is predicted correctly in terms of the anomalous Z^0 magnetic moment of neutrino [M6]. Verbal cognition and hearing involve Z^0 magnetic spin flipping transitions of cognitive neutrinos and this might give rise to the fundamental experience. Hearing involves crucially a discrimination of frequencies and the increment of Z^0 magnetic energy in the transition determined by the frequency of the sound is the correlate of the pitch of sound. This would suggest that some kind of primitive auditory sensation could accompany any sensory quale and be determined by the frequency of the transition in question. The fact that audible frequencies are above 20 Hz and below $2E + 4$ Hz is perhaps not an accident: it might be that all qualia induced by EEG frequencies some kind of auditory side quale in this range is associated but is very weak. Note that the gradient of energy with respect to subjective time for a particular neural pathway should determine the intensity of the auditory quale, and in fact, of any quale.

2. Do all values of Δn correspond to variants of the same sensory quale?

Various values of Δn correspond to harmonics of the same basic frequency and there are good physical reasons to expect that several harmonics are present in a given cortical region. If the frequencies associated with the magnetic transitions involving also spin flip result by an amplitude modulation in which EEG waves which are superpositions of cyclotron frequencies modulate waves with frequencies which correspond to various flips, then also the frequencies inducing flips associated with various values of n are present in the combined spectrum. Thus the natural first guess is that without further conditions these harmonics must correspond to variants of the same sensory quale: otherwise synesthetic experiences would be a general rule rather than rare exception. This conclusion is of course in accordance with music metaphor.

This interpretation is consistent with the fact that not only EEG frequencies but temporal EEG patterns are important correlates of conscious experience. Music metaphor suggests that the presence of the higher harmonics make for the quale same as it makes for single monotonous sound, that is makes it a personal voice by giving it color and tone. Music metaphor suggests that it is possible to speak about EEG selves each talking with their own voice recognized even when same carrier frequency is used. It seems that speech uses also modulation of the carrier wave by superposition of waves which come as multiples of 10 Hz which is the basic frequency of speech organs. The superpositions of multiples of cyclotron frequencies would give rise to EEG patterns.

One must also consider the possibility that EEG wave contains only octaves of some minimal frequency which is n_L multiple of cyclotron frequency, perturbation theory allows only transitions for which Δn is multiple of n_L: in the lowest non-vanishing order of perturbation theory $\Delta n = n_L$. In this case one can introduce hierarchy of variants of a given quale or even different qualia according to the value of the integer n_L characterizing the lowest frequency in the Fourier expansion of EEG wave. By the scaling law to be discussed in [M5], this frequency is fixed by the sized of quale self by the formula

$$L = \frac{v}{n_L f_c}$$

relating the size of the quale self to the apparent phase velocity and frequency of EEG wave. These variants would be like various notes produced by music instrument and provide several versions of the same basic quale.

Whether different values of n_L correspond to different qualia or, more probably, variants of the same quale can be decided only empirically. The empirical data support the idea that they correspond to variants of the same quale.

1. In the case of odor perception the ranges of EEG frequencies activated are roughly 20-40 Hz and 40-80 Hz and could be identified as $n_L = 5$ multiples of cyclotron frequencies and their first octaves in Argon period. A possible interpretation is that orientation-position

information about odor by these magnetic frequencies. This would allow the possibility that $n_L = 3$ and its octaves correspond to orientation-position information associated with some other quale. In fact, as will be found in [M5], $n_L = 3$ multiples of cyclotron frequency in Argon band could be identified as frequencies related to hearing. Thus in this case orientation position information associated with different senses would be coded to different values of n of same.

2. The empirical data about auditory alertness [48] suggest that at least the frequencies corresponding to $n = 1, 3, 5$ in Krypton period are excited during auditory alertness. This supports the view that the presence of different values of n in EEG reflects alertness related to geometric qualia.

3.4.4 Increments of spin and momentum and figure-background separation

In M^4_+ degrees of freedom there are two quantum numbers corresponding to the $SO(2) \times R$ Cartan algebra of $SO(3,1)$. These quantum numbers can be chosen to be spin and momentum in direction of the quantization axis. It is probably of significance that just these quantum numbers are also associated with the magnetic states besides magnetic quantum number which is analogous to the conformal weight in the case of Virasoro algebra. This suggests that discrete magnetic qualia and Super Virasoro qualia in Lorentz degrees of freedom might have a close relationship. Universality of the kinesthetic qualia indeed implies this kind of a relationship.

There is no change in orbital degrees of freedom involved with spin flip, which suggests that sensation of torque is not involved. A possible identification is in terms of figure background separation. In the case of magnetic and Z^0 magnetic qualia spin flips associated with the representations of objects of the external world could correspond to figure-background separation since transition frequencies for spin flip transitions are shifted with respect to the frequencies of transitions without spin flip.Indeed, by music metaphor the addition of the spin-flip frequency to the cyclotron frequency implies that figure is separated from background like dissonance from harmony.

There is also a second metaphor for what figure-background separation means. In order to separate figure from background one can to give it a small push upwards or perform a tiny twist for the figure with respect to background. This is what increments of spin and momentum in the direction of quantization axes could represent. This kind of tiny pushes and rotations would give vanishing net effect in the sequence of quantum jumps but take care that the object of the perceptive field gains attention. Perhaps this has something to do with the fact that primitive organisms like insects are unable to see objects which are not moving with respect to the surrounding world. Saccadic motion might be essential in generating artificially the motions separating figure from background: if saccadic motion is made impossible, visual field gradually falls in total darkness [52].

'Push-or-twist' metaphor would allow to assign figure-background separation also to super-canonical spin flips. For super-canonical algebra transition frequencies of the transitions induced by classical gauge fields associated wit MEs are however harmonics of the fundamental frequency and the generation of figure-background separation by the shift of the EEG frequency is not possible. This implies that there is infinite number of qualia or variants of the same quale associated with given increments of color quantum numbers.

In the case of Z^0 magnetic spin-flip transitions neutrino spin flip should give rise to some aspect of the experience of hearing. Neutrino spin flip could induce some kind of figure background separation distinguishing speech from ordinary sounds and spin-flip could universally give rise to this kind of sensation. Note that there should be no sense of spatial torque involved with the spin flip since the orbital part of the wave function of neutrino does not change.

3.5 Tactile qualia

Concerning the identification of the tactile qualia (sense of touch, pressure sense, temperature sense, physical pain and pleasure), the first hint comes from the observation that a topological phase transition involving the formation of join along boundaries contacts with the object is involved. Thus the number of the join along boundaries contacts could play the number of particles in this case.

In the case of purely physical pain/pleasure (different from the emotional aspect of pain and pleasure) the splitting/formation of the join along boundaries contacts associated with the tissue occurs and the number of these contacts could define the relevant particle number. The purely emotional aspect of pain and pleasure in turn would correspond to the presence of entropy gradient with respect to the subjective time implied by this process. The most naive interpretation is that primary sensory experience is located with skin since the replication of this kind of activity at brain level would seem somewhat artificial.

Join along boundaries bonds are natural space-time correlates for quantum entanglement and their splitting means a loss of entanglement. Rational (algebraic) entanglement corresponds to positive information and also information is lost in the splitting process. At higher levels of dark matter hierarchy physical pain is replaced with more abstract psychic pain but the space-time correlate for it would remain same.

This is however not the only possible option. Also tactile qualia could be induced by EEG frequencies as our qualia at the level of cortex. This would mean a rather concrete representation of the topological aspects of tactile qualia. The fact that various objects of perceptive field are represented as recognizable patterns of neural activity supports the view that also tactile experiences are regenerated at the level of the virtual world of cortex. EEG waves should induce the generation and splitting of internal and internal-external join along boundaries bonds inside cortex and this requires that the energy for the generation of join along boundaries bond is extremely small, of order of 10^{-14} eV for 10 Hz frequency for ordinary value of $\hbar$: for $k_{em} = 4$ level of dark matter hierarchy energy is above thermal threshold.

The join along boundaries bonds in question must be electric (magnetic flux conservation does not allow splitting of the bond). By assuming that the electric flux through the bond is given by elementary charge, one obtains that the electric energy associated with the bond is given by the potential energy difference over the bond for electron. Josephson junctions with potential differences of this order of magnitude should be indeed present in bio-matter and the number of the Josephson junctions would become the basic variable. The Josephson junctions acting as join along boundaries could be also MEs, which indeed can have very small thickness and can carry also constant component of electric and magnetic fields in the case that they appear as pairs (the throats of wormhole contacts connecting the members of ME pair would serve as sources of these fields).

The purely physical aspect of the temperature sense (as opposed to the emotional aspect) most naturally corresponds to energy flow in the direction of subjective time. Temperature sense would be energy sense basically. Sensors for cold and hot would detect consciously the flow of energy from body/into body and code this into increment of energy for magnetic or super-canonical states. The average increment of transition frequency using p-adic frequency scale as unit would measure the intensity of sensation.

3.6 Emotions

The thermodynamical approach suggests that emotions correspond to the gradients with respect to subjective time for various entropy like variables associated with sub-systems of self. Thus positive/negative emotions should reflect the increase/decrease of order. This identification is supported by the general characteristics of emotions.

Emotions contain only few bits of information but this information is very important for survival. Emotions are holistic, 'single-pixel' qualia and about the state of the entire body or relatively large part of body. Emotions are very much like conscious representations for time rates for the deviations from homeostasis realized as many-sheeted ionic flow equilibrium and tend to appear in complementary pairs. Emotions correlate very strongly which the chemical state of the body. In particular, peptides are often regarded as both the molecules of emotion as well as of information. Since peptides perform bio-control as information molecules they must induce especially intense entropy gradients with respect to subjective time and thus strong emotions if TGD view is correct.

In the sequel TGD view about emotions are compared with the ideas of Damasio described in his book [34]. To avoid confusions it is good to emphasize that in TGD approach emotions are defined as sensations rather than as motor responses to sensory input about state of body as Damasio defines them [34]. In the following various classifications of emotions and various aspects of the concept of emotion are discussed. After that the general identification of emotions as generalized sensory qualia about state of body and CNS containing both geometric and non-geometric component is described.

3.6.1 About classification of emotions

In order to even try to say something sensible about the identification of correlates of emotions, one must try first to try to develop general view about different kinds of emotions.

1. One classification of emotions [36] is based on the notions of cognitive world model and goal structure. The simplest emotion is excitement which does not involve any recognizable goal or cognitive model. Surprise and relief involve conflict or resolved conflict between prediction of model world and real world experience. 'Amygdalar emotions' fear, anger, craving, protection and disgust are directed and involve goals and external threats to goals. Also cortico-striatal emotions like sadness, hate, embarrassment, contentment and joy involve goal structures and failure or success to achieve the goal in essential manner. A general representation for goal should be in terms of generalized geometric qualia representing the desired state of body or some other system and represented as mind like space-time sheets.

2. Damasio classifies emotions to six universal 'big' emotions: happiness, sadness, fear, anger, surprise and disgust; to background emotions or moods (feeling good/bad, tired, excited, depressed, strong,..) and to social emotions (feeling embarrassed, ashamed, guilty,..). One can also classify emotions to bipolar pairs (fear/anger, craving/disgust, pain/pleasure,...) according to whether they involve approach or withdrawal from some situation (fight or flight) or ambivalent rest and digest emotions (surprise, excitement) or emotions related to seeking of pleasure. Drives induce emotions like hunger or thirst and satiation follows the achievement of the related goal. The dichotomic nature of these emotions conforms nicely with the fact that Super algebra generators appear as complementary pairs.

3. If simple emotions are just generalized sensory qualia, it is natural to interpret emotional expression as a generalized motor action so that motor action, imagination and emotional expression would be very much analogous to each other. It is known that the expression of emotions is indeed very brain area specific and hence very much analogous to motor expression [34]. The ideas about e-motor expression and emotional imagination sounds perhaps strange since emotions are often regarded as something which just come from heaven and do not involve volition. This is not the case always: for instance, actors have specialized in practicing e-motor activities. Damasio tells in his book about pianist who told about emotional currents going through her body and about her ability to control them at her will: it turned out that this ability had direct neurophysiological signatures. One can also distinguish between active and passive emotions. For instance, pleasure and craving, anger

and hate, and fear and anxiety (not a direct reaction) differ in that they are passive/active emotions.

4. Some metaphorical representations of emotions as qualia like tastes and basic tactile senses [(warm,cold,pain) at least] appear very naturally. This could be understood if also emotions are accompanied by super-canonical qualia. As already found, there are however strong objections against this identification.

5. The fact that emotions are holistic 'single-pixel' experiences suggests that emotions represent experiences about average state of body or body part. This averaging is natural if emotions correspond to $k = 67_3, 101_2$ and/or $k = 103_2$ level sensory qualia at length scales $32, 45$ and 180 cm and are determined as reactions to what happens in shorter length scales. Of course, also shorter length scales $L(k)$, $k = 191, 193, 97_2, 197, 199$ could be involved.

6. There are also very refined emotions like those accompanying music experience. It is not at all clear whether these emotions can be regarded as representing 'average pixels' of lower level sensory experience about body and might be primary emotions experience directly and correlating with the patterns of ELF em waves. One can indeed assign to the Fourier decomposition of EEG wave entropy in terms of the probabilities defined by the Fourier coefficients of EEG wave and the gradient of this kind of entropy with respect to subjective could correlate with the emotional aspects of music. White noise and monochromatic sound (and more generally EEG wave) would represent the two extremes. Interestingly, $1/f$ noise for the distribution of frequencies and durations of notes is a characteristic of musical sounds. The assignment of entropy gradients with respect to subjective time (this is important!) as correlates of aesthetic experiences is indeed natural.

7. There are also emotions which indeed seem to 'come from heaven'. It is difficult to believe that religious and spiritual experiences could be mere representations of the state of body and CNS. More feasible assumption is that these emotions are communications from the higher levels of self hierarchy to our level. Communication mechanism would be semitrance mechanism transforming the communications to emotions and e-emotor actions. Probably a loop in which selves below us in self hierarchy are affected and yield e-emotor expression which is perceived by us and in turn stimulates emotion at our level.

3.6.2 How emotions differ from ordinary sensory experiences?

Emotions differ from ordinary senses in that they seem to be relatively simple in some respects. Instead of providing a detailed picture with each pixel having several possible colors they seem to provide a single big pixel. Thus a plausible view about emotions is as 'single pixel qualia' associated with the levels $k = 67_3, 101_2$ and $k = 103_2$ levels of the self hierarchy (at least). There are also alternative explanations for the diffuse character of emotions. These explanations are however consistent with this first principle explanation.

1. The sensory information about internal milieu is about pH, ionic concentrations, hormone levels,.. and thus not topographical bit map type information. If this information dominates emotional input, it is easy to understand why emotions tend to have single pixel character: the color of the pixel simply various very slowly. Also the control of moods by mono-aminergic and catecholaminergic and other neuromodulator systems is based on diffuse projections. On the other hand, the somatosensory information from muscles (in insular cortex and some regions of parietal lobe), known to be important for emotions, has bitmap character. One could also see the correlation of emotions with peptides and other important bio-molecules whose presence induces large entropy gradients as a direct support for the view that emotions are associated with entropy gradients.

2. Our emotions are determined to a high degree by experiences which are averages....over averages over all sub-selves of the lower level self. These averages replace a picture containing very many colored pixels with single pixel picture having the average color. The generalized sensory experiences of the lower level selves are in turn determined by the input from muscles, smooth muscles and inner environment and by hormonal communications.

3. It could be also that at least some emotions (for instance, those involving comparison of what happened with long term goals) are communicated to us from the higher levels of self hierarchy. The primary communication could be to some lower level self and we would experience these emotions both as averaged experiences and by reading our body language (also the body language spoken by the inner organs) language. Unconscious-to-us sensory qualia also induce e-motor reactions realized as bodily expression of emotion. We perceive this bodily expression and it affects strongly our emotional state. Thus there is close relationship between pure emotional coloring and the generalized geometric qualia inducing it. This option is consistent with the ideas of Damasio about self hierarchy [34].

According to Damasio [34], the ability to experience and express mood like emotions is preserved even when neocortex suffers lesions destroying practically all cognitive abilities and the ability to process sensory information and respond to it. On basis of this fact Damasio suggests that mood like emotions are associated with 'pre-self'. Pre-self is prerequisite of nuclear consciousness and extended consciousness involving cognition and long term goals [34]. The regions assigned by Damasio to 'pre-self' correspond to the nuclei of brainstem, hypothalamus, basal forebrain, insular cortex and somatosensory regions (S1 and S2) in the medial parietal cortex. Perhaps these regions represent sub-selves which receive the sensory input determining our emotions. The hypothesis that primary and secondary regions of the cortex correspond to the first and second period of the periodic table and do not correspond to sensory input directly conscious-to-us is consistent with this picture.

3.6.3 Can one identify emotion with its expression?

There are empirical data supporting Damasio's view that our emotions can be identified with their expressions. For instance, if the motor pathways in the reticular formation are destroyed, person is unable to perform volitional movement and the bodily expression of emotions becomes impossible. Contrary to what one might expect, the patients are calm and peaceful although they can feel frustration and sorrow at intellectual level. Damasio interprets this as support for the correctness of the identification of emotions with their bodily expressions.

