General Theory of Qualia

M. Pitkänen,

November 30, 2016

Email: matpitka@luukku.com.
http://tgdtheory.com/public_html/.
Recent postal address: Karkinkatu 3 I 3, 00360, Karkkila, Finland.

Contents

1 Introduction **5**
1.1 The Notion Of Self And Qualia . . . 6
1.2 Qualia And Thermodynamics . . . 7
1.3 Spectroscopy Of Consciousness . . . 8

2 General Vision About The Quantum Correlates Of Qualia **9**
2.1 What Qualia Are? . . . 11
2.1.1 Qualia as quantum phase transitions and as discharges of quantum capacitor 11
2.1.2 Non-geometric and geometric qualia . . . 12
2.1.3 Comparison with ideas of Noe and Regan . . . 14
2.1.4 What about emotions? . . . 15
2.1.5 General classification of qualia inspired by the connection with quantum measurement theory and statistical physics . . . 16
2.2 Classification Of Qualia In Thermodynamical Framework . . . 16
2.2.1 Do qualia depend on the averages of quantum number increments only? . . 16
2.2.2 Various types of non-geometric qualia . . . 18
2.2.3 About quantum correlates of alertness and attention . . . 20
2.3 Critical Questions And Open Problems . . . 21
2.3.1 Does the brain construct meta-stable sensory maps? . . . 21
2.3.2 Are super-symplectic qualia associated with vision only? . . . 21
2.3.3 How qualia are compared? . . . 23
2.3.4 Association problem . . . 23

3 About The Identification Of The Non-Geometric Qualia **24**
3.1 Color Vision And Super-Symplectic Algebra . . . 24
3.1.1 Basic facts about color vision . . . 24
3.1.2 Can one understand colors Lie-algebraically? . . . 25
3.2 Chemical Qualia . . . 27
3.2.1 Quantum correlates of "our" chemical qualia . . . 27
3.2.2 Some facts about odors . . . 28
3.2.3 Evidence for infrared vision based on odor molecules? . . . 28
3.2.4 Odor perception as IR vision at the level of odor receptors? . . . 29
3.2.5 Frequency coding of odors . . . 29
3.3 Magnetic Qualia As Generalized Chemical Qualia . . . 29
3.3.1 Endogenous NMR spectroscopy? . . . 30
3.4 Kinesthetic Qualia . . . 30
3.4.1 Are kinesthetic qualia universal? . . . 30
3.4.2 Linear and angular acceleration . . . 31
3.4.3 Hearing as time-like counterpart of force sense? . . . 32
3.4.4 Increments of spin and momentum and figure-background separation . . . 32
3.5 Tactile Qualia . . . 32
3.6 Emotions . . . 33
3.6.1 About classification of emotions . . . 34
3.6.2 How emotions differ from ordinary sensory experiences? . . . 35
3.6.3 Can one identify emotion with its expression? . . . 36
3.6.4 Peptides as molecules of emotion and information molecules . . . 36
3.6.5 What emotions could be in TGD framework? . . . 37
3.6.6 Some examples of concrete identification of emotions . . . 38
3.7 Dark Matter Hierarchy And Emotions . . . 39
3.7.1 Emotions as higher level qualia? . . . 39
3.7.2 Emotions are whole body feelings . . . 40
3.7.3 Could Josephson radiation to the magnetic body generate emotions? . . . 40
3.8 Dark Matter Hierarchy, Hierarchical Structure Of Nervous System, And Hierarchy Of Emotions . . . 40
3.8.1 Reptilian brain as $k_{eff} \leq 205$ system? . . . 41
3.8.2 Limbic system . . . 41
3.8.3 Neocortex and two kinds of intelligences . . . 42
3.8.4 The levels of dark matter hierarchy associated with short and long term memory . . . 42
3.8.5 What about transpersonal levels of consciousness? . . . 43
3.8.6 Boolean qualia, fermions, and memetic code . . . 43

4 Constraints On The Fermionic Realization Of Genetic Code From The Model For Color Qualia **45**
4.1 Fermionic Representation . . . 45
4.2 Various Options For The Fermionic Representation Of A, T, C, G . . . 46
4.3 Realization Of Color Qualia For Quark Option . . . 46

5 Flag-Manifold Qualia **48**
5.1 Basic Structure Of WCW . . . 48
5.2 Quantum Honeybee . . . 49
5.2.1 Dance of the honeybee . . . 49
5.2.2 TGD based model of the honeybee dance . . . 50
5.2.3 Questions . . . 52
5.2.4 Some mathematical background . . . 53
5.3 Quantum Honeybee And DNA As Topological Quantum Computer . . . 55
5.3.1 The progress in understanding of quantum TGD . . . 55
5.3.2 General model for DNA as topological quantum computer . . . 56
5.3.3 Realization of 1-gates of TQC in terms of color rotations and connection with honeybee dance . . . 57