The sharp distinction between emotional and purely sensory aspects of pain can be understood if emotions accompany generalized sensory experiences. The purely sensory aspect of pain would correspond to non-geometric and geometric qualia giving information about the state of body and CNS whereas emotional coloring would be due to the entropic gradients necessarily involved with the sequence of the quantum jumps. The reason why sensory input from our body induces much stronger entropic gradients than that from the everyday external world would be dictated by the relatively higher importance of this input and positive feedback loops exaggerating the entropic gradients from body might quite well be involved. That also the sensory input from external world can induce emotional reactions is in accordance with this view.

A more detailed TGD based model of emotions consistent with the observations of Damasio is following. Emotions are based on sensory perceptions about the state of body directly by some lower level self, perhaps the 'pre-self' of Damasio. We experience these qualia as averaged qualia which is much like objective sensory perception: emotions provide summaries rather than bitmaps. The more levels there are between the primary experiencer the slower is the dynamics of emotions and moods correspond therefore to the lowest level self, perhaps the level of 'pre-self' of Damasio.

The lower level self reacts to its emotional percepts by e-motor activity generating emotional expression affecting the state of body and of internal organs, which higher level selves in hierarchy and also we in turn perceive. The entropic gradients characterizing this perception determined the emotion and in turn the reaction and it is easy to imagine a positive feedback generating a response which contains increasingly stronger entropic gradients. It seems to be the perception of the e-motor responses of pre-self to which cause mostly the suffering at our level.

If lower level self of the patient is not able to react e-motorially to its emotional percepts, the patient do not get in a state of horror. Of course, an open question is what 'pre-self' experiences, when it cannot express its experiences: not necessarily anything dramatic and not necessarily anything emotional. It might be that the holistic nature of emotional content is essentially due to single pixel character of emotional experience. Note that this feedback loop resembles the loop created by typing text or talking loudly one's own thoughts. Lower level self communicates directly to us via our body using body language and via lower level selves below us via nervous system. This model explains also why many bodily expressions of emotions occur before we become conscious about them.

3.6.4 Peptides as molecules of emotion and information molecules

It is known that peptides correlate strongly with emotions and moods [51] and they are even called molecules of emotions. Peptides are also regarded as information molecules. This connection between information and emotions fits nicely with the fact that peptides and other important bio-molecules certainly induce strong entropy gradients with respect to subjective time. We do not taste or smell the presence of peptides or other information molecules in our body. A possible explanation is that Bose-Einstein condensation of peptides on super-conducting space-time sheets does not occur. This could quite well be the case for the simple reason that peptides are macromolecules. Of course, one could also argue that the color of emotion is nothing but a generalized taste or odor.

Although it looks more plausible that peptides are only one step in a control sequence leading to quantum phase transition giving rise to quale, one cannot rule out the possibility is that also magnetic and Z^0 magnetic transition frequencies of peptides (short proteins acting as hormones) correspond to geometric aspects of emotional qualia. The cyclotron frequencies of singly charged aminoacids are in the range of $1-4$ Hz and it is known that proteins carry constant charge density per unit length. If this density is same as for DNA, the charge per protein would be about 6 elementary charges. For unit charge per single protein $n = 1$ cyclotron transition is in delta band whereas for 6 elementary charge per unit $n = 1$ cyclotron transition frequency is in alpha band and would be conscious-to-us.

Since proteins and DNA are spin glass type system allowing huge number of ground states and angular momenta, explosion in complexity is expected to occur and make possible extremely rich spectrum of geometric aspects of emotions.

3.6.5 What emotions could be in TGD framework?

TGD suggests several visions about emotions and it is not yet completely clear whether these views are really mutually consistent.

1. The statistical physics approach to qualia leads to the hypothesis that emotions correspond to rates for the generation of various type of entropies for sub-systems of self. The sign of rate tells whether emotion is positive or negative and thus negative emotions would thus be conscious control variables warning self when some sub-system is generating entropy. The holistic nature of emotions can be understood easily in this picture and also the fact that they are not directly related to sensory input. One could perhaps also understand

higher level emotions like sorrow as reflecting the growing disorder of the virtual world of brain resulting from the primary cause of sorrow. The connection of peptides and other information molecules with emotions provides a strong support for this view.

2. Many emotions are comparison type emotions. These emotions tend to be negative (say envy).
   i) At fundamental level one could perhaps regard comparison type emotions as resulting from the comparison of geometric and subjective memories occurring automatically in any quantum jump and thus to some degree with any quale. Unfortunately, it is very difficult to imagine how to concretely test this kind of hypothesis and it is also difficult to see how the connection with entropy gradient could emerge.
   ii) One must also seriously consider the possibility that emotions result from the comparison of remembered/anticipated quale and real quale rather than the fundamental comparison involved with anticipation and memory: kind of quasi-computerized version of geometric memory would be in question. The result of comparison would be coded to the sign of the growth rate of some entropy variable. The comparison could perhaps be realized in such a manner that subsequent quantum jumps for comparing sub-system could represent either the anticipated or real quale. If this were the case, the difference between anticipated and real would automatically induce growth of entropy and negative emotion would result. This would be the basic mechanism of disappointment.

3. One could also regard emotion as or induced by generalized sensory qualia giving information about CNS itself rather than external world or the boundary between external world and body. Regulation involved with the homeostasis involves comparison in an essential manner so that one could perhaps regard emotions as analogous to control variables representing consciously the result of comparison of expected and desired forcing the organism to behave in a manner to reduce this difference and end up to a rest and digest state. This aspect is consistent with the statistical interpretation since the entropy gradients associated with the organism are stronger than those associated with surrounding world. Also amplification mechanisms exaggerating the entropy gradients might have developed. For instance, our reactions to some odors or tastes could involve this kind of amplification.

4. A hypothesis consistent with these views is that emotional component is involved with all sensory experiences and that we are used to call generalized sensory experiences emotions when they are about body. The emotionality of qualia indeed increases in the sequence of perceptive fields external world – CNS-world boundary – body. The degree of emotionality of experience should be characterized by the deviation of real from expected or desired and this suggests that the emotional component is much stronger for sensory experiences about CNS itself, since the system in question is much less predictable than the external world consisting of dead objects. Interpretation of emotion as measure for entropy gradient explains also this hierarchy.

5. A further point of view is provided by music metaphor. Music is language of emotions which suggests that emotions are at least partially coded into the EEG pattern. Perhaps pure emotions which seem to involve no obvious comparison (love, joy, excitement,..). At least the emotions produced by music might represent this kind of emotions. The view about emotions as entropy gradients allows to understand also emotions of this kind. In state of deep love, self enters into very low-entropy state and mental images (not necessarily even present in 'enlightened states') become very pure. Comparison type emotions could be seen as a system of rewards and punishments used to control the self (the controller could be higher level self (conscience) or higher levels selves which also want to survive (the emotions generated by hunger, first, and physical pain).

6. Sensory qualia can be divided to geometric and non-geometric ones. One can classify also emotions in this manner. Emotions corresponding to the localization in zero modes would perhaps correspond to 'higher level emotions' about external world (say, aesthetic qualia) whereas the non-geometric emotions associated with the state preparation would correspond to 'self-centered' emotions about the state of body (pain, physical pleasure,...).

3.6.6 Some examples of concrete identification of emotions

In the following some examples about the identification of emotions are discussed to see what problems are encountered in attempts to concretize the general theory.

1. Simple emotions

Pleasure and pain are the most important emotions (pain as emotion must be distinguished from physiological pain which is ordinary sensory experience). The identification as conscious entropy type variables works very nicely in this case. Relief and disappointment are examples of simple emotions induced by some unexpected event and involving comparison and goal structures. Emotions as entropy gradients vision allows to understand these emotions along the lines already described. Surprise is an ambivalent emotion which is associated with the deviation between expected and real. The lack of comparison aspect could be understand if surprise involves a generation of totally new mental image. Getting bored is more or less a complementary emotion to surprise. It probably involves the growth of the entropy content of the mental images. There are six basic emotions involving goal structures arrangeable into two triplets (happiness, sadness, craving) and (fear, hatred, disgust) or three doublets (happiness,sadness), (fear,rage), (craving,disgust). These emotions are comparison type emotions allowing description in terms of entropy gradients.

2. About geometric aspect of emotions

Simplest comparison type emotions involve comparison of the model of reality with reality. More complicated emotions involve goals and their comparison with what was achieved. This suggest that world model and abstract goals can be mapped the generalized geometric qualia. The metaphorical correspondence of emotions and motions suggests that flag-manifold qualia indeed could represent abstract goals and cognitive structures. The infinite-dimensional flag-manifold associated with the group of zero mode canonical symmetries of configuration space must describe the geometric aspect of emotional experience. This gives huge flexibility and good hopes of coding various goals to the geometry of the space-time sheet (and thus also to cyclotron frequency) by applying appropriate canonical transformation to it.

The most concrete goals are expressible as desired position and posture of body. Consciousness builds geometric metaphors for abstract concepts and goals and metaphorizes also abstract evolution in terms of simple dynamical concept. For instance, goals are often metaphorized using expressions like achieving certain position in society. This suggest that various metaphorization might have developed from these concrete 'geometrodynamical' goals. Therefore one must take seriously the possibility that flag-manifold qualia associated with Lorentz and color group can code also geometric aspects of emotional experience. This reduction could be also due to the fact that flag-manifold coordinates must be eventually mapped to concrete standard configurations of the magnetic flux tubes characterized by position, orientation and internal states achieved by applying Lorentz boosts in the longitudinal direction of tube.

3. Higher level emotions

TGD suggests that higher level emotions are communicated to us by higher level selves by semitrance mechanism in which some part of brain, presumably belonging to right temporal lobe and including hippocampus and amygdala, entangles with higher level self and serve as a medium allowing higher level self to communicate its message as emotions, sensory 'hallucinations' or

internal speech as nerve pulse patterns to the audience consisting of those parts of brain which are in wake-up state. The physical correlate for this process would be standing EEG waves which in turn correspond to spatially constant 'space-like' soliton sequences associated with the region of brain serving as medium whereas propagating EEG waves are associated with soliton sequences propagating in linear circuits of brain. The standing wave part of EEG would clearly correspond to 'free part' of EEG wave not induced by sensory experience alone and identifiable as active aspect of collective consciousness represented by ELF MEs.

The assumption of Damasio that emotion accompanies a generalized sensory experience about the state of body seems to be in conflict with the idea that higher level emotions are communicated to us by higher level selves. Entropic interpretation of emotions does not require that emotions are always about state of body. One the hand, body could serve as an instrument making possible to represent higher level emotions. Higher level self could use semitrance mechanism to induce nerve pulse patterns giving rise to characteristic temporal patterns of EEG in turn giving rise to communicated emotions. Higher level selves could also induce neural activity at some lower level of self hierarchy which would in turn be experienced by us as average emotions like moods.

For instance, higher level selves above us could be responsible for the higher level social emotions like shame and experience of having done something wrong. The experiences of higher level self could be communicated to us, or rather to our lower level sub-selves, as kind of artificially generated virtual world emotions which correspond to EEG frequencies which are higher octaves of the magnetic transition frequencies associated with the fundamental experience. p-Adic length scale hypothesis implies that this communication optimal. The spectrum of super-canonical frequency scales indeed comes as powers of 2 for primary p-adic length scales: if secondary and higher p-adic length scales are included, frequency scales come as powers of $\sqrt{2}$.

3.7 Dark matter hierarchy and emotions

The ideas related to dark matter hierarchy led to a progress in the attempts to understand what emotions and cognition might correspond physically. The new views discussed in more detail in [M4] challenge the assumption that emotions reduce to negentropy gradients and suggest that the sensory qualia of the magnetic body assignable to cyclotron phase transitions correspond to emotions and cognitions. Only the negative-positive coloring of emotions would reduce to the sign of the negentropy gradient in this framework. In the following earlier view and the dark matter inspired vision about emotions are confronted.

3.7.1 Emotions as higher level qualia?

Emotions have metaphoral resemblance to qualia (white/black, cold-warm,...) but intuitively correspond somehow to a higher level than sensory qualia. For instance, insects presumably possess sensory qualia but do not look emotional. Pain-pleasure dichotomy is especially interesting since physical pain can be regarded as a sensory quale and psychological pain as an emotion. This suggests that emotions might be qualia of some kind, perhaps sensory qualia of the magnetic bodies at higher levels of the dark matter hierarchy. This correspondence might however be illusory: the association of certain kind of emotions with certain kind of qualia could explain these metaphors.

It is not at all clear whether this identification is consistent with the assignment of emotions to the negentropy change. One can of course ask whether the "sign" of the emotion as a higher level sensory quale is determined by the sign of the negentropy change. One could also argue that the sign of the negentropy change for sub-self defines one particular higher level sensory quale.

3.7.2 Emotions are whole body feelings

Emotions are holistic and not localizable in any part of the biological body. The time scale for the change of emotions is long as compared to that for the sensory qualia. Emotions possess time scale hierarchy and vary from temporary irritation as you find that you email box is full of junk mail to moods and emotional states like love and hatred lasting for decades. To love some-one for decades one must be able to remember this person. If one assumes that the time scale associated with the level of dark matter hierarchy fixes the geometric duration of the moment of conscious and the characteristic time span of long term memories at that particular level of hierarchy, the conclusion would be that emotions are associated with the higher levels of dark matter hierarchy and are indeed assignable to the magnetic bodies.

3.7.3 Could Josephson radiation to the magnetic body generate emotions?

The simplest hypothesis is that magnetic bodies share the sensory mental images localizable at the sensory organs. The same would hold true for the mental images generated by brain as symbolic representations of the sensory input. The sharing of mental images would correspond to quantum entanglement between sub-selves of the magnetic body and biological body. Charge entanglement induced by W MEs is a good candidate in this respect and would be also in a key role in the motor control. The selection involved in the state function reduction process would correspond to a selection of percepts known to occur (binocular rivalry provides a standard example).

This leaves open the interpretation of the communications to the magnetic body based on Josephson radiation at frequencies $nf_c \pm f_J$, where f_c is ionic cyclotron frequency and f_J Josephson frequency determined by membrane resting voltage. Also more general frequencies are possible. In particular, communications based on slow (in cyclotron time scale) modulations of Josephson frequency induced by modulation of membrane voltage are of special interest.

The Josephson radiation consisting of dark photons induces cyclotron transitions at the magnetic body and in the absence of any other identification, the natural interpretation would be that these transitions define emotions as somatosensory experiences of the magnetic body. The intentionally generated generalized motor actions involving charge entanglement by W MEs would induce the emotional expression just like other motor interactions.

If magnetic body experiences emotions as somatosensory input, it is difficult to avoid the question whether magnetic body is also able to move and change its shape. The model for various kind of OBE experiences [H10] indeed relies on the assumption motor control is induced by motor actions deforming the magnetic body: biological body would be like a puppet hanging from strings.

There is quite recent finding that the sensation of movement is generated by the intention to move rather than by the real motion of body part itself [64]. The explanation would be that the sensation of movement is a somatosensory of magnetic body about its own motion (the interference patterns for Josephson radiation from the body are changed and therefore also cyclotron transition patterns). The communication-control loop between magnetic body and biological body would guarantee that the two movements correspond to each other. This interpretation would provide also a new view about dreams and hallucinations.

3.8 Dark matter hierarchy, hierarchical structure of nervous system, and hierarchy of emotions

One can wonder what emotions have to do with dark matter hierarchy. The brief answer is that there are two kinds of intelligences: the fast, computational intelligence and the slow emotional and holistic intelligence crucial for goal directed behavior which has evolved via the emergence of new levels in dark matter hierarchy. The basic picture wherefrom one can start is following (for

a detailed vision about great leaps in biological evolution as emergence of new dark matter levels see [L2, M3]).

1. The emergence of nervous system corresponds to the emergence of $k_{em} = 3$ level of dark matter hierarchy. For instance, worms and insects would correspond to this level.

2. Vertebrates have EEG and thus the most primitive vertebrates (reptiles) should correspond to $k_{em} = 4$. $k_{em} = 7$ is the highest level for which the natural time scale is below the duration of the human life cycle but need not be the highest level present in CNS of the highest mammals.

3. The emergence of new structures need not mean the emergence of new levels of dark matter hierarchy. Rather, the most reasonable criterion for the presence of these levels is the emergence of behaviors involving long term goals and the magnetic bodies of the parts of brain assignable to the control of this kind of behaviors would correspond to higher values of k_{em}. Also the maximum span of memories at given level should be characterized by the value of k_{em} associated with the brain structures involved (hippocampus, mammillary bodies). This picture conforms with the fact that already insects possess neurons, ganglia, and head containing the predecessor of cerebrum but correspond to $k_{em} = 3$ most naturally.

It is useful to list some basic time scales. 5 Hz frequency in EEG defines the characteristic "drum beat" associated with $k_{em} = 4$ level. The counterpart of .2 second time scale would be 6.7 minutes for $k_{em} = 5$, 9.3 days (day=24 hours) $k_{em} = 6$, and 50.7 years for $k_{em} = 7$ for $\lambda \simeq 2^{11}$.

For goal related emotions the maximal time scale assignable to the achievement of the goal might allow to identify the time scale characterizing corresponding level of dark matter hierarchy. The lowest level emotions would be "primitive" emotions not related to any goal and would be assignable to organs consisting of ordinary cells and correspond to $k_{em} \leq 2$ levels of dark matter hierarchy. Also the typical span of memories should correspond to the time scale $T(k_{em})$.

Brain has anatomic division into midbrain, hindbrain, and forebrain [53]. Midbrain and hindbrain (sometimes both are included in brain stem) is possessed by even the most primitive vertebrates and its emergence could hence correspond to the emergence of $k_{em} = 4$ level and EEG. The emergence of $k_{em} > 4$ levels relates naturally to the emergence of long term planning of motor actions in motor areas. The emergence of limbic brain, which defines the most primitive forebrain, could mean the emergence of $k_{em} = 5$ level and goal related emotions. This conforms with the fact that for mammals forebrain and cerebral hemispheres dominate whereas for other vertebrates hindbrain and cerebellum are in the dominant role.

3.8.1 Reptilian brain as $k_{em} = 4$ system

Reptilian brain contains only the structures corresponding to brain stem (midbrain and hind brain, in particular cerebellum) and would thus correspond to $k_{em} = 4$ level of the hierarchy. Cerebellum is not believed to contribute directly to our consciousness and this might be true quite generally for $k_{em} = 4$ level of dark matter hierarchy (visual awareness might be an exception as will be found).

Simplest emotions correspond to emotions involving no goal. Moods like excitement, feeling good/bad/tired/strong, etc.. could represent examples of such emotions and could be experienced already by reptilians. Of course, the scaled up variants of these emotions could appear at higher levels of hierarchy and would relate to the states of magnetic bodies (degree of the quantum coherence of Bose-Einstein condensates!).

3.8.2 Limbic system

Limbic system is not possessed by reptiles [55]. It is responsible for emotions, control of emotions, and also emotional intelligence. Limbic system corresponds to the brain of the most mammals. The limbic brain includes the amygdala, anterior thalamic nucleus, cingulate gyrus, fornix, hippocampus, hypothalamus, mammillary bodies, medial forebrain bundle, prefrontal lobes, septal nuclei, and other areas and pathways of the brain.

1. The sub-cortical part of the limbic system involves amygdalar and septal divisions. According to [55] amygdalar division promotes feeding, food-search, angry, and defensive behaviors related to obtaining food. Septal division promotes sexual pleasure, genital swelling, grooming, courtship, and maternal behavior. These divisions are emotional mirror images of each other hand could correspond to $k_{em} = 5$ with 6.7 minute "drum beat".

2. The cortical part of the limbic system contains cingulate gyrus which is the newest part of the limbic system and belongs to thalamo-cingulate division which promotes play, vocalization (e.g., the separation cry), and maternal behavior. $k_{em} = 6$ level would correspond to a "drum beat" of 9.3 days.

3. Frontal lobes [56] are often regarded as the organ of volition. The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior. Prefrontal lobes representing the extreme front part of frontal lobes belong also to the limbic system and are responsible for motivation and ability to pose long term goals. This ability distinguishes humans from other primates. For these reasons frontal lobes, in particular prefrontal lobes, could involve the highest levels of dark matter hierarchy in the case of humans. $k_{em} = 7$ with a characteristic time scale of 50 years could be assigned naturally to this level.

Cortico-striatal emotions like sadness, hate, fear anger, surprise, embarrassment, happiness, contentment, and joy involve goal structures and failure or success to achieve the goal in essential manner and would involve prefrontal cortex.

$k_{em} = 7$ and even lower levels can also relate to collective levels of consciousness coded by hyper genes. Hence these emotions could also relate to goals not directly related to the fate of biological body. Mirror neurons are crucial prerequisite of social behavior (autistic children seem to lack them), which suggests that hyper genes are involved at least with them.

Social emotions (feeling embarrassed, ashamed, guilty, loved, accepted, ...) could be induced by the collective levels of dark matter hierarchy as punishments or rewards for social behavior very much like neurotransmitters are believed to provide rewards and punishments at neuronal level.

3.8.3 Neocortex and two kinds of intelligences

Neocortex is often assumed to be superior ("neomammalian") part of the brain and makes the majority of brain hemispheres. The species which are considered to be highly intelligent, such as humans and dolphins, tend to have large amounts of neocortex. The amount of neocortex is roughly proportional to the brain size for primates.

Neocortex cannot correspond to $k_{em} = 7$ as a whole. The decomposition of sensory areas to layers is consistent with $k_{em} = 4$ since it is time resolution which matters in the case of sensory representations. Same conclusion applies to sensory association areas. The fine tuning of the motor control performed by cerebellum is of course consistent with $k_{em} = 4$. Intelligence understood in the conventional sense of the word is accurate, works fast, and is computer like. The part of neocortex responsible for ordinary intelligence would be a rapid and accurate processor of sensory and cognitive representations. Hence $k_{em} = 4$ would be naturally characterize sensory areas,

secondary and primary motor areas, to hippocampal representation of declarative memories, and all association areas except dorsolateral prefrontal sensory-motor association cortex where short term memories are represented.

Emotional intelligence works slowly and is responsible for visions and holistic views and would thus correspond to higher levels of dark matter hierarchy. Limbic system is involved with emotions, motivation and long term planning and would thus be responsible for emotional intelligence. Indeed, the damage to frontal lobes [56] need not affect ordinary intelligence but affects emotional intelligence.

3.8.4 The levels of dark matter hierarchy associated with short and long term memory

The time spans of memories should correspond to the time scales assignable to the dark matter hierarchy. According to [59], the span of other than visual short term memories is 30-45 seconds. Visual short term memories [60] representing selected features of visual field are reported to have time span of few seconds whereas so called iconic memories representing entire visual field have much shorter time span.

Visual short term memories are marginally consistent with $k_{em} = 4$ level of hierarchy since for the right brain hemisphere $T = 2$ seconds is predicted to correspond to the lowest EEG frequency. Iconic memories could also correspond to $k_{em} = 4$ level and to higher EEG frequencies.

$k_{em} = 5$ level of dark matter hierarchy corresponds to 400 second "drum beat": hence 40 seconds would correspond to 50 Hz EEG frequency by scaling so that the time span of other than visual short term memories is consistent with $k_{em} = 5$ identification. The short term memories representing stimuli to which motor system is going to respond are located in dorsolateral prefrontal sensory-motor association cortex which could thus correspond to $k_{em} = 5$.

$k_{em} = 6$ would correspond to memories whose span would have upper limit of 9 days. Scaling up of short term memory span would give span of about 1 day and this might relate to the sleep-wake-up cycle. Perhaps it is good to remember what I did during the day and that I existed yesterday! This could also relate to the fact that dreams use the memories of previous day as a material. Usually long term memories are defined as memories with a span longer than year so that few days time scale is a hopefully testable prediction. Frontal lobes are central for personality, which must based on some kind of a self narrative. Hence at least $k_{em} = 6$ should be assignable with some regions of frontal lobes.

$k_{em} = 7$ would correspond to the time scale of 50 years assignable to prefrontal cortex [57] forming part of the limbic system. Scaling from the span of short term memories would give 10 year scale. The stimulation of some regions of temporal lobes induces vivid sensory memories. Hence also temporal lobes should contain $k_{em} = 7$ regions crucial for the long term memory recall. The instantaneous communications with geometric past as a mechanism of long term memory recall involve naturally higher levels of dark matter hierarchy.

Hippocampus and mammillary bodies involved with long term memory recall are part of the limbic system. That hippocampal theta rhythm is in the range 4-12 Hz suggests $k_{em} = 4$ for hippocampus itself and that hippocampus just builds kind of bit sequence which during memory recall is communicated from the geometric past to some part of the future brain or magnetic body.

Anterograde amnesia means an inability to restore long term memories. The damage of hippocampus or of mammillary bodies can induce anterograde amnesia. In the usual conceptual framework the explanation would be the inability to store new long memories. In TGD framework this would be inability to construct those cognitive representations which are communicated to the geometric future in long term memory recall. Retrograde amnesia seems to involve almost always anterograde amnesia and means loss of memories for some time span before the injury. A possible explanation is that injury can propagate also to the geometric past of the brain quantum jump by quantum jump.

During ageing memories tend to be lost but the memories of childhood are the most stable ones. A possible interpretation is that at $k_{em} = 7$ level faster rhythms of generalized EEG tend to disappear: kind of scaled up variant for the process of falling into sleep accompanied by silencing of higher EEG bands could be in question.

3.8.5 What about transpersonal levels of consciousness?

$k_{em} > 7$ levels of dark matter hierarchy cannot relate to the biological body. They could relate to higher collective levels of dark matter hierarchy and evolution of social structures. For instance, the "god module" located to temporal lobes could correspond to $k_{em} > 7$ level of dark matter hierarchy. The memories extending over personal life span claimed by meditators could have interpretation in terms of $k_{em} > 7$ transpersonal levels of consciousness.

3.9 Boolean qualia

Super algebra contains also super generators carrying fermion number and having otherwise same quantum numbers Lie algebra generators. Depending on whether ordinary Lie-algebra generator or super generator is in question, quale corresponds to sensory or Boolean quale (fermion number 1/0 $\leftrightarrow$, 'this is true/false' sensation): thus sensory and Boolean qualia are in one-one correspondence which suggests that the contents of a Boolean statement associated with a given fermionic generator relates closely to the sensory quale represented by the corresponding bosonic generator. Thus bosons would correspond to sensory consciousness and fermions to logical mind and the structure of the super canonical and Super Kac-Moody algebra would relate directly to the general structure of conscious mind. The conservation of fermion number poses strong constraints on the realization. Since mind like MEs seem to appear as pairs of space-time sheets with positive and negative time orientations and hence with opposite signs of energy, the realization of Boolean algebras as pairs of generators acting on the positive and negative energy space-time sheets suggests itself.

The obvious problem is that Bose-Einstein condensation is not possible for fermions.

1. In the model of hearing cognitive neutrino-antineutrino pairs condensed on different space-time sheets and having vanishing net energy, are in a key role. In this case the classical light-like Z^0 currents associated with MEs could create correlated neutrino-antineutrino pairs (it is not clear whether they are massive when topologically condensed on MEs). Also the light-like vacuum currents associated with MEs could generate neutrino antineutrino pairs.

2. In TGD also space-time sheets with negative time orientation and negative energy are possible and if MEs can appear as pairs then positive and negative energy fermions could appear as correlated pairs condensed at different space-time sheets: BE condensation for these states could occur. Cognitive neutrino pairs are assumed to be this kind of states topologically condensed and cellular and cell membrane space-time sheets.

3. One possibility is that magnetic quantum phase transition for fermions inducing spin flip is responsible for a geometric quale. In the case of cognitive neutrino pairs spin flip indeed occurs.

In principle the change of Boolean statement would cost no energy or any other quantum numbers and statement and its negation would be represented at the two space-time sheets. One can consider also the situation in which the statements do not have same energy: the frequency associated with the transition would be integer multiple of the fundamental super-canonical frequency in the case that classical gauge field associated with ME induces the transition. What would be nice in this correspondence that there would be one-one correspondence between fermionic and bosonic generators fixing the meaning of a particular Boolean statement.

It is important to distinguish between the experience of 'this is true' and formal Boolean statement representable as a bit sequence having no inherent meaning. Sequences of cognitive neutrino pairs identifiable as bit sequences could code besides numbers also Boolean statements with no inherent meaning. On case of cognitive neutrino pairs the spin of the cognitive antineutrino could represent Boolean statement (yes or no) and quantum phase transition changing the spin directions of some neutrinos in the sequence of 126 neutrinos would generate the experience 'this statement is true'. The emergence of the memetic code might have been the prerequisite for the ability to perform formal logical truth preserving operations: this decoupling of truth and meaning seems to be one of the factors distinguishing between humans and lower life forms. One must however be very cautious here: bit sequences represent also numbers and memetic codewords could do nothing but this. As such they would add to the geometric consciousness quantitative aspect.

4 A general model for sensory receptor

Various sensory qualia correspond to the average increments of quantum numbers for a quite long sequence of quantum jumps. Quantum numbers could be spin, momentum, energy, eletromagnetic charge, color quantum numbers (isospin and hypercharge in a constant proportion), various particle numbers, etc... What happens in the sensory receptors is that the gradient of some physical quantity is transformed to average increments of appropriate quantum numbers responsible for the quale representing the gradient of the physical quantity. Spatial gradients are transformed first to temporal gradients by a process, which is essentially scanning (say saccadic motion). Temporal gradients are then transformed to non-vanishing average increments of appropriate charges per quantum jump in a long sequence of quantum jumps. The problem is to understand how this process is realized at the level of sensory receptors.

4.1 Capacitor model for sensory receptor

The assumption that sensory qualia are realized at the level of sensory receptors, when combined with the requirement that the average increments are non-vanishing, and perhaps even same from quantum jump to quantum jump, poses strong constraints on the model of the sensory receptor.

These constraints suggest what might be called the capacitor model of the sensory receptor.

1. There are two reservoirs of quantum charges having total charges of equal magnitude but of opposite sign. The charges are macroscopic in order to guarantee robustness. These reservoirs are analogous to capacitor plates, and only the second one corresponds to the sensory experienced quale unless both the quale and its conjugate are experienced simultaneously. Capacitors plates can carry several charges.

2. When the sensory quale is generated, there is a flow of charge quanta between the quantum capacitor plates. The charge quanta are more or less constant. This requirement could be relaxed to the condition that only the average increment is constant.

Cell membrane, or rather the pair formed by cell interior and exterior, and synaptic junction are excellent candidates for quantum capacitors.

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of a millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and this should give rise to a chemical experience defined by the quantum numbers

of the carrier particle. Not only the increment of electric charge but increments of magnetic quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.

2. In the synaptic contact the vesicles containing neurotransmitter are transmitted, and the net quantum numbers for the vesicles should determine the neuronal chemical qualia associated with the process.

This model does not apply to all qualia. Qualia can be also associated with the quantum phase transitions at magnetic flux quanta. A typical example is a coherently occurring cyclotron transition for a macroscopic phase of Cooper pairs. It would seem that quantum phase transitions at the magnetic flux quanta and particle flows between the quantum electrodes associated with electret type structures could define two basic types of qualia. Note that electret structures are dual to magnetic flux quanta as solutions of field equations. Vision and hearing would be basic examples of these two types of qualia.

4.2 Capacitor model for color vision

Capacitor model allows to attack the problem of how color qualia are generated physically.

1. Color sensation results from a spatial gradient of illumination at a given wavelength transformed first to a temporal gradient: presumably by a saccadic motion. This explains color constancy naturally. The temporal gradient of illumination in turn induces a quantum jump sequence for which average increments of color isospin and hypercharge per quantum jump are non-vanishing and characterizes the color in question.

2. What is needed are two color capacitor plates with opposite color charges. Since color confinement implies the vanishing total color charges below certain length scale, the notion of color capacitor is very natural. The fact that a region of a given visual color has at its boundaries a narrow stripe with the complementary color could relate closely to color confinement. Also the after images with varying colors could relate to the back-flow of the color charges establishing the equilibrium situation between the plates of color capacitor. The color black experienced when eyes are closed could be interpreted as being due to a background flow occurring even in the absence of the visual stimulus (this sensation disappears and visual consciousness is lost if saccadic motions is not allowed to occur).

3. The temporal gradient of illumination induces a flow of color charges between the plates of the color capacitor. The coding of photon frequencies to colors results if the quanta transferred between the plates are colored particles with an isospin-hypercharge ratio characterizing the visual receptor in question. The simplest possibility is that color octet particles are in question so that three primary colors and their conjugates define the basic colors. A Bose-Einstein condensate of colored bosons is the most elegant manner to realize the capacitor. This mechanism requires only that the receptor is frequency sensitive, and that the quantum numbers of the colored particles associated with the capacitor plates depend on the receptor. Depending on the direction of the color charge flow a given receptor contributes color or its conjugate color to the experience, which is average over some set of receptors and thus a mixed color.

4. 3+3 primary colors (black and white are counted as conjugate colors) correspond naturally to the charged "gluons" in the octet representation. For higher color representations a more refined color palette results. For white-black vision the increment of the color hypercharge would be vanishing on the average. It could be also vanishing for the quanta involved

(charged "gluons" belonging to $SU(2)$ triplet of gluons). If the classical color gauge field associated with the plates of the color capacitor reduces to $SU(2)$ one could indeed expect that black-white vision results.

4.2.1 The role of classical color gauge fields

The classical color gauge fields associated with the receptor plates could favor BE condensate with particular color quantum numbers. Classical color gauge fields in general give rise to vacuum color currents, and these could generate coherent states of some gluon like particles giving in turn rise to BE condensates. Since classical color fields are proportional to the induced Kähler field, one expects that strong color gauge fields are associated to solutions which are far from vacuum extremals. Other sensory receptors might differ from visual receptors in that they correspond to almost vacuum space-time sheets with very weak classical color gauge fields. A weaker condition is that the classical color gauge fields are so random that only weak coherent state and BE condensate results. MEs are excellent candidates for the carriers of colored BE condensates since their CP_2 projections are 2-dimensional and the classical color gauge field is Abelian and thus corresponds to a fixed $U(1)$ sub-group.

The model leaves a lot of room for the identification of the colored particles. The color could be in color rotational degrees of freedom of the space-time sheets, it could be gluonic color for a QCD realized in cellular length scale, or super-conformal color associated with what might be called configuration space photons.