6 A General Model For Qualia And Sensory Receptor 58
6.1 A General Model Of Qualia . . . 59
6.2 Detailed Model For The Qualia . . . 59
6.2.1 Overall view about qualia . . . 62
6.2.2 Guesses about detailed identification of the qualia . . . 63
6.2.3 Could some sensory qualia correspond to the sensory qualia of the magnetic body? . . . 63
6.3 Capacitor Model For Sensory Receptor . . . 64
6.4 Capacitor Model For Color Vision . . . 65
6.4.1 The role of classical color gauge fields . . . 66
6.4.2 Rigid body color? . . . 66
6.4.3 Gluons of scaled down versions of QCD and dark matter hierarchy . . . 67
6.4.4 WCW photons? . . . 67
6.5 The Structure Of The Retina And Sensory Organs As Sites Of Sensory Qualia . . 67
6.5.1 Various micro-tubular structures as photoreceptors/transducers . . . 68
6.5.2 The identification of the color capacitor structure . . . 69
6.5.3 Back projection mechanism . . . 69
6.5.4 Does the back projection emerge in the transition from invertebrates to vertebrates? . . . 72
6.5.5 How to test the general model? . . . 74
6.6 Some Examples About Deficits Of Color Vision As A Test Of The Model For Cognitive Representations . . . 76
6.6.1 First example . . . 77
6.6.2 Second example . . . 77
6.6.3 Third example . . . 78
6.7 Odor Perception And Quantum Coherence . . . 78
6.7.1 Vibrational theory of odor perception . . . 79
6.7.2 Comparison of Turin's model with TGD and Callahan's theory . . . 79
6.7.3 Isotope effect of olfaction as an additional guideline . . . 81
6.8 Is It Possible To See Without Brain? . . . 83
6.9 How Are The Visual Percepts Constructed? . . . 84

7 TGD Based Models For Cell Membrane As Sensory Receptor 86
7.1 Could Cell Correspond To Almost Vacuum Extremal? . . . 87
7.1.1 Cell membrane as almost vacuum extremal . . . 87
7.1.2 Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals . . . 89
7.1.3 Are photoreceptors nearly vacuum extremals? . . . 90
7.2 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell . . . 93
7.2.1 Pollack's findings . . . 94
7.2.2 Dark nuclei and Pollack's findings . . . 94
7.2.3 Fourth phase of water and pre-biotic life in TGD Universe . . . 95

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.

1. The notion of self and qualia

The notion of self has been problematic and the recent progress in this respect clarifies also the situation concerning qualia. In ordinary quantum measurement theory repetition of state function reduction leaves the state unchanged. In TGD state function reduction can occur at both boundaries of causal diamond (CD) and in this case the state remains invariant only at the boundary at which the repetition takes place. This allows to understand how the arrow of time and its flow correspond essentially the increase of the average temporal distance between the tips present in the superposition of CDs with second end localized at fixed light-cone boundary. Self can be identified as a sequence of state function reductions occurring at given boundary of CD. The act of free will corresponds to the occurrence of quantum jump to the opposite boundary of CD and changes the arrow of geometric time at the level of the hierarchy of CDs corresponding to self. Qualia must characterize to the experiences of self assignable to the repeated state function reductions.

The original model of qualia was based on the idea that all quantum jumps involve change of quantum numbers so that increments of quantum numbers would characterize qualia. This assumption does not make sense for the quantum jumps at the fixed boundary of CD but at the opposite boundary of CD flow of quantum numbers between two subsystems is possible. Hence the increments of quantum numbers or rather the rates for their change would characterize qualia. The capacitor model for sensory receptor, which emerged before the correct view about self, actually assumed this.

2. Model of qualia

One ends up with the following model of qualia.

1. Only the increments of zero modes and quantum numbers are experienced consciously. In the original model these increments were associated with quantum jumps: in the updated model their are associated with a flow of quantum numbers between two sub-systems at the non-fixed boundary of CD.
2. 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.
3. 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.

3. Thermodynamics and qualia

Thermodynamical approach to qualia suggested itself.

1. The sequence of the states assignable to the changing boundary of CD 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.
2. 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).