4.2.2 Rigid body color?

The identification of the color as a degree of freedom analogous to rigid body rotational degrees of freedom is rather attractive because of its simplicity.

1. Every space-time sheet has color-rotational rigid body degrees of freedom. Since the space-time sheet is topologically condensed at a larger space-time sheet and connected by join along boundaries bonds to other space-time sheets, these degrees of freedom are partially frozen. This means breaking of color symmetry to a subgroup of color group. $U(2)$, $U(1) \times U(1)$, and $U(1)$ are the options besides complete breaking of color symmetry. This could explain why color capacitor mechanism is not involved with all cell membranes but requires special receptors.

2. The gluing operation for two space-time sheets occurs along 3-dimensional surface for both wormhole contacts and join along boundaries bonds. The requirement that gluing is possible implies that this portion of surface is a fixed point with respect to the subgroup of color group, which remains unbroken. If the region in question corresponds to a single point of CP_2, the isotropy group is maximal and equal to $U(2)$. This means that quantum states correspond to a rigid body motion in $U(2)$. For $U(1) \times U(1)$ the states are also characterized by isospin and hypercharge. For $U(1)$ only isospin labels the states and this would correspond to black-white vision.

3. The simplest states correspond to the restriction of color representations in $SU(3)$ realized as matrix elements of color representations to $U(2)$. The restriction means that certain states drop off. To get some grasp on the situation, consider a simple example first. In the case of $SO(3)$ CP_2 is replaced by the sphere S^2 and the restriction to the group $U(1)$ drops away all matrix elements which vanish at the equator. For $J = 1$ triplet only the states having spin $J_z = \pm 1$ remain. Probably also in the case of $SU(3)$ only charged gluons survive in the octet representation restricted to $U(2)$. Since also color neutral states must be possible, the restrictions of higher representations must contain also color neutral states.

4. The freezing of color degrees of freedom means that the remaining degrees of freedom for the space-time sheet are zero mode like degrees of freedom. These degrees of freedom define what is known as a flag manifold. For $U(2)$ these degrees of freedom correspond to $CP_2 = SU(3)/U(2)$, for $U(1) \times U(1)$ the flag manifold is six-dimensional $SU(3)/U(1) \times U(1)$. Flag manifold qualia would correspond to sequences of constant changes for flag manifold coordinates. In the simplest case, sequences of steps along one parameter subgroup of $SU(3)$. The connection between the dance of the honeybee and color group made by Barbara Shipman supports the view that flag manifold coordinates define fundamental geometric qualia and are responsible, not only for the geometric aspects of vision, but of also other sensory modalities.

4.2.3 Gluons of scaled down versions of QCD and dark matter hierarchy

It become years ago clear that TGD allows a hierarchy of QCDs. The assumption that these QCDs are not asymptotically free allowed to circumvent the experimental bounds on the number of elementary particles. Given QCD would exist only in a certain range of p-adic length scales and thus in a certain range of energy and momentum transfers.

After the discovery of dark matter hierarchy with levels labelled by the values of Planck constant [J6, M3] it became clear that TGD not only allows but predicts hierarchies of electro-weak and color physics. Particles of different physics do not have direct interactions and bosons at a higher level of dark matter transform to bosons of a lower level by de-coherence phase transitions. In particular, ordinary intermediate gauge bosons do not decay to the particles of the predicted exotic color and electro-weak physics, and asymptotic freedom can be assumed for all these QCDs.

This forces to consider the possibility that QCDs could exist even in cellular length scales, and that Bose-Einstein condensates of gluons give rise to the opposite color charges of color capacitors. The topological condensation of gluons forces the breaking of the color symmetry for all colored particles, even gluons.

4.2.4 Configuration space photons?

TGD predicts also configuration space color degrees of freedom. What is remarkable is that these states do not carry any energy and momentum. Actually infinite-dimensional super canonical representations decomposing into representations of color group are in question. Rigid body color would represent the lowest states of these representations. MEs are especially good candidates for carrying this kind of color. If MEs with sizes below cell membrane thickness are involved with the transfer of color between the color capacitor plates, the energies of the particles involved must be in ultraviolet range by Uncertainty Principle. If the transfer occurs between cells, the length scale could be of order micrometer and thus visible wavelengths would be in question as is indeed natural. Perhaps the structures formed by cell layers are involved with our color qualia.

4.3 The structure of the retina and sensory organs as sites of sensory qualia

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. 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 characteric of color qualia re-realized 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 predictions about the character of the back projection for various sensory modalities, and one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

4.3.1 Various micro-tubular structures as photoreceptors/transducers

There is a definite evidence supporting the idea that micro-tubuli might be involved with a primitive vision. The information below is from the lecture "Quantum Vitalism" of Stuart Hameroff during an online course about quantum consciousness held in Arizona University 1999.

Albrecht-Buehler [20] has shown that single fibroblast cells move toward red/infra-red light by utilizing their micro-tubule-based centrioles for directional detection and guidance; he also points out that centrioles are ideally designed photodetectors. Photoreception/phototransduction mechanisms at all stages of evolution involve the nine micro-tubule doublet or triplet structures found in centrioles, cilia, flagella and axonemes. The centriole is a pair of micro-tubule-based mega-cylinders arrayed in T shape [28]. Albrecht-Buehler has identified centrioles as the photoreceptor/phototransducer in photosensitive eukaryotic cells.

Flagellar axonemes are the photosensitive structures in protozoa such as Euglena gracilis. Cilia in rod and cone retinal cells in vertebrate eyes (including humans) bridge two parts of the cells and have length distribution covering visible wavelengths. Photosensitive pigments (rhodopsin) is contained in the outer segment while cell nucleus, mitochondria and synaptic connection are contained in the cell body. Light enters the eye and traverses the cell body and cilium to reach the rhodopsin-containing outer segment.

Mari Jibu, Kunio Yasue and colleagues [44] have proposed that super-radiance in a micro-tubule could be involved with the photo-reception.

1. The energy gain due to the thermal fluctuations of tubulins is assumed to increase the number of water molecules in the first excited rotational energy state.

2. A collective mode of the system of water molecules in rotationally excited states is excited. A long-range coherence is achieved inside a micro-tubule by means of spontaneous symmetry breaking. The collective mode of the system of water molecules in rotationally excited states loses its energy collectively, and creates coherent photons in the quantized electromagnetic field inside a micro-tubule.

3. Water molecules, having lost their first excited rotational energies by super-radiance, start again to gain energy from the thermal fluctuation of tubulins, and the system of water molecules ends up to the initial state. Jibu and collaborators have predicted that cellular vision depends on a quantum state of ordered water in micro-tubular inner cores. The authors postulate a nonlinear quantum optical effect termed "super-radiance" conveying evanescent photons by a process of "self-induced transparency" (the optical analogue of super-conductivity) involving formation of BE condensate of photons.

Interestingly, the energy scale of the rotational excitations of water is that of microwave photons, and microwave MEs play a key role in bio-control in the TGD based model of living matter. Perhaps the mechanism proposed by Jibu and collaborators could have a variant realized in terms of TGD based physics and involving microwave-, visible-, and very low frequency MEs. In particular, the collective excitation of the water inside micro-tubule could be generated by coherent radiation of microwave photons accompanying microwave MEs rather than thermally. On basis of the second law one could indeed argue that thermal excitations cannot lead to the generation of macroscopic quantum coherent states.

In simple multicellular organisms, eyes and visual systems began with groups of differentiated light-sensitive ciliated cells which formed primitive "eye cups" (up to 100 photoreceptor cells) in many phyla including flatworms, annelid worms, molluscs, crustacea, echinoderms and chordates (our original evolutionary branch). The retinas in human eyes include over 4×10^8 rod and cone photoreceptors each comprised of an inner and outer segment connected by a ciliated stalk. Since each cilium is comprised of about 3×10^5 tubulins, our retinas contain about 3×10^{13} tubulins per eye. Retinal rods, cones and glia are interconnected by gap junctions [46] and this could be crucial for the generation of the macro-temporal quantum coherence, which quite generally relies on the generation of join along boundaries bonds connecting the boundaries of the space-time sheets forming the bound state in question.

It is usually assumed that the cilium is a purely structural element, but the centriole/cilium/flagella micro-tubular structure, which Albrecht-Buehler has analyzed as an ideal directional photoreceptor, may detect or guide photons in eye spots of single cells, primitive eye cups in early multicellular organisms, and rods and cones in our retinas. The proposal that retinal macro-temporal quantum coherence leading to a new qualitative level of consciousness with much longer de-coherence time could have emerged in sheets of gap junction-connected ciliated cells in eye cups of early Cambrian worms, generalizes the vision of Hameroff and Penrose to TGD context.

4.3.2 The identification of the color capacitor structure

The first segment of the photoreceptor consists of the cell soma and a part containing mitochondria. This segment is connected by ciliated stalk to a layered structure containing the photosensitive pigments. The length distribution of the ciliary micro-tubuli covers visible wavelengths.

The closing of eyes generates so called dark current [26] flowing along the receptor and inducing the hyper-polarization of the receptor membrane. Since visual consciousness is not lost, the natural TGD inspired conclusion is that dark current is the neural correlate for the quale black as a background color quale which in turn results by the color capacitor mechanism.

The fact that vertebrate retina differs by inversion from the retina of invertebrates [24] inspires the question whether the micro-tubular vision of invertebrates about external world might have been inverted to produce "inner vision" providing back projection in the case of the vertebrates. If so vertebrate cilia would receive the "inner light" or generate it itself with brain remotely controlling the process. Mitochondria in turn could provide the needed metabolic energy but could also act as amplifiers of the incoming light.

The photosensitive layers consist of endoplasma membranes so that the realization of the capacitor mechanism would be the same as for the ordinary axonal membrane (nerve pulse inducing flows of ions giving rise to the neuronal chemical qualia). The membrane would be at criticality as regards to the occurrence of the spontaneous color discharge and incoming photon would cause the breakdown. Since the color discharge can be assumed to flow from the side determined by the direction of the membrane electric field, each layer generates same visual qualia although the direction of the color discharge varies. Layered structure would increase the sensitivity of the retina and facilitate the recharging of the capacitors since discharge would make intermediate regions charged and thus unstable.

It would not be surprising if also the endoplasma membranes filling the cell interior might serve the purpose of acting as quantum capacitors providing neuron with sensory receptors of various kinds. Also neuronal vision is quite possible: the difference from our vision would be that our vision involves integration of a very large number of neuronal experiences (more than .1 billion receptors) by quantum entanglement to form our vision. The gap junctions between visual receptors would make possible macro-temporal quantum coherence and the fusion of receptor level visual mental images to our visual mental images.

4.3.3 Back projection mechanism

The basic mechanism responsible for the back projection would involve curved low frequency MEs. Low frequency MEs could be regarded as topological light rays inside effective wave cavities defined by the magnetic flux tubes parallel to the axons, and leading from the cortex to lateral geniculate nucleus to ganglions to the retina. These magnetic flux tubes would form a part of the magnetic body associated with the retina and have quite large a size. Inside low frequency MEs high frequency MEs would propagate as effectively massless particles. In the case of vision high frequency MEs would have lengths in the wavelength range covering that of the visible light.

1. The inverted structure of retina and back projection hypothesis

Photo receptors consist of rods and cones. Only rods are active at low luminance level (black-white vision). Cones are active at high luminance levels and sensitive to the wavelength of the light. Receptor cells are coupled via bipolar cells to ganglions which in turn feed the sensory input along the inner surface of the retina to the blind spot, and from the blind spot to the lateral geniculate nucleus (LGN) of the thalamus. Below (above) bipolar cells are horizontal (amacrine) cells responsible for the lateral couplings between receptor bipolar synapses.

Back projection hypothesis could allow to understand why the incoming light meets first ganglions and wanders through amacrine, bipolar, and horizontal cells to receptors. The inverted structure is indeed required by the back projection: the inner light (coming along, say curved MEs parallel to magnetic flux tubes parallel to micro-tubuli to ganglions or even remotely generated in the ciliated stalk), must superpose with the incoming light. If the structure would be what a naive engineering argument would suggest, the inner light should meet the receptors from an opposite side than the light from the external world, and thus from a wrong side.

2. Back projection and retinal magnetic body

It is interesting to relate back projection to the retinal magnetic body. The following two arguments lead to the same estimate for the size of the retinal magnetic body.

1. The value of the ratio f_h/f_l of high and low frequencies appearing in the scaling law of homeopathy [K5] determines f_l. For the value $f_h/f_l \simeq 2 \times 10^{11}$ identifiable as the ratio of the ionic zero point kinetic energy at atomic space-time sheets and ionic cyclotron energy E_c in the Earth's magnetic field, this would predict that f_l is about $f_l \sim 3$ kHz so that retinal magnetic body would have size of order 100 km.

2. The scaling law relating the sizes L_{CNS} of brain structures to the sizes L_{magn} of the corresponding magnetic bodies would give in the case of eye $L_{magn} = (c/v)L_{CNS}$, where v is the conduction velocity of nerve pulses or some other relevant velocity parameter. For $v = 10$ m/s and the size of retina about $L_{CNS} \sim 1/3$ cm, this would give $L_{magn} \sim 300$ kilometers so that the estimates are of same order of magnitude.

The ratio c/v could be interpreted as the ratio of the ionic zero point kinetic energy at the cell membrane space-time sheet and of the ionic cyclotron energy E_c. The thickness of the ionospheric cavity is approximately $d = 100$ km. Could this mean that the size of the retinal magnetic body

is determined by the thickness of this cavity believed to also give rise to Schumann resonances? If so, then low frequency retinal MEs could be seen as correlates for a radiation moving between the Earth's surface and ionospheric lower boundary forth and back, somewhat like between two mirrors. For $d = 100$ km the period for a single forth-back reflection would be $\tau = .67$ ms, which is near to the duration .78 ms for a single bit of the memetic codon. For $d = 118$ km the duration of the memetic bit would result. Of course, retinal magnetic flux tubes could also be loops returning from the surface of the ionosphere which would make τ longer. If this identification is correct, the temporal variations of various perceptive time scales, say the time resolution of visual perception, determined by the duration of memetic bit, could correlate directly with those of d. In particular, during night time, when ionosphere tends to fall to lower heights, the time scales would become shorter making reaction times shorter.

3. Negative or positive energy MEs or both?

There are reasons to believe that negative energy MEs act as quantum entanglers whereas positive energy MEs are dissipative structures in the sense that the effective phase velocity of the classical fields associated with them is much slower than light velocity. The quantum mechanism leading to the lowering of the effective phase velocity would be basically the stucking of the ME along its boundaries to say cell membrane space-time sheet and to the magnetic flux tube of the Earth's magnetic field.

According to the general model of the motor action as a geometric time reversal of the sensory perception, motor action involves always the generation of low frequency negative energy MEs. Their presence explains the findings of Libet related to the active aspects of consciousness and implies that motor action involves precognitive aspect. The interpretation would be that some higher level structure of CNS or even magnetic body draws negative energy from the motor organs with the mediation of the negative energy MEs. In the case of sensory perception low frequency negative energy MEs would act as bridges allowing the sharing of the mental images between brain and sensory organ.

To sum up, one has two basic options: classical and quantum: 1) Positive energy MEs are involved with the back projection. In this case back-projection would be based on classical communications.

2) Negative energy MEs are responsible for the back projection which might be regarded as a generalized motor action. The phase conjugate of the laser wave would be the standard physics analog. If so then buy now-let other pay mechanism making possible remote metabolism could be involved with the back-projection. This mechanism is the basic mechanism of the metabolism in TGD framework [K6] and implies extreme flexibility.

There are reasons to believe that both options are realized, and one can classify sensory modalities according to whether the back projection is realized by classical or quantum communications. One can also relate these two options to what happens to the embryo during the gastrulation and neurulation.

4. Where the control of back projection mechanism is?

One should also understand where the MEs at visible frequencies are generated.

1. Fractality suggests that the back projections are generated at several levels: ganglions, LGN and various sensory areas. For option 2) the generation of the inner light could mean generation of the quantum entangling negative energy low frequency ME carrying inside it negative energy visible frequency MEs to the appropriate part of the brain. The process could be interpreted as sucking of negative energy from retina.

2. Back projection could be partially responsible for the appearance of the conjugate color at the boundary of a region of given color to improve contrast. Neuronal level would mimic this

qualia level phenomenon at levels of the hierarchy. Whether back-projection from ganglia could relate the on-off structure of the receptive fields even at ganglion level, is an open question. The appearance of the conjugate color at the boundaries of a region of the visual field of a given color could relate to the vanishing of the net color charge for the "positive" electrodes of the system of parallel color capacitors formed by the photoreceptors coupled by gap junctions to form single macroscopic color neutral system.

3. The chromo-oxidase (CO) blobs associated with the visual areas V1 and V2 [27] are a signature of high metabolic activity. For option 2) this would mean that the mitochondria in the neurons of CO blobs suck negative energy photons from some part of the retina, perhaps from the micro-tubuli in the ciliated stalk. The interpretation would be that retina shares the mental image representing the desire of some higher level structure to modify the sensory image and acts accordingly. For option 1) CO blobs would generate positive energy visual MEs propagating to the retina along low frequency MEs: this communication would be classical and limited by the effective phase velocity of the positive energy MEs, presumably of order 10 m/s.

5. Which cellular structures are involved with the generation of the inner light?

The basic question is which cellular structures are involved with the, possibly non-local, generation of the inner light and which are the mechanisms involved. One can imagine several options. Option 1) is most plausible in the case of vision and olfaction whereas option 2) might be realized when the back projection occurs via classical communications.

1. Mitochondria could act as suckers of the negative energy from the retina. Cytochrome oxidase (CO) [27] is involved with the liberation of the metabolic energy and is associated with mitochondria which are everywhere. The large amount of CO in CO blobs suggest that they are metabolically very active. This could be due to the sucking of negative energy photons responsible for the remote metabolism at retina. Note that this mechanism would be essentially lossless and could be said to involve a temporal change of the arrow of the geometric time at the level of MEs. In fact, it is known that metabolism is almost lossless.

2. Mitochondrial autofluorescence could generate the inner light actively [21] rather than as a mere by-product of metabolism: in this case however positive energy photons would be generated at CO blobs. The study of fluorescent life forms, say fireflies and life forms able to change their skin color might provide understanding about the feasiblity of back projection using this mechanism (applying for option 1)).

3. Also cell nucleus must be considered as a candidate for the source of the inner light. Cell nucleus is believed to produce bio-photons and they cover just the right frequency range. The TGD based model for bio-photons leads to the conclusion that pairs of positive and negative energy MEs are involved with the standard mechanism of the bio-photon emission. Nucleus could participate in the processing of the neuronal sensory input actively if the intronic portion of the genome expresses itself using MEs obeying swift dynamics. In the case of positive energy MEs communications would be classical and memetic code could be involved. The nuclear inner light is naturally involved with the communications between cell nucleus and membrane and cellular vision. If the cell nucleus is the brain of the cell, one must keep mind open for the possibility that cell nuclei inside CO blobs control the generation of inner light by drawing negative energy photons from receptors. The absorbtion of compensating positive energy photons from the mitochondria would be however necessary and make the mechanism too complicated. A somewhat more natural mechanism would be

based on sending of negative energy bio-photons to mitochondria and positive energy bio-photons to the retinal receptors along low frequency MEs. Certainly the simplest option is that mitochondria control back-projection by sucking negative energy from retina.

6. Do the cilia/mitochondria in photoreceptors serve as pre-amplifiers?

Cilia might act as pre-amplifiers for the light coming the external world, at least in the case that the illumination is very weak. If the inner light comes from brain as positive energy photons (option 1)), it is expected to have extremely weak intensity and pre-amplification mechanism could be at work also now. For option 2) the pre-amplification mechanism would be replaced by the sharing of the mental image representing the desired modification of the visual mental image and realized by buy now-pay later mechanism.

One can consider at least two different options for the pre-amplification mechanism.

1. Cilia act as pre-amplifiers and the process is triggered by the incoming inner light by a stimulated emission mechanism for which the rate for the generation of photons is proportional to N^2, N the number of photons already existing in the system. For option 1) this mechanism would be at work also for the inner light.

2. The article about reversible excited light induced enhanced fluorescence (briefly RELIEF [21]) supports the view that mitochondria need not only produce fluorescence as a passive by-product of energy yield but could act as amplifiers of the incoming light [21]. Also now buy now-pay later mechanism could be involved. RELIEF phenomenon allows to consider the possibility that the large number of mitochondria preceding cilia in the visual receptors could serve as a pre-amplifier for the incoming inner light. The precise information about the mechanism of autofluorescence in the case of fireflies and life forms able to change their skin color might provide strong constraints on the model.

4.3.4 Does the back projection emerge in the transition from invertebrates to vertebrates?

Three inversions characterize the transition from invertebrates to vertebrates.

1. The inversion of the retina occurs [24].

2. In vertebrates *resp.* invertebrates incoming color generates hyperpolarization *resp.* polarization of the receptor membrane [24]. Thus it would seem that the roles of white and black are changed in the vision of invertebrates: invertebrates detect the lack of light.

3. During morphogenesis the generation of neural tube giving rise to spinal cord, motor nerve, eyes and other sensory organs in head occurs [23, 19]. Neural tube is formed through a folding process implying that neural tube results essentially from an inside-outside inversion of the outer epithelial sheet of the skin.

The finding that neural tube and skin are related by inversion inspires the following questions.

1. Could one relate the first two inversions to the the third one? The following arguments summarizing the basic facts about gastrulation and neurulation support this guess.

2. What implications the inversion could have for consciousness? Did it change the character of some sensory modalities in a decisive manner so that one see "skin senses" and "brain senses" as inversions of each other in some sense. Could it be that the "skin senses" do not involve the telepathic back projection and that the possible back projection is based on classical

communications in this case? Could one understand the emergence of the vertebrates as a step in which the telepathic back projection emerged in vision and perhaps also in some other sensory modalities like olfaction, and made vertebrates dreamers and artists building visual representations as charicatures? Could it be that under appropriate circumstances tactile senses could provide telepathic information from the external world making possible a telepathic remote sensing which in general need however not provide information directly conscious-to-us?

1. Gastrulation and the differences between vertebrates and invertebrates

Gastrulation [23, 19] during which the growing embryo gets gut, is said to be the most important and vulnerable period in the life cycle of a multi-cellular organism. During this period the embryo begins to express its own genome (mother's genome has taken care of development hitherto). The details of this process differ for invertebrates (sea urchin is standard example), amphibians (say frog), and higher vertebrates (birds, reptiles, mammals). In the case of vertebrates the process leads to the generation of essentially three kinds of cell populations. Endoterm develops to inner organs like stomach, intestine and lungs. Mesoderm consists of cells originally contained by the surface of the blastula and differentiates to muscles and inner organs like heart. Ectoterm is the outermost cell layer of the embryo consisting two parts which differentiate later to the nervous system and skin.

For invertebrates gastrulation occurs through a process known as invagination, which is essentially the inpocketing of the epithelial sheet. The pocket like structure elongates to gut tube like structure consisting mainly of endoderm. The nervous system develops from the mesoderm.

Gastrulation occurs differently for amphibians and higher vertebrates. In the case of amphibians gastrulation involves so called involution which means that the mesoderm part of the epithelial sheet rolls below the epiderm to form a double-layered structure (the folding of a rug gives idea of what happens). This process occurs for both halves of the embryo and give. In the case of birds, reptiles, and mammals the gastrulation starts from a situation to which gastrulation leads in the case of amphibians. This in the sense that the outer surface of the blastula is a double layered structure consisting of epiblast and hypoblast below it already in the beginning of the gastrulation. The ingression (detachment) of the cells from the the epiblast *resp.* hypoblast sheet to the interior of the blastula gives rise to mesoderm (muscles, heart,..) *resp.* endoterm (stomach, intestine, lungs,...). The remaining epiblast will later transform to skin and nervous system.

2. Neurulation and the difference between "skin senses" and "brain senses"

Before neurulation the outer surface of the vertebrate embryo consists of two parts: the future skin and neural plate forming the future nervous system [23, 19]. During neurulation the ectoderm in neural plate invaginates to form neural tube and neural crest between the neural tube and the ectoderm surface forming the future skin. Neural crest is formed by the ingression of cells from the skin and gives rise to sensory and autonomic nerves, Schwann cells, pigment cells, ... Neural tube in turn gives rise to brain, spinal cord, motor nerves, eyes,...

The surface of the neural tube is essentially the outer layer of the skin, which has suffered inside-outside inversion. The inversion might mean that the external world is replaced effectively by internal world as far as possible sensory experiencing relying on micro-tubule based sensory organs is considered. This suggests that all "brain" senses such as vision and olfaction involve a telepathy based back projection (sharing of mental images) in an essential manner. "Skin senses", in particular hearing, would in turn involve non-telepathic back projection based on classical communications. Invertebrate eye is formed from the surface cell layer which has not suffered inversion: this could explain why vertebrate and invertebrate eyes differ by inversion. Invertebrates are "almost-predicted" to have back projection based on the classical signalling, in particular in the case of vision: this prediction is testable.

If hearing is "skin sense", as suggested by the fact that we "hear" low frequencies by skin (besides my fragmentary information on the development of the embryo), one must conclude that the back projection to ears must be classical. This conforms with the fact that geometro-temporal patterns of sound waves are the key element of audition. Oto-acoustic sounds audible even by outsiders are indeed a well-known phenomenon and also tinnitus should be caused by back projection involving classical signalling, perhaps by MEs inducing oscillations of nuclei and thus sounds in the inner ear. The hallucinations in "skin senses" and "brain senses" should have a different character. This might explain why dreams are usually either visual or based on internal speech whereas the dreams accompanied by auditory hallucinations are rare and those involving tactile sensations even rarer.

Telepathic "skin senses" (with hearing included) are predicted to be possible and should involve a sharing of remote mental images. The shared mental image need not be directly conscious-to-us. Interestingly, galvanic skin response is a well-known physiological correlate of parapsychological effects and skin seems to play an important role quite generally (e.g. healing by touch and the time varying magnetic fields emitted by the hands of some persons with psykokinetic abilities). Blind people can develop tactile vision and also tactile hearing is possible: an interesting question is whether these senses involve quantum entanglement with the object of the perceptive field. The "sense of presence" might also be seen as a remote "skin sense". That car driver experiences the road through the heels of the moving car as if the vehicle were a part of his body, might be understood in terms of the entanglement associated with touch. Furthermore, it is far from trivial how we know that the sounds from the external world really enter from the external world: perhaps quantum entanglement with the sources of the sound waves is part of the explanation.

The notion of bicamerality introduced by Jaynes [43] inspires the hypothesis that bicamerals and also schizophrenics can receive conscious information from collective levels of consciousness as auditory and visual hallucinations (see the last part of the book). The direct sharing of sensory mental images or of symbolic mental images back projected to sensory mental images would be in question. In the case of auditory hallucinations this process should involve classical back projection unless a genuine telepathy is in question. This prediction could be perhaps tested by studying the physiological correlates of hallucinogen induced experiences.

3. Back projection hypothesis and olfaction

Back projection hypothesis could allow to understand also some strange findings about insect olfaction.

1. As Callahan has demonstrated, insects experience odorant molecules through the infrared light that they generate, rather than chemically [69].

2. Olfactory and visual receptors resemble strongly each other. The fact that olfactory bulb can be seen as part of brain, suggests that the inversion of the receptors occurred also for infrared sensitive micro-tubular receptors, that the back projection is "telepathic" also in the case of the odor perception, and that for "brain senses" the sensory input is always transformed to photons at some wavelength range before it enters to the quantum capacitor and is transformed to qualia.

The infrared light responsible for the "inner odors" could be generated by the same mechanism as the "inner light" the case of vision and would probably involve micro-tubular structures. The micro-tubuli involved with odor receptors should have lengths in the range 5-100 micrometers. Albrecht-Buehler, who has done a lot of experimental work in cellular infrared vision, has demonstrated that infrared signals affect the behavior of cells and that the infrared detector is in the centrosome [22].

4.3.5 How to test the general model?

The basic assumption of the model are following.

1. Sensory organs are the seats of the sensory qualia and basic sensory representations are realized at the magnetic bodies associated with the sensory organs.

2. Back projection is based on quantum *resp.* classical communications for "brain senses" *resp.* "skin senses".

There are huge quantities of information about sensory perception so that one can invent tests for these assumptions by just going to Mednet and by loading abstracts.

1. Phantom sensations, back projection, and the notion of magnetic body

Tactile hallucinations provide interesting tests and challenges for the notion of magnetic body and for the assumption about sensory organs as seats of sensory qualia.

1. It is known that a tactile stimulation of the existing leg can evoke a dual phantom sensation in a symmetric position, that visual input affects the spontaneous but not the evoked phantom sensation, and that sensory-motor input affects the spontaneous phantom leg sensation [39]. The role of the visual input suggests that the evoked phantom leg sensation involves an erratic localization of the tactile sensation at the level of the sensory map of the geometric now and thus involves cortical information processing. The loss of the leg need not lead to the loss of the magnetic body associated with the leg. The tactile back projection could generate tactile mental image in the stump of the leg, which would be entangled with a point of the magnetic body of the amputated leg at the same position as as the tactile mental image associated with the existing leg.

2. The sharing of mental images in principle makes possible to have sensory experiences without sensory input to cortex, a genuine quantum telepathy in the scale of the human body. Anton's syndrome could be seen as an example of this. Also various bodily sensations experienced when the afferents to the brain are anesthetized could be seen as sensory telepathy. Typically sensations of swelling, elongation, and shortening as well as of cold, warm, and prickling are involved ("numbness" of hand is familiar to anyone) [50]. The latter sensations could be interpreted as an evidence for the sharing of sensory mental images. The experiences about swelling, elongation and shortening would result from the erratic estimation of the geometric parameters of the body part in the absence of the sensory input to the cortex implying in turn the distortion of the image of the body part at the magnetic body.

2. Basic tests for back projection mechanism

Dreams and hallucinations should not involve "skin senses" except in the case that classical back projection is activated. Auditory/tactile hallucinations should involve classical communications from brain to ears/skin unless geometric memories or remote sharing of mental images are involved. Hypnotically induced hallucinations combined with the physiological monitoring of primary sensory organs and sensory pathways allow to test whether the predicted differences between skin and brain senses are indeed there.

The presence of the back projection could be tested by using hypnotic suggestion to experience particular qualia. One can test whether it is possible at all experience hypnotically induced tactile qualia and does this experience involve classical signalling from brain. One could test whether something occur in color receptors of a person with closed eyes or in a dark room under hypnotic suggestion. One could investigate whether the activity of CO blobs or say P cells in LGN correlates

directly with the activity at the retinal level during hallucinations. One could check whether the back projection for invertebrates involves always classical signalling.

3. Hypnosis and back projection

The findings about hypnosis and color vision [45] suggest more detailed tests for the back projection hypothesis.

1. The study in question was designed to determine whether hypnosis can modulate color perception. Such evidence would provide insight into the nature of hypnosis and its underlying mechanisms.

2. Eight highly hypnotizable subjects were asked to see a color pattern in color, a similar gray-scale pattern in color, the color pattern as gray scale, and the gray-scale pattern as gray scale during positron emission tomography scanning by means of CO_2. The classic color area in the fusiform or lingual region of the brain was first identified by analyzing the results when subjects were asked to perceive color as color versus when they were asked to perceive gray scale as gray scale.

3. When subjects were hypnotized, color areas of the left and right hemispheres were activated when they were asked to perceive color, whether they were actually shown the color or the gray-scale stimulus. These brain regions had decreased activation when subjects were told to see gray scale, whether they were actually shown the color or gray-scale stimuli. These results were obtained only during hypnosis in the left hemisphere, whereas blood flow changes reflected instructions to perceive color versus gray scale in the right hemisphere, whether or not subjects had been hypnotized.

4. The conclusions were that among highly hypnotizable subjects the observed changes in subjective experience achieved during hypnosis were reflected by changes in brain function similar to those that occur in visual perception. These findings support the claim that hypnosis is a psychological state with distinct neural correlates and is not just the result of adopting a role.

The findings of [45] inspire following comments.

1. The occurrence of hypnotically induced changes in brain function similar to those occurring in visual perception supports the view that sensory organs are the seats of the primary sensory experience. If eyes are the seats of color qualia, hypnosis should induce back projection as is also obvious from the fact that hypnosis induces hallucinatory experiences. The occurrence of the back projection could be tested by using hypnosis in the absence of external light stimulus by testing what happens whether color receptors are active when person is hypnotized to see color.

2. That the left hemisphere is less gullible in ordinary wake-up consciousness supports the role of right hemisphere as the new-ageish entangler and of the left hemisphere as the skeptic loner. Parts of right brain would become more easier extensions for the brains of suggestive persons even without hypnosis. Right brain hemisphere could also be the the sensory artist, and thus the dominating generator of the inner light associated with the back projection. Right brain hemisphere could also generate the inner "voices" of auditory hallucinations as Jaynes proposes [43] or be entanglement with some higher level of self hierarchy using right brain hemisphere to generate the hallucinations.

4. Models for sensory organs and back projection

The insights provided by the study of the structure of the retina encourage to think that a detailed data about various sensory receptors and their development during embryo period could provide a lot of insights about the mechanisms generating sensory qualia and about the mechanisms of the back projection and lead to testable predictions. This would however require a lot of professional knowhow. Also the possible role of bio-photons in back projection might be amenable to study.

4.4 A possible modification of the capacitor model of sensory qualia

From the time scale of sensory experience it seems obvious that all qualia are realized at the level of dark matter. .1 seconds defines a unit of time for sensory experience which suggests that EEG relates closely to sensory qualia.

A modification of the original capacitor model of sensory receptor must be considered. In the original model the capacitor discharge was associated with the sensory receptor. The time scale .1 seconds characterizing sensory mental images would support the view that the capacitor discharge producing the sensory qualia should be assigned to the Josephson junctions at $k_{em} = 3$ level of dark matter hierarchy rather then cell membrane which corresponds to $k_{em} = 0$ level in the hierarchy of selves [M5].