The thermodynanical expression for dE suggests a general classification of qualia consistent with the "holy trinity" of existences implied by TGD. Emotions - such as pain and pleasure

- can be identified as order-disorder qualia with the sign of the gradient of negentropy associated with negentropic entanglement defining the coloring of emotion. Kinesthetic qualia are associated with generalized forces: senses of force and torque, hearing, and intensity of color sensation would serve as examples. Generalized chemical qualia correspond to flows between two sub-systems for various quantum numbers such as those associated with charged particles, ions, molecules, Cooper pairs, etc. Chemical qualia and color vision would serve as examples. The fermionic generators of super-conformal algebras and states created by them are labeled by binary digits labeling spin like quantum numbers, whose increments could give rise to Boolean consciousness with intrinsic meaning ("This is true"). The flows associated with these binary digits could define Boolean qualia.

4. How qualia are generated?

There are two basic mechanisms generating sensory qualia.

1. 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 superconducting magnetic flux tubes provide a basic example of this mechanism, and the quantum model of hearing relies on Z^0 magnetic quantum phase transitions.
2. 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.

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of imbedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane. The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

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 [L1] and in [L2]. 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.

The recent progress in the understanding of the hierarchy has led to the discovery of a fractal hierarchy of quantum criticalities whose levels are labelled by the values of $h_{eff} = n \times h$ and understanding of evolution taking place as spontaneous integer scaling of h_{eff} reducing the criticality. This view allows to understand basic aspects of living systems elegantly. Further closely related step of progress relates to the p-adic physics as physics of cognition. The adelic view about space-time and quantum physics allows to understand cognition and imagination as basic aspects of existence also at space-time level. ZEO based view about state function reduction leads automatically to the notion of self as a sequence of state function reductions at the same boundary of CD and death of self as the first reduction to the opposite boundary where time reversed self is generated. Sensory-motor cycle could correspond to the sequence having as basic step the death of sub-self representing sensory mental image and birth of time-reversed sub-self representing motor mental image.

These advances force to modify the original view about qualia. Qualia do not correspond to increments of quantum numbers in quantum jump as state function reduction as believed first. Rather, the flow of quantum numbers between subsystem representing sub-self and environment during the life-time of self representing sensory mental image gives rise to qualia. Typical lifetime of sensory mental image is about .1 seconds. This picture is consistent with the capacitor model of qualia introduced already before explicit formulation of the modified view about qualia. This implies some modifications to the identification of qualia. For instance, in the earlier model visible colors were identified as increments of quark color quantum numbers of quark color and representable as gluon quantum numbers. In the recent model same color quantum numbers correspond to those for gluons. Furthermore, also color quantum numbers fo quarks as such can correspond to visual colors. quantum numbers in the recent picture.

1.1 The Notion Of Self And Qualia

The notion of self has been problematic and the recent progress in this respect clarifies also the situation concerning qualia. In ordinary quantum measurement theory repetition of state function reduction leaves the state unchanged. In TGD state function reduction can occur at both boundaries of causal diamond (CD) and in this case the state remains invariant only at the boundary at which the repetition takes place. This allows to understand how the arrow of time and its flow correspond essentially the increase of the average temporal distance between the tips present in the superposition of CDs with second end localized at fixed light-cone boundary. Self can be identified as a sequence of state function reductions occurring at given boundary of CD. The act of free will corresponds to the occurrence of quantum jump to the opposite boundary of CD and changes the arrow of geometric time at the level of the hierarchy of CDs corresponding to self. Qualia must characterize to the experiences of self assignable to the repeated state function reductions.

The original model of qualia was based on the idea that all quantum jumps involve change of quantum numbers so that increments of quantum numbers would characterize qualia. This assumption does not make sense for the quantum jumps at the fixed boundary of CD but at the opposite boundary of CD flow of quantum numbers between two subsystems is possible. Hence the increments of quantum numbers or rather the rates for their change would characterize qualia. The capacitor model for sensory receptor, which emerged before the correct view about self, actually assumed this.

One ends up with the following model of qualia.

1. Only the increments of zero modes and quantum numbers are experienced consciously. In the original model these increments were associated with quantum jumps: in the updated model their are associated with a flow of quantum numbers between two sub-systems at the non-fixed boundary of CD.

2. 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.

3. 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.

One can of course consider also the possibility that sensory qualia do not require any quantum number flow to the system corresponding to sub-self and it would be interesting to see whether this idea leads anywhere.

The vision about metabolism as transfer of negentropic entanglement (or rather stealing it from other conscious entities) suggests that the quantum numbers assignable to metabolites correspond to fundamental qualia. At least in the case of biomolecules serving as nutrients this could make sense. Also for olfaction metabolic qualia could be important.