Charge entanglement by W ME would induce non-local capacitor discharges which can be regarded also as exchanges of virtual W bosons inducing exotic ionization leading to dark plasma oscillation patterns inducing various kinds of physiological activity such as Ca^{2+} waves. .1 seconds could be seen as a period of recurring plasma oscillations.

This model would unify models for emotions, cognition, and sensory qualia in the sense that emotions and cognitions would correspond to sensory qualia of the magnetic body assignable to cyclotron phase transitions and ordinary sensory qualia would result in capacitor discharges induced by entanglement by W MEs and color charged gluonic MEs. Even sensory organs would cognize and feel to some extent. The temporal coherence of cognitive and emotional would be spoiled by nerve pulses. Sensory receptors do not fire so that this is not a problem. At the level of cortex however only glial cells would remain viable candidates for carrying higher level sensory, cognitive, and emotional qualia. Neural activity would be responsible for the carving of the sensory percepts: sensory back projections to sensory organs would be in crucial role in this process. This picture is discussed in more detail in [M5].

5 Flag-manifold qualia

Sensory mappings are basic aspect of what brain is doing and therefore one expects that this kind of mappings are performed routinely also at the level of brain. For instance, our tendency to visualize very abstract concepts as geometric objects suggests that they are indeed represented as sub-selves having definite positions inside brain (and as it seems also outside!).

I encountered this kind of mappings in rather early stage, much before the TGD inspired theory of consciousness allowed to even say much about this kind of mappings. The reason was the work of Barbara Shipman about honeybee dance [29]. The strange findings of Shipman suggest that the color symmetry of hadron physics plays key role in sensory experiencing of the tiny honeybees, and led ultimately to the realization that classical color fields predicted by TGD are crucial for understanding visual qualia in TGD framework. Place and time coding by magnetic frequencies has been already considered in the section describing the general vision about the identification of qualia. In this section the attention will be focused to particular geometric qualia associated with the flag manifold defined by the possible choices of the quantization axes for the super-canonical algebra and the findings of the Barbara Shipman will be discussed in TGD framework.

5.1 Basic structure of the configuration space

The basic mathematical structure of quantum TGD is the infinite-dimensional space of 3-surfaces. If Kähler action were deterministic, the configuration space would effectively reduce to the space of 3-surfaces on the light-cone boundary $\delta M_+^4 \times CP_2$ representing the moment of big bang. The classical non-determinism of the Kähler action however forces to consider also the spaces of 3-surfaces belonging to the light-like M_+^4 projections of the light-like boundaries of the massless extremals (MEs), which are thus extremely natural geometric correlates of selves. These selves could perhaps be called light-like selves. The fact that the M_+^4 projections of CP_2 extremal representing elementary particle is a random light-like curve, suggests strongly that one must also allow space-like three-surfaces as correlates of selves. In this respect theory does not yet say anything definite but magnetic flux tubes are very attractive candidates (certainly not the only ones) for what might be called space-like selves.

Configuration space degrees of freedom can be divided into quantum fluctuating degrees of freedom and zero modes which do not quantum fluctuate (being thus 'classical') and characterize the size and shape of 3-surface and are excellent candidate for representing information about the state of organism (3-surface itself) geometrically. The zero modes of the configuration space are special in the sense that in each quantum jump localization occurs in these degrees of freedom.

The hypothesis is that the sequence of events leading to experience geometric qualia involves localization in (measurement of) zero modes parametrizing among other things also the possible choices of quantization axes. One cannot assign geometric qualia to the flag-manifold of the entire isometry group since the localization occurs only in zero modes: rather the sub-group generated by canonical generators labelled by even conformal weights is in question. The flag-manifold in question corresponds to the extension of canonical group of $E^2 \times CP_2$ generated by generators of even conformal weight by CP_2 local conformal transformations of light-cone boundary generated by algebra generators having even conformal weight divided by the Cartan group of $SO(2) \times SU(3)$.

One must consider also the possibility that infinite-dimensional canonical flag-manifold actually reduces (at practical level at least) to finite-dimensional flag-manifold F_3 by the requirement that the choice of the quantization axes for the super-canonical algebra is induced by the choice of the quantization axes for color. Note that in the case of MEs the quantization axis for spin is completely fixed for $E^2 \times CP_2$ whereas for $S^2 \times CP_2$ the sphere S^2 parametrizes the choices of the quantization. Thus the flag manifold F_3 encountered by Barbara Shipman [29] emerges naturally for MEs.

5.2 Quantum honeybee

Barbara Shipman [29] has made rather puzzling observation about the possible connection of the dance of honeybee with the color group $SU(3)$ appearing as the gauge group of strong interactions. The dance of honeybee, providing information of and depending on the distance and direction of the food source, could be regarded as a map of a certain path in the flag manifold $F_3 = SU(3)/U(1) \times U(1)$ mapped to a hexagon like plane region serving as a dance floor.

Barbara Shipman suggests a possible connection between biophysics and quantum physics at quark level. From the point of view of standard physics this suggestion looks inplausible since color confinement should make dynamical effects related to color invisible above the hadronic length scale of order one fermi (10^{-9} times cellular length scale!). In TGD framework it is however possible to understand the observations of Barbara Shipman and these observations are also consistent with the general model for the universal submodalities of sensory qualia. In fact, the work of Barbara Shipman served as an important impetus during the process leading to the general TGD based model of sensory qualia.

5.2.1 Dance of the honeybee

The dance of the honeybee occurs at the vertical face of the honeycomb and codes the information about the distance and direction of the food source. Von Frisch discovered the choreographic syntax and interpretation of the dance and published the results of his work in his 1967 book 'Dance language and Orientation of Bees' [25].

The pattern of the dance is that of figure eight above certain critical distance to the food source and that of a circle below this distance.

1. The angle of the figure eight pattern with respect to the vertical codes the angle between the direction of the food source and the horizontal projection of Sun. For instance, when the food source is in the direction of Sun, figure eight pattern is vertical. The dancer waggles and produces buzzing sound during the first phase of the dance and then walks to the original position along the other circle of the figure eight. After that the dancer waggles again but now along the second circle of the figure eight so that the waggling phases of the dance form the pattern of a figure V in the middle of the figure 8. The buzzing sound produced by the wings of the dancer makes it possible for the audience to locate the dancer (dance occurs in darkness). The opening angle of the figure V codes the distance to the food source for distances above some critical distance.

2. Below the critical distance the pattern changes to a circle. Now the waggling parts of the dance correspond to two disjoint straight line portions located at the opposite sides of the hexagon.

What Barbara Shipman found [29] was that the images of certain curves of 6-dimensional flag manifold under the so called momentum map reproduce the dancing pattern of the honeybee if the six initial values determining the curve are chosen suitably. Only two of these parameters code the information about the food source. The article about the model of honeybee dance is not published yet but on the basis of short abstract [29] it is very plausible that the curves in question are solution curves associated with a completely integrable system known as a full Kostant-Toda lattice studied by Barbara Shipman [30, 31]. The solutions of the $2(n-1)$ equations of motion associated with this model can be mapped to the solutions of certain completely integrable Hamiltonian system in the flag manifold $F_n = SL(n,C)/B$, where $SL(n,C)$ is the space of complex matrices with unit determinant and B is the space of upper triangular matrices with unit determinant. F_n is in turn isomorphic with $SU(n)/U(1)^n$ and this implies a connection with the quantum measurement theory of color charges in $n = 3$ case.

The dance of honeybee should somehow map the some curve of the flag-manifold to a planar curve representing the dancing pattern. $SU(n)$ acts as Hamiltonian transformations of the flag manifold but not as symmetries of Kostant-Toda lattice: in particular, the Cartan algebra generators define Hamiltonians $H_I(x)$ and $H_Y(x)$ in F_3. The so called momentum map associating to the point x of the flag manifold F_3 the point $(H_I(x), H_Y(x))$ characterizing the values of the isospin and hypercharge Hamiltonians at the point x. The image of F_3 under this map is hexagonal region of plane and the image of Kostant-Toda orbit under this map is identified as the dancing pattern of the honeybee. It is obvious that $SU(3)$ cannot act as symmetries of the Kostant-Toda system since in this case Hamiltonians would be constant along the solution curves and momentum map would map every orbit to single point.

To summarize the result concisely: *a) if the orbit of 3-surface in the flag manifold is characterized by Hamiltonian equations related to the so called Kostant-Toda lattice, which is a completely integrable system, b) if the hexagonal planar region defined by the image of the momentum map corresponds to the 'dance floor' and c) if the the orbit of the bee corresponds to the image of the orbit of flag manifold under the momentum momentum map,*

one can indeed understand the dance of honeybee as a representation for the information content of thought of the honeybee. What forces one to take the model seriously is that it reproduces also the dependence of the dancing pattern on bee community and predicts correctly the spectacular change of the V shaped dancing pattern to a union two disjoint lines on the opposite boundaries of the hexagon like region.

5.2.2 TGD based model of the honeybee dance

The concept of self and the TGD based model for sensory experiencing lead directly to the prediction that mental images, also those of tiny honeybee, should correspond to almost continuous curves of infinite-dimensional flag-manifold containing F_3 as sub-flag-manifold. If these orbits are solution curves of dynamical system defined by Kostant-Toda lattice, one can understand the observations of Barbara Shipman.

1. Why curves in flag-manifold?

1. Flag manifold F_3 characterizes especially interesting zero modes. If the contents of the sensory experience is determined by the localization in zero modes occurring in quantum jump, the coordinates of F_3 for mind like space-time sheet generated in sensory perception and representing object of perceptive field, should code some basic data about sensory experience. Since F_3 represents geometric qualia, it is associated with all senses, not only vision and that this role might be similar for all sensory qualia.

2. F_3 is indeed identical with the flag manifold $SL(3,C)/B$ studied by Barbara Shipman. The dimension of $SU(n)/H$, $H = U(1)^{n-1}$, is $D = n(n-1)$ and same as the dimension of the flag-manifold and In $n = 2$ case the two spaces are identical as direct inspection shows. In the general case the isomorphy follows from the observation that arbitrary $SL(n,C)$ matrix s can be expressed as a product $s = b_1 u$, where u is $SU(n)$ matrix and b_1 belongs to the group $B_1 \subset B$ of the upper diagonal matrices with real elements on the diagonal. The elements of B in turn are expressible in the form $b = b_1 h$, where h is diagonal matrix belonging to Cartan group and b_1 belonging to B_1. Therefore the flag manifold can be written as $F = SL(n,C)/B = B_1 SU(n)/B_1 H = SU(n)/H$.

3. Time development by quantum jumps means hopping in zero modes and since the increment of the geometric time in single quantum jump is expected to be very short, of order 10^4 Planck times, the time development should define an almost continuous curve in F_3. In particular, subjective memory of self about quantum jump sequence corresponds to curve in F_3 defined by the averaged increments of zero modes represented by sub-selves.

4. In the ideal case honeybee could code the coordinates and velocities for entire fly path to the food source but this kind of feat is impossible even for us. In practice only the distance and direction of the food source is needed. This information must correspond to sub-self of the honeybee and sub-self in turn corresponds a curve of the flag-manifold F_3. If the projection of this orbit to F_3 is determined by the dynamics of a completely integrable system known as full Kostant-Toda lattice, the physical foundations for the model of Barbara Shipman can be understood in TGD framework.

2. Why the projection of flag-manifold curve to hexagonal plane region

A possible explanation for the reduction of the path to a two-dimensional path is based on the following observations.

1. MEs, and in fact all space-time surfaces carrying Abelian gauge fields, in particular pure electromagnetic or Z^0 type classical fields, have two-dimensional CP_2 projection. On can gauge rotate the color gauge algebra to some $U(1) \times U(1)$ subalgebra of $SU(3)$ and two CP_2 coordinates can serve as the coordinates of these space-time surfaces. Also the dance floor of honeybee can be coordinatized by two CP_2 coordinates.

2. Each space-time surface has by topological field quantization a unique Cartan algebra $U(1) \times U(1)$. Since the values of the color Hamiltonians are well defined functions in CP_2, a very natural choice for the two coordinates is as Hamiltonians H_I and H_Y appearing also as the coordinates of the dance floor in Shipman's model. The region defined by H_I and H_Y has the hexagonal shape and since its boundaries naturally correspond to the boundaries of a mind like space-time sheet such as ME, the mapping of the sequence of increments of flag-manifold coordinates to space-time sheet to a curve inside diffeomorph of the hexagon in plane looks natural. It seems that honeybee really experiences these coordinates directly as imagined positions in plane.

3. Why solutions of full Kostant-Toda lattice?

The hexagonal shape of the dance floor is very strong qualitative prediction as such involving no dynamical models and the attempt to reduce the dynamics to Kostant-Toda lattice might be more that one can desire. Certainly so, if honeybee represents its memories about entire non-deterministic path to the food source rather than just the minimum data abstracted from what honeybee remembers. Of course, honeybee dance might represent only the minimum information making possible to find the food source and this would be achieved if dance represents a deterministic dynamical system with a very high symmetry. Thus it makes sense to ask why just the solution curves of full Kostant-Toda lattice should approximate the almost continuous orbit of F_3 defined by quantum jump sequencesummarizing the memories of honeybee.

1. A possible explanation is that the mental images of the honeybee are result of long evolution and self organization and that mental images with standardized content such as position of the food source, correspond to a solution of some very symmetrical dynamical system.

2. That the full Kostant-Toda lattice is needed can be partially understood. For the full Kostant-Toda lattice time evolution is not unitary transformation but similarity and $SU(3)$ does not in general act as symmetries: if this were the case Cartan group associated with the 3-surface would be a constant of motion. Rather, the eigenvalues of the traceless SL(3,C) Lie-algebra matrix S (see appendix) are the needed two complex constants of motion. For instance, geodesic motion in flag manifold would have $SU(3)$ as symmetries and this would imply that Cartan algebra would define constants of motion and the momentum map would map the orbits to the points of plane. The breaking of $SU(3)$ symmetry is natural since also quantum jump sequence defining the memory of honeybee represents sequence of changes of color quantization axes.

5.2.3 Questions

There are several questions to be answered.

1. The representation curve in F_3 is determined by the initial values of six coordinates. The information coded into the dance fixes only two coordinates and the initial values of the remaining coordinates must be constants specific to hive or subspecies of honey bees. It would not be surprising that these parameters are somehow complementary to the 2 complex constants of motion (eigenvalues of S) associated with the Kostant-Toda dynamics.

2. Somehow the direction of food source and its distance should be coded into the initial values: perhaps the initial values of the flag manifold point develop in time during the flight of the honeybee from the food source to the nest according to a simple rule from initial values corresponding to vanishing distance and ill defined direction angle. The flight occurs along a straight line so that this mechanism looks plausible.

3. For the information to become properly interpreted, the dance should generate the original representation of the information as a flag manifold orbit in the minds of the audience. This requires that the direction with respect to vertical and opening angle are mapped to the initial values of the flag manifold orbit. One can also consider possibility is that the orbit of the flag manifold provides a mental representation for the shortest path to the food source. Magnetic fields are known to be important for the ability of the bee to fly in straight line and the fact that magnetic fields give rise to color magnetic fields suggests that quantum measurement of color charges during the flight might be an important factor in the orienteering of the honeybee. Perhaps the comparison of the measured real color charges with the measured color charges in the mental representation of the orbit is involved.

5.2.4 Some mathematical background

1. Complete Kostant-Toda lattice

Completely integrable systems [18] allow quite generally a Hamiltonian formulation such that there exist maximal number of constants of motion in involution (having vanishing Poisson brackets). This makes the quantization of the completely integrable systems possible. The so called Lax pair allows to transform the dynamics of completely integrable systems to a time dependent unitary transformation of some tensorial or spinorial quantity and this leads to the so called inverse scattering method allowing to solve completely integrable models.

An example of a finite-dimensional completely integrable system is provided by the so called Toda lattice consisting of $n-1$ lattice points on line (one can formally add the point at $Q_n = \infty$ to make equations more symmetrical. To each lattice point $a = 1, ..., n$ a coordinate variable Q^a is attached. The interaction potential is non-vanishing for the nearest neighbors only and has exponential dependence on the coordinate difference $Q^a - Q^b$. The Hamiltonian of the system can be written as

$$H = \sum_{a=1}^{n} \left[\frac{1}{2}(P^a)^2 + exp(-Q^{a+1} + Q^a) \right] \quad . \tag{2}$$

Toda equations allow group theoretical interpretation [18]. The change of variables $q^a = Q^a - Q^{a-1}$ allows to cast the Lagrangian associated with the action into the form into the form

$$L = \frac{1}{2} \sum_{a,b=1}^{n-1} \frac{dq^a}{dt} K^{-1}_{ab} \frac{dq^b}{dt} - \sum_{a=1}^{n-1} exp(-q_a) \quad . \tag{3}$$

The equations of motion for S read as

$$\frac{dS}{dt} - [S, U] = \frac{1}{2} \sum_{a,b=1}^{n-1} H_a K^{-1}_{ab} \left[\frac{d^2 q^b}{dt^2} - \sum_{c=1}^{n-1} K_{bc} exp(-q_c) \right] = 0 \quad , \tag{4}$$

and by the unitarity requirement are equivalent with the original equations of motion for the Toda lattice.

The Lax pair of the so called full Kostant-Toda lattice (presumably relevant to the model of the dance of honeybee) is defined in the following manner (for a detailed and very technical description see the articles [30, 31]). The dynamical variable S belongs to the space $B_- + \varepsilon$ of matrices belonging to $SL(n,C)$ Lie algebra. ε is a matrix having units only above the diagonal: $\varepsilon_{ij} = \delta_{j,i+1}$. B_- consists of the lower triangular matrices with trace zero. The equations of motion read

$$\begin{aligned} \frac{dS}{dt} &= i[H,S] \ , \\ S &= b_- + \varepsilon \ , \\ H &= \Pi_{N_-} S \ . \end{aligned} \tag{5}$$

$H = \prod_{N_-} S$ is the strictly lower triangular part of S, which is nilpotent, and acts as a nonhermitian Hamiltonian in the quantum form of the equations of motion. The time development is not unitary but corresponds to a similarity preserving the eigenvalues of S, which in fact define $2(n-1)$ constants of motion.

There exists a natural imbedding of the space $B_- + \varepsilon$ to the flag manifold $F_n = SL(n,C)/B$, where B consists of upper diagonal matrices with units in diagonal. The mapping is obtained by first identifying $B_- + \varepsilon$ with B_- and then noticing that the complement of B_- represent the Lie-algebra elements of $Sl(2,C)$ modulo matrices having upper triangular part with vanishing diagonal elements. The standard exponential mapping of Lie-algebra to the group maps B_- to $Sl(n,C)/B$. The equations of motion in F_n reduce to Hamiltonian equations of motion generated by the Hamiltonian $H = \frac{1}{2}Tr(S^2)$ [31]. The simplest constants of motion are the eigenvalues of the matrix S and give four constants of motion. In the case of $SL(n,C)$ the eigenvalues span the space C^{n-1}.

$SL(n,C)$ Cartan algebra action induces Hamiltonian flow in the flag manifold and one can associate with the $SU(n)$ Cartan algebra Hamiltonian functions $H_i(x)$, $i = 1,...,n-1$ defined in the entire flag manifold. Since Konstant-Toda dynamics is not unitary, the Cartan algebra of $SU(n)$ does not act as symmetries and the corresponding Hamiltonians are not constants of motion. The Toda flows associated with the diagonal traceless matrices are trivial so that the points in the image of C^{n-1} are fixed points of the Hamiltonian evolution associated with the Cartan algebra. The level sets of the Kostant-Toda Hamiltonian consist of unions of $(n-1)$-dimensional complex tori.

The values $H_1, H_2, ..., H_{n-1}$ of the compact Cartan algebra Hamiltonians at given point x of the flag manifold F_n define a map of the flag manifold to $(n-1)$-dimensional convex polytope known as momentum map. For $n = 3$ the polytope is hexagon. Since the solutions of the Toda equations correspond to certain curves in flag manifold they are mapped to curves inside this hexagon. If Cartan algebra would act as symmetries, the momentum map would map the flag manifold to a single point.

2. Flag manifold F_3 from topological field quantization

A less general manner to end up with the flag-manifold concept is based on what I call topological field quantization. The first approach is certainly more attractive in its generality and by its close relationship with the basic concepts of TGD inspired theory of consciousness (entanglement has interpretation as attention in TGD inspired theory of consciousness) and topological field quantization could at best provide a concrete realization of the picture based on the quantum measurement theory.

1. Topological field quantization corresponds to the formation of 3-surfaces of a finite spatial size with a choice of a preferred 'quantization axes' for rotations (say z-axis) and color hyper charge and color isospin. One can express the angle coordinates Ψ and Φ associated with

hyper charge and isospin in terms of the angle coordinate ϕ associated with the rotations around z-axis as

$$\Psi = n_1\phi + k_1 z + \text{Fourier expansion}$$
$$\Phi = n_2\phi + k_2 z + \text{Fourier expansion}$$

n_1 and n_2 are almost topological quantum numbers expressing the change of angles Ψ and Φ in a rotation around z-axis. In the case of nonvacuum space-time sheets one can say that there are hypercharge and isospin currents rotating in the direction of ϕ. The choice of the hyper charge and isospin quantization axes leads naturally to the possibility to associate to a given 3-surface a point of the flag manifold encountered in the work of Barbara Shipman.

2. The requirement that the Cartan group H fixing the quantization axes corresponds to the subgroup of $SU(3)$ determined by quantum entanglement fixes uniquely topological field quantization and implies the equivalence of the topological field quantization approach with the picture based on quantum measurement theory.

3. The choice of the quantization axes with constant values of n_i over the entire 3-surface is *not* possible for an arbitrary 3-surface globally: rather the 3-surface decomposes into several regions with varying values of n_i. It might however happen that only 3-surfaces consisting of only single region are dynamically stable. On the other hand, the assumption that the choice is global in general fixes the choice uniquely since small change in the direction of the rotational quantization axes implies that a region where the change of angle variable around closed curve around the new z-axes is trivial. Same applies to the change of quantization axes in color degrees of freedom. Note however that for a general closed curve around z-axes, small change in the direction of quantization axes does not change the value of the phase increment. When 3-surface allows global choice of n_i, one can associate to the 3-surface a unique point of the flag manifold. Physical intuition suggests that this point is same as that determined by the quantum entanglement. In the general case one can decompose the 3-surface into several regions, such that each of them has different values of topological quantum numbers for a given choice of quantization axes. It is tempting to interpret the maximal region with fixes values of n_i as a maximal sub-system for which it makes sense to perform the measurement of color charges with given quantization axes.

5.3 Quantum honeybee and DNA as topological quantum computer

The model for the dance of honeybee was an idea before its time and remained in a dormant state for several years. The increased understanding of quantum TGD proper making possible to develop a model for how DNA could act as a topological quantum computer eventually provided a fresh perspective to the problem.

5.3.1 The progress in understanding of quantum TGD

It is appropriate to make a list of new concepts and ideas which are prerequisites for the model of DNA as topological quantum computer.

1. "The world of classical worlds" can be identified as the space of light-like 3-surfaces identifiable also as partonic orbits with dynamics which is not completely deterministic so that 3-dimensionality in discretized sense and local effective 2-dimensionality are obtained [C1]. A considerable generalization of the conformal symmetries of string models and a formulation of quantum TGD as almost topological quantum field theory emerged.

2. The evidence that planetary orbits are identifiable as Bohr orbits led to a generalization of the notion of imbedding space obtained by replacing it with a union of infinite number of sectors

labeled by different values of Planck constant [D7, D8, A9]. The generalization explains dark matter as phases in which Planck constant differs from its value for the visible matter (visible to us, the notion of darkness is relative). Phases of matter with arbitrarily large values of Planck constant are predicted and give rise to macroscopic quantum phases even in astrophysical length scales. These phases are especially important in living matter. The value of Planck constant characterizes topological field quanta serving as space-time correlates for the interactions between particles. Dark matter residing at magnetic flux quanta of field body having large value Planck constant would be responsible quantum control of living matter [M3, J7]. Magnetic body would have an onion like structure consisting of layers with increasing value of Planck constant. The highest layer determines the evolutionary level of system and great leaps in evolution would correspond to the emergence of a new layer with larger value of $\hbar$ to the magnetic body.

3. A more precise characterization for the fundamental notion of quantum criticality emerges from the generalization of the notion of imbedding space. The sectors intersect along $M^4 \times S^2$ and $M^2 \times CP_2$ and maximal quantum criticality corresponds to $M^2 \times S^2$. The geodesic sphere S^2 of CP_2 with trivial homology plays key role in this picture and vacuum extremals $X^4 \subset M^4 \times S^2$ define one particular example of quantum critical surfaces. The isometries of S^2 correspond to $SO(3) \subset SU(3)$. Notice that the flag manifold $F = SU(3)/U(1) \times U(1)$ reduces naturally to $F_{red} = SO(3)/U(1) = S^2$ for almost vacuum extremals.

4. In TGD positive energy ontology must be replaced with what I have christened zero energy ontology [C1, C3]. In zero energy ontology physical states correspond to zero energy states decomposable to pairs of positive and negative energy states localizable at the future and past directed boundaries of a pair of light cones forming a causal diamond. Zero energy ontology allows to identify time-like entanglement coefficients - M-matrix - as a "complex square root" of the density matrix decomposing to a product of positive square root of density matrix and unitary S-matrix so that thermodynamics becomes part of quantum theory.

5. Von Neumann algebras known as hyper-finite factors of type II_1 [C6, A9] play a fundamental role in the formulation of quantum TGD [C1, C3]. This means a profound deviation from standard quantum field theories and ordinary quantum mechanics. The notion of quantum group whose physical interpretation has remained poorly understood represents a key aspect of this difference [A7]. Finite measurement resolution [C3] becomes the key notion of the quantum measurement theory in this framework. It can be represented as an inclusion of von Neumann algebras with included algebra defining the measurement resolution. More concretely, complex rays of state space are replaced with sub-spaces generated by the included algebra and the Hermitian elements of this algebra represent symmetries of the M-matrix. These enormous symmetries allow to fix the possible M-matrices highly uniquely in terms of Connes tensor product. Thus the mere fact that measurement resolution is finite fixes the quantum dynamics of the theory almost completely and leads to a new kind of description of coupling constant evolution allowing also to understand the origin of p-adic length scale hypothesis.

5.3.2 General model for DNA as topological quantum computer

The progress in the understanding of quantum TGD led to various biological applications. The presence of dark matter with the properties predicted by TGD can be deduced from the strange findings about the behavior of cell membrane [32]. These properties are not quite the same as they are believed to be: dark matter has classical interactions with ordinary matter - in particular electromagnetic interactions - but only particles with same value of $\hbar$ (belonging to same sector of imbedding space) can appear in interaction vertices. This is enough to achieve consistency with

what is really known about dark matter. Detailed models for nerve pulse [M2] and EEG [M3] emerge. One of the most fascinating applications is the model of DNA - cell membrane system as a topological quantum computer (tqc) [L7]: this model leads to a further insights about findings of Shipman.

1. The model for DNA as topological quantum computer [L7] assumes that magnetic flux tubes connecting DNA nucleotides to lipids of nuclear/cell membrane define braid strands. To be precise, wormhole magnetic fields consisting of two parallel magnetic flux tubes with opposite fluxes are in question. Wormhole magnetic flux tubes have at their ends wormhole contacts with quark and antiquark at their throats (these defining light-like 3-surfaces) [J5]. Braid strands are "colored" and the four colors correspond to the four nucleotides A,G,T,C. Coloring corresponds physically to a map of nucleotides to quarks u,d and their antiquarks at the upper throat of wormhole contact at the DNA end of wormhole magnetic field (second end contains the conjugate of this state). Kind of 1-1 genetic code is in question and has profound implications for the understanding of the selectivity of bio-catalysis. Quarks have large $\hbar$ and obey a scaled up variant of QCD like dynamics. Note that in this framework the proposal of Barbara Shipman that quarks are involved with honeybee dance begins to make sense.

2. Tqc program is coded by the "dance" of lipids defining a time-like braiding. Since the lipids are connected to nucleotides, their dance defines also space-like braiding coding tqc program to memory: an extremely general mechanism of memory storage is in question which might been present already during pre-biotic era. The braiding is generated by the motion of lipids in liquid crystal phase forced by the motion of cellular water in gel phase because the hydrophobic ends of lipids are anchored to the moving water molecules. Dissipation in the presence of metabolic energy feed means that the liquid flow approaches to an asymptotic self organization pattern depending only weakly on the initial conditions: the interpretation is as a Darwinian selection of tqc programs. There is actually a fractal hierarchy of tqc programs and each sub-program appears as an emsemble of similar copies so that tqc gives automatically probability distributions as an outcome represented as a four-dimensional pattern of classical fields and various rates (chemical rates, firing rates for nerve pulses,...).

3. The basic braiding operation - a twist permuting the position of lipids- defines the universal 2-gate. Besides this 1-gates are needed and SU(2) rotation is enough. Here one can consider several candidates: since quarks and antiquarks are in crucial role in tqc, one of them corresponds to color SU(3) or its subgroup. This could explain the mysterious looking discovery of Barbara Shipman. This aspect is described in more detail below.

5.3.3 Realization of 1-gates of tqc in terms of color rotations and connection with honeybee dance

The realization of single particle gates as $U(2)$ transformations leads naturally to the extension of the braid group by assigning to the strands sequences of group elements satisfying the group multiplication rules. The group elements associated with a n^{th} strand commute with the generators of braid group which do not act on n^{th} strand. G would be naturally subgroup of the covering group of rotation group acting in spin degrees of spin 1/2 object. Since $U(1)$ transformations generate only an overall phase to the state, the presence of this factor might not be necessary. A possible candidate for $U(1)$ factor is as a rotation induced by a time-like parallel translation defined by the electromagnetic scalar potential $\Phi = A_t$.

One of the challenges is the realization of single particle gates representing $U(2)$ rotation of the qubit. The first thing to come mind was that $U(2)$ corresponds to $U(2)$ rotation induced by magnetic field and electric fields. A more elegant realization is in terms of $SU(3)$ rotation, where

$SU(3)$ is color group associated with strong interactions and this suggests connection with the findings of Shipman.

1. The realization of qubit as ordinary spin

A possible realization for single particle gate $s \subset SU(2)$ would be as $SU(2)$ rotation induced by a magnetic pulse. This transformation is fixed by the rotation axis and rotation angle around this axes. This kind of transformation would result by applying to the strand a magnetic pulse with magnetic field in the direction of rotation axes. The duration of the pulse determines the rotation angle. Pulse could be created by bringing a magnetic flux tube to the system, letting it act for the required time, and moving it away. $U(1)$ phase factor could result from the electromagnetic gauge potential as a non-integrable phase factor $exp(ie \int A_t dt/\hbar)$ coming from the presence of scale potential $\Phi = A_t$ in the Hamiltonian.

One can criticize this model. The introduction of magnetic pulses does not look an attractive idea and seems to require additional structures besides magnetic flux tubes (MEs?). It would be much nicer to assign the magnetic field with the flux tubes defining the braid strands. The rotation of magnetic field would however require changing the direction of braid strands. This does not look natural. Could one do without this rotation by identifying spin like degree of freedom in some other manner? This is indeed possible.

2. The realization of 1-gate in terms of color rotations

TGD predicts a hierarchy of copies of scaled up variants of both weak and color interactions and these play a key role in TGD inspired model of living matter. Both weak isospin and color isospin could be considered as alternatives for the ordinary spin as a realization of qubit in TGD framework. Below color isospin is discussed but one could consider also a realization in terms of nuclei and their exotic counterparts [F9] differing only by the replacement of neutral color bond between nuclei of nuclear string with a charged one. Charge entanglement between nuclei would guarantee overall charge conservation.

1. Each space-time sheet of braid strands contains quark and antiquark at its ends. Color isospin and hypercharge label their states. Two of the quarks of the color triplet form doublet with respect to color isospin and the third is singlet and has different hyper charge Y. Hence qubit could be realized in terms of color isospin I_3 instead of ordinary spin but third quark would be inert in the Boolean sense. Qubit could be also replaced with qutrit and isospin singlet could be identified as a statement with ill-defined truth value. Trits are used also in ordinary computers. In TGD framework finite measurement resolution implies fuzzy qubits and the third state might relate to this fuzziness. Note that hyper-charge would induce naturally the U(1) factor affecting the over all phase of qubit but affecting differently to the third quark.

2. Magnetic flux tubes are also color magnetic flux tubes carrying non-vanishing classical color gauge field in the case that they are non-vacuum extremals. The holonomy group of classical color field is an Abelian subgroup of the $U(1) \times U(1)$ Cartan subgroup of color group. Classical color magnetic field defines the choice of quantization axes for color quantum numbers. For instance, magnetic moment is replaced with color magnetic moment and this replacement is in key role in simple model for color magnetic spin spin splittings between spin 0 and 1 mesons as well as spin 1/2 and 3/2 baryons.

3. There is a symmetry breaking of color symmetry to subgroup $U(1)_{I_3} \times U(1)_Y$ and color singletness is in TGD framework replaced by a weaker condition stating that physical states have vanishing net color quantum numbers. This makes possible the measurement of color quantum numbers in the manner similar to that for spin. For instance, color singlet formed by quark and antiquark with opposite color quantum numbers can in the measurement of color quantum numbers of quark reduce to a state in which quark has definite color quantum

numbers. This state is a superposition of states with vanishing Y and I_3 in color singlet and color octet representations. Strong form of color confinement would not allow this kind of measurement. The almost vacuum extremal property suggests also the reduction of $SU(3)$ to $SO(3)$ with ensuing reduction of F to S^2.

4. Color rotation in general changes the directions of quantization axis of I_3 and Y and generates a new state basis. Since $U(1) \times U(1)$ leaves the state basis invariant, the space defined by the choices of quantization axes is 6-dimensional flag manifold $F = SU(3)/U(1) \times U(1)$. In contrast to standard model, color rotations in general do not leave classical electromagnetic field invariant since classical em field is a superposition of color invariant induced Kähler from and color non-invariant part proportional classical Z^0 field. Hence, although the magnetic flux tube retains its direction and shape in M^4 degrees of freedom, its electromagnetic properties are affected and this is visible at the level of classical electromagnetic interactions.