1.2 Qualia And Thermodynamics

Thermodynamical approach to qualia suggested itself.

1. The sequence of the states assignable to the changing boundary of CD 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.

2. 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).

The thermodynanical expression for dE suggests a general classification of qualia consistent with the "holy trinity" of existences implied by TGD. Emotions - such as pain and pleasure - can be identified as order-disorder qualia with the sign of the gradient of negentropy associated with negentropic entanglement defining the coloring of emotion. Kinesthetic qualia are associated with generalized forces: senses of force and torque, hearing, and intensity of color sensation would serve as examples. Generalized chemical qualia correspond to flows between two sub-systems for various quantum numbers such as those associated with charged particles, ions, molecules, Cooper pairs, etc. Chemical qualia and color vision would serve as examples. The fermionic generators of super-conformal algebras and states created by them are labeled by binary digits labeling spin like quantum numbers, whose increments could give rise to Boolean consciousness with intrinsic meaning ("This is true"). The flows associated with these binary digits could define Boolean qualia.

The recent formulation of NMP - weak form of NMP - suggests strongly an optimistic analogy of thermodynamical world view. Strong NMP would demand maximum entanglement negentropy gain, and would be in case of dark matter almost deterministic principle. The weak form of NMP allows also reductions in which negentropy gain is not maximal and the negentropy of the final state can also vanish meaning vanishing entanglement entropy [K18]. At first glance TGD Universe looks like a diametrical opposite of the standard Universe. Negentropic entanglement is generated continually and entanglement negentropy increases in statistical sense and life evolves spontaneously and unavoidably. Only the analogs of thermodynamical fluctuations can perturb this trend and imply that TGD Universe is not the best possible one but on the other hand make possible even larger negentropy gains as possible for the strong form of NMP. On the other hand, in standard Universe second law says that ensemble entropy (to be distinguished from entanglement entropy) increases and life is a thermodynamical fluctuation doomed to disappear eventually. Note

that second law holds in TGD Universe for processes in which visible matter is not permanently transformed to dark matter.

One can consider the possibility that the thermodynamical relationships could be written by replacing entropy in thermodynamical formulas by entanglement negentropy. The formal structure would remain the same but interpretation would be completely different. Quantum critical systems would be those in which dark matter with large h_{eff} is generated and gives rise to long range quantum fluctuations. An interesting question is whether also thermodynamical criticality could involved generation of large h_{eff} phases [K32].

1.3 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 [J23] [K8] . 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-symplectic 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-symplectic transitions assuming p-adic length scale hypothesis. Dark matter hierarchy predicts scaled up variants of these frequencies.

A fascinating possibility is that super-symplectic generators generating the algebra are labelled by zeros of Riemann zeta so that their number is infinite. The generic state would have conformal weight which is linear combination of zeros of zeta. Conformal confinement would hold true and there are two alternatives: the real part of total conformal weight equals to 1/2 or its imaginary part vanishes. The first case could correspond to energy and second case to mass squared as observable. In the first case the number of "energy" qualia would be infinite. Energy metabolism is fundamental and the qualia associated with it could be "energy" qualia.

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. Recall that p-adic length scale hypothesis and its generalization stating that p-adic primes, which are near but below powers of any prime are favored follows now from NMP and strong form of holography. Strong form of holography allows to realize number theoretical universality in terms of string world sheets and partonic 2-surfaces (briefly 2-surfaces) by continuing them to 4-D preferred extremals and assuming that the parameters characterizing the 2-surfaces belong to an algebraic extension of rationals.

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 modellers 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.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. There are concept maps about topics related to the contents of the chapter prepared using CMAP realized as html files. Links to all CMAP files can be found at `http://tgdtheory.fi/cmaphtml.html` [L4]. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5]. The topics relevant to this chapter are given by the following list.

- TGD inspired theory of consciousness [L8]
- Quantum consciousness [L6]
- Quantum model of qualia [L7]
- Two models for cell membrane [L9]

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-symplectic algebra defining the group of isometries for the WCW . 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 field configurations which in turn determine magnetic transition 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 transitions for ions in Earth's magnetic 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 [K18] 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. This picture makes for sub-selves and was inspired by the standard view about state function reduction.

A more recent view inspired by ZEO is that qualia correspond to flows of quantum numbers between two subsystems at the boundaries opposite to the fixed boundary of CD at which state function reduction does not affect the state. Zero energy stat involves actually quantum superposition of these boundaries or equivalently, of CDs with fixed light-cone boundary containing the second boundary. This picture was actually deduced before the realization that self corresponds to sequence of state function reductions at same boundary of CD.