5. If color isospin defines the qubit or qutrit in topological quantum computation, color quantum numbers and the flag manifold F should have direct relevance for cognition. If nearly vacuum extremals are involved one might understand also the reduction of parameters from 6 to two as the effective replacement of F with $S^2 = SO(3)/SO(2)$; this is actually rather natural if the information communicated is the 2-D coordinates of the food source. Color rotations of the the lipid ends of the magnetic flux tubes would define 1-gates representing this geometric information. Subsequent state function reduction would provide conscious representations in terms of trits characterizing for instance sensory input symbolically.

To sum up, this picture suggests that 1-gates of DNA tqc (understood as "dance of lipids") are defined by color rotations of the ends of space-like braid strands and at lipids. The color rotations would be induced by sensory and other inputs to the system. Topological quantum computation would be directly related to conscious experience and sensory and other inputs would fix the directions of the color magnetic fields. The findings of Barbara Shipman give support this picture.

Acknowledgements

I want to thank for Daniel Dubois and Peter Marcer for providing the opportunity to participate CASYS'2000 conference. It was the very enlightening representation of Peter Marcer experimental data concerning the effects of laser light on DNA which re-stimulated the work with massless extremals and quantum antenna hypothesis and led to the realization of connection with the spectroscopy of consciousness. An important stimulus came from Claude Rifat to whom I am also grateful. I want also to express my gratitude to Gene Johnson for sending all kinds of material as well as enlightening debates concerning the relation between quantum brain to neuroscientist's brain.

References

Online books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.* http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.* http://www.helsinki.fi/∼matpitka/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time*.
http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *Quantum TGD*.
http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html.

[5] M. Pitkänen (2006), *TGD as a Generalized Number Theory*.
http://www.helsinki.fi/∼matpitka/tgdnumber/tgdnumber.html.

[6] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy*.
http://www.helsinki.fi/∼matpitka/paddark/paddark.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics*.
http://www.helsinki.fi/∼matpitka/freenergy/freenergy.html.

Online books about TGD inspired theory of consciousness and quantum biology

[8] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems*.
http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html.

[9] M. Pitkänen (2006), *Quantum Hardware of Living Matter*.
http://www.helsinki.fi/∼matpitka/bioware/bioware.html.

[10] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness*.
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html.

[11] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*.
http://www.helsinki.fi/∼matpitka/genememe/genememe.html.

[12] M. Pitkänen (2006), *TGD and EEG*.
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html.

[13] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms*.
http://www.helsinki.fi/∼matpitka/hologram/hologram.html.

[14] M. Pitkänen (2006), *Magnetospheric Consciousness*.
http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html.

[15] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*.
http://www.helsinki.fi/∼matpitka/magnconsc/mathconsc.html.

Articles related to TGD

[16] M. Pitkänen (2000) *About identification of the quantum correlates of sensory qualia* .
CASYS'2000, Fourth International Conference on Computing Anticipatory Systems, Liege, 2000. Abstract Book, Ed. M. Dubois.

[17] M. Pitkänen (2001), *Spectroscopy of consciousness*, International Journal of Computing Anticipatory Systems (to be published).

References to the chapters of books

[A1] The chapter *An Overview about the Evolution of Quantum TGD* of [1].
http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html#tgdevo.

[A7] The chapter *Equivalence of Loop Diagrams with Tree Diagrams and Cancellation of Infinities in Quantum TGD* of [1].
http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html#bialgebra.

[A9] The chapter *Does TGD Predict the Spectrum of Planck Constants?* of [1].
http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html#Planck.

[B2] The chapter *Construction of Configuration Space Kähler Geometry from Symmetry Principles: Part I* of [2].
http://www.helsinki.fi/∼matpitka/tgdgeom/tgdgeom.html#compl1.

[B3] The chapter *Construction of Configuration Space Kähler Geometry from Symmetry Principles: Part II* of [2].
http://www.helsinki.fi/∼matpitka/tgdgeom/tgdgeom.html#compl2.

[C1] The chapter *Construction of Quantum Theory* of [4].
http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#quthe.

[C3] The chapter *Construction of Quantum Theory: S-matrix* of [4].
http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#towards.

[C6] The chapter *Was von Neumann Right After All* of [4].
http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#vNeumann.

[D7] The chapter *TGD and Astrophysics* of [3].
http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html#astro.

[D8] The chapter *Quantum Astrophysics* of [3].
http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html#qastro.

[F8] The chapter *TGD and Nuclear Physics* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#padnucl.

[F9] The chapter *Nuclear String Physics* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#nuclstring.

[H10] The chapter *TGD Based Model for OBEs* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#OBE.

[H1] The chapter *Matter, Mind, Quantum* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#conscic.

[H2] The chapter *Negentropy Maximization Principle* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#nmpc.

[H3] The chapter *Self and Binding* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#selfbindc.

[H4] The chapter *Quantum Model for Sensory Representations* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#expc.

[H5] The chapter *Time and Consciousness* of [10].
http://www.helsinki.fi/~matpitka/tgdconsc/tgdconsc.html#timesc.

[H7] The chapter *Conscious Information and Intelligence* of [10].
http://www.helsinki.fi/~matpitka/tgdconsc/tgdconsc.html#intsysc.

[I1] The chapter *Quantum Theory of Self-Organization* of [8].
http://www.helsinki.fi/~matpitka/bioselforg/bioselforg.html#selforgac.

[I3] The chapter *Biological Realization of Self Hierarchy* of [8].
http://www.helsinki.fi/~matpitka/bioselforg/bioselforg.html#bioselfc.

[I4] The chapter *Quantum Control and Coordination in Bio-systems: Part I* of [8].
http://www.helsinki.fi/~matpitka/bioselforg/bioselforg.html#qcococI.

[I5] The chapter *Quantum Control and Coordination in Bio-Systems: Part II* of [8].
http://www.helsinki.fi/~matpitka/bioselforg/bioselforg.html#qcococII.

[J1] The chapter *Bio-Systems as Super-Conductors: part I* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#superc1.

[J2] The chapter *Bio-Systems as Super-Conductors: part II* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#superc2.

[J3] The chapter *Bio-Systems as Super-Conductors: part III* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#superc3.

[J4] The chapter *Quantum Antenna Hypothesis* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#tubuc.

[J5] The chapter *Wormhole Magnetic Fields* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#wormc.

[J6] The chapter *Coherent Dark Matter and Bio-Systems as Macroscopic Quantum Systems* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#darkbio.

[J7] The chapter *About the New Physics Behind Qualia* of [9].
http://www.helsinki.fi/~matpitka/bioware/bioware.html#newphys.

[K1] The chapter *Time, Spacetime and Consciousness* of [13].
http://www.helsinki.fi/~matpitka/hologram/hologram.html#time.

[K3] The chapter *General Theory of Qualia* of [13].
http://www.helsinki.fi/~matpitka/hologram/hologram.html#qualia.

[K5] The chapter *Homeopathy in Many-Sheeted Space-Time* of [13].
http://www.helsinki.fi/~matpitka/hologram/hologram.html#homeoc.

[K6] The chapter *Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin* of [13].
http://www.helsinki.fi/~matpitka/hologram/hologram.html#metab.

[L1] The chapter *Genes and Memes* of [11].
http://www.helsinki.fi/~matpitka/genememe/genememe.html#genememec.

[L2] The chapter *Many-Sheeted DNA* of [11].
http://www.helsinki.fi/~matpitka/genememe/genememe.html#genecodec.

[L4] The chapter *Pre-Biotic Evolution in Many-Sheeted Space-Time* of [11].
http://www.helsinki.fi/∼matpitka/genememe/genememe.html#prebio.

[L7] The chapter *DNA as Topological Quantum Computer* of [11].
http://www.helsinki.fi/∼matpitka/genememe/genememe.html#dnatqc.

[M1] The chapter *Magnetic Sensory Canvas Hypothesis* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#mec.

[M2] The chapter *Quantum Model for Nerve Pulse* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#pulse.

[M3] The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#eegdark. The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#eegdark.

[M4] The chapter *Quantum Model for EEG: Part I* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#eegI.

[M5] The chapter *Quantum Model of EEG: Part II* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#eegII.

[M6] The chapter *Quantum Model for Hearing* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#hearing.

[N1] The chapter *Magnetospheric Sensory Representations* of [14].
http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html#srepres.

Mathematics related references

[18] A. Das(1989), *Integrable Models*, World Scientific.

[19] Zeeman, E., C.(1977), *Catastrophe Theory*, Addison-Wesley Publishing Company, Inc..

Biology

[20] G. Albrecht-Buehler (1995), *Changes of cell behavior by near-infrared signals.* Cell Motility and the Cytoskeleton 32:299-304.
Ibid (1997),Autofluorescence of live purple bacteria in the near infrared. Experimental Cell Research 236:43-50
Ibid (1990) *The iris diaphgram model of centriole and basal body formation.* Cell Motility and the Cytoskeleton, 17:187-213 (1990).

[21] G. Albrecht-Buehler (2000), *Reversible excitation light-induced enhancement of fluorescence of live mammalian mitochondria.* FASEB J..
See also the web article *Are mitochondria capable of generating light pulses?*, http://www.basic.northwestern.edu/g-buehler/relief.htm .

[22] G. Albrecht-Buehler (1991), *Surface extensions of 3T3 cells towards distant infrared sources.* J. Cell Biol. (1991)114:493-502.
Ibid (1994), *The cellular infrared detector appears to be contained in the centrosome.* Cell Motiltiy and the Cytoskeleton 27:262-271.

[Becker and Selden] R. O. Becker and G. Selden (1990) *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York.

[23] A. Balinsky (1965), *An Introduction to Embryology*, (Saunders, Philadelphia and London) 2nd edition. See also a brief online summary about gastrulation and neurulation by A. Albert Harris *Gastrulation*, http://www.bio.unc.edu/courses/2002spring/bio104/gastrulation.htm.

[24] Richard Dawkins (1986), *The Blind Watchmaker*. Penguin Books.

[25] K. von Frisch (1967), *The Dance Language and Orientation of Bees*, Harward University Press.

[26] A. K. Hodgkin *et al* (1985), *The ionic selectivity and calcium dependence of the light sensitive pathay in toad rods*. J. Physiol. 358:447-468.

[27] M. Hubener and J. Bolz (1992), *Relationships between dendritic morphology and cytochrome oxidase compartments in monkey striate cortex*. J. Comp. Neurol. Oct 1;324(1):67-80.

[28] B. H. H. Lange and K. Gull (1996), *Structure and function of the centriole in animal cells: Progress and questions*. Trends in Cell Biology 6:348-352.

[29] B. Shipman (1998) *The geometry of momentum mappings on generalized flag manifolds, connections with a dy mechanics and the dance of honeybee.* http://math.cornell.edu/ oliver/Shipman.gif .

[30] B. Shipman (1998), *On the geometry of certain isospectral sets in the full Kostant-Toda lattice.* http://nyjm.albany.edu:8000/PacJ/1997/Shipman.html .

[31] B. Shipman (1998), *A symmetry of order two in the full Kostant-Toda lattice.* http://www.math.rochester.edu:8080/u/shipman/symmetrypaper/.

[32] G. Pollack (200?), *Cells, Gels and the Engines of Life*, Ebner and Sons. http://www.cellsandgels.com/ .

Brain science

[33] J. R. Cronly-Dillon, and R. L. Gregory (1991), *Evolution of the eye and visual system*, (Vision and visual dysfunction Vol 2) CRC Press, Boca Raton.

[34] A. Damasio (1999), *The Feeling of What Happens*, Sane Töregard Agency.

[35] T. Deboer (1998), *Brain temperature dependent changes in the electroenceplahogram power spectrum of humans and animals*, J. Sleep Res. 7(4): 254-62. http address too!!

[36] D. Fouzzner (1999),
The symphonic architecture of mind: the circulating wavetrain of consciousness. Thesis, http://www-douzzer.ai.mit.edu:8080/wavetrain.html .

[37] J. A. Grey (2000), "Contents of consciousness: a neuropsychological conjecture", Behavioral and Brain Sciences 18 (4):659-722.

[38] C. C. Hiew (1995), *Hemi-Synch into creativity*. Hemi-Synch Journal, XII (1), pp. 3-5.

[39] J. P. Hunter *et al* (2003), *The effect of tactile and visual sensory inputs on phantom limb awareness* Brain, Vol. 126, No. 3, 579-589, March.

[40] E. Insinna (1997), *Co-evolution of vision and consciousness.* In: Toward a Science of Consciousness, 1996. The second Tucson discussions and debates. Eds S. Hameroff, A. Kaszniak, A. Scott. MIT Press, Cambridge.

[41] R. Joseph (2000), *Hippocampus.* http://www.brain-mind.com/Hippocampus.html .

[42] E.R. Kandel. J.H. Schwartz, T. M. Jessel (1991), Principles of neural science, Prentice-Hall International Inc. .

[43] Julian Jaynes (1982), *The origin of consciousness in the breakdown of the bicameral mind*, Princeton University Press.

[44] M. Jibu, S. Hagan, S. Hameroff, K. Pribram, and K. Yasue (1994), *Quantum optical coherence in cytoskeletal micro-tubules: implications for brain function.* Bio-systems 32:195-209.

[45] S.M. Kosslyn *et al* (2000), *Hypnotic Visual Illusion Alters Color Processing in the Brain* Am. J. Psychiatry 157:1279-1284, August.

[46] K. N. Leibovic (1990), *Science of Vision.* Springer-Verlag N.Y.

[47] B. Libet *et al* (1979). *Subjective referral of the timing for a conscious sensory experience.* Brain 102:193-224.

[48] Scott Makeig (1993),*Auditory Event-Related Dynamics of the EEG Spectrum and Effects of Exposure to Tones*, Electroencephalogr. clin. Neurophysiol. , 86:283-293.

[49] S. E. Palmer (1999) *Color, Consciousness, and the Isomorphism Constraint*, Behavioral and Brain Sciences 22 (6). (Accepted for publication)

[50] X. Paqueron *et al* (2003), *The phenomenology of body image distortions induced by regional anaesthesia*, Brain, Vol. 126, No. 3, 702-712, March.

[51] C. B. Pert (1997), *Molecules of Emotion*, Simon & Schuster Inc..

[52] J.K. O'Regan and A. Noe (2000), *A sensorimotor account of vision and visual consciousness*, submitted 14 July 2000, as revision of manuscript under review in Behavioral and Brain Sciences. http://nivea.psycho.univ-paris5.fr .

[53] *Brain*, http://en.wikipedia.org/wiki/Brain.

[54] *Brain stem*, http://en.wikipedia.org/wiki/Brain_stem.

[55] *Limbic system*, http://en.wikipedia.org/wiki/Limbic_system.

[56] *Frontal lobes*, http://en.wikipedia.org/wiki/Frontal_lobes.

[57] *Prefrontal cortex*, http://en.wikipedia.org/wiki/Prefrontal_cortex.

[58] *Temporal lobes*, http://en.wikipedia.org/wiki/Temporal_lobes.

[59] *Short term memory*, http://en.wikipedia.org/wiki/Short_term_memory.

[60] *, Visual short term memory* http://en.wikipedia.org/wiki/Visual_short-term_memory.

[61] C. Rifat(1999), *Conscious dreaming and controlled hallucinations.* http://www.dog.net.uk/claude/dreams.html .

[62] Vanderwolf, C.H. (1969), *Hippocampal electrical activity and voluntary movement in the rat.* Electroencephalography and Clinical Neurophysiology, 26, 407-18.

[63] J. P. Miller (1996), *Brain Waves Deciphered*, article about the work of Wehr and Laurent in Nature, vol 384 (14 November).

[64] *How the mind senses the movement*, New Scientist , 04 February, 2006, issue 2537, http://www.newscientist.com/channel/being-human/mg18925375.000.html.

[65] M. Pines, *A Secret Sense in The Human Nose?.* http://www.hhmi.org/senses/ .

[66] D.J Bierman and D. I. Radin (1998), *Anomalous unconscious emotional responses: Evidence for a reversal of the arrow of time.* http://www-psy.uva.nl/resedu/pn/PUBS/BIERMAN/1998/tucson/tucson3.html.

Effects of em fields on living matter

[67] C. F. Blackman (1994), "Effect of Electrical and Magnetic Fields on the Nervous System" in *The Vulnerable Brain and Enviromental Risks, Vol. 3, Toxins in Air and Water* (eds. R. L. Isaacson and K. F. Jensen). Plenum Press, New York, pp. 331-355.

[68] N. Cherry (2000), Conference report on effects of ELF fields on brain, http://www.tassie.net.au/emfacts/icnirp.txt .

[69] Callahan, P. S. (1977). *Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent.* Applied Optics. 16(12) 3089-3097.

[70] P. Gariaev *et al* (2000), *The DNA-wave biocomputer*, International Journal of Computing Anticipatory Systems. Ed. Daniel Dubois, Published by CHAOS, Vol. 10, 2001.

Anomalies, etc.

[71] C. Smith (2001), *Learning From Water, A Possible Quantum Computing Medium*, talk in CASYS'2001, 5th international conference on Computing Anticipating Systems held in Liege, Belgium, August 13-18. Abstract book published by Chaos.

[72] S. V. Krischevskii (1996), *Extraordinary Fantastic States/Dreams of the of the Astronauts in Near -Earth Orbit: a New Cosmic Phenomenon.* Sozn. Fiz Real 1(4) 66 -69.