One can imagine at least two mechanism inducing qualia.

1. Quantum phase transition producee 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. In ZEO this self-organization process is 4-dimensional. Entire temporal patterns for fields are replaced by new ones in the size scale of CD in the process.

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.

3. "Final" solution to the problem of qualia

The TGD inspired theory of qualia [K12] has evolved gradually.

1. The original vision was that qualia and and other aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.

2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.

3. The view that emerged while writing the critics of IIT of Tononi [K33] is that qualia correspond to the quantum numbers measured in the state function reduction. That in ZEO the qualia remain the same for the entire sequence of repeated state function reductions is not a problem since qualia are associated with sub-self (sub-CD), which can have lifetime of say about .1 seconds! Only the generalization of standard quantum measurement theory is needed to reduce the qualia to fundamental physics. This for instance supports the conjecture that visual colors correspond to QCD color quantum numbers. This makes sense in TGD framework predicting a scaled variants of QCD type physics even in cellular length scales.

   This view implies that the model of sensory receptor based on the generalization of di-electric breakdown is wrong as such since the rate for the transfer of the quantum numbers would not define the quale. A possible modification of the model simple: the analog of di-electric breakdown generates Bose-Einstein condensate and the the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

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 WCW 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-symplectic and Super Kac-Moody representations. This suggests that non-geometric sensory qualia can be classified at brain level into super-symplectic qualia and Super-Kac Moody qualia.

1. Super-symplectic qualia are higher level qualia in the sense that quantum jump occurs at the level of the entire WCW rather than at the level of space-time only. The quantum number increments (spin and color quantum numbers) associated with BE-condensing super-symplectic boson characterize the quale. BE-condensation occurs for " WCW photons" rather than ordinary photons whose WCW 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 [K6].

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-symplectic and Super Kac-Moody algebras defined by WCW 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-symplectic algebra with respect to the light-like coordinate coordinate of the light-like boundary of ME so that the generators are labelled by super-symplectic 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-symplectic 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-symplectic 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-symplectic algebras [1], the latter being related to the isometries of WCW 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 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 annihilation 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 [J40]. 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 [J40] 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

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

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 WCW 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 WCW . 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 [K23] .

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 pulse".

3. Magnetic body shares the mental images created in brain via entanglement of sub-selves. From the point of view of magnetic bod the 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 [J42]). 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 could determine the emotions. Also cellular qualia about nearby chemical environment 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 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 sub-self 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-symplectic 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-symplectic 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. I

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-symplectic 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 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 fields of MEs with magnetic 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 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-symplectic qualia the number of Bose-Einstein condensed possibly colored " WCW photons" having nontrivial dependence on WCW 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 WCW 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 flux tubes 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 flux tubes. 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 flux tubes 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-symplectic and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-symplectic 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 anti-fermion at causal horizons of the wormhole contact (having interpretation as partons) are used. The assumption that only fermions/anti-fermions 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".

In zero energy ontology quantum states are pairs of positive and negative energy states with opposite net quantum numbers. Therefore it is possible to represent Boolean statements in such a manner that fermion number represents bit. This also gives rise to a representation of Boolean rule $A \rightarrow B$ as quantum superposition of pairs of Fock states of fermions with individual instances of A and B represented by the states in the Fock basis for fermions. The basic "laws" for this system of rules would be consistent with the conservation laws.

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 [K13] 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. The most plausible realization of the codon of the memetic code is in terms of electron's CD of duration.1 s containing d quark sub-CDs of duration 1/1.28 ms representing the bits. 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 $T = rT_0$, $T_0 = .1$ seconds and r is integer valued.

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 of the 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 [J40] 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 [J40] 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 [K17]. 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 [J40] 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-symplectic qualia associated with vision only?

Super-symplectic 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-symplectic 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-symplectic BE condensation type phase transitions or possible phase transition changing the direction of spin polarization of the BE condensate of WCW 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-symplectic 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-symplectic-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-symplectic 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-symplectic 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 WCW photons belonging to only single color representation are produced in sensory pathway. It is difficult to imagine a mechanism producing WCW photons belonging to only single color representation unless it is octet representation. One could also argue that only WCW 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 [J36] 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 [J18]. 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 slightly 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-Symplectic Algebra

Super-symplectic 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 [A3] about the dance of honeybee, makes sense.

TGD predicts that classical em field are accompanied by classical long range color fields and super-symplectic 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 [J42]. 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 [J36]. 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:

$$\begin{array}{ll} \begin{pmatrix} 0 \\ 1 \end{pmatrix} \leftrightarrow white & \begin{pmatrix} 0 \\ -1 \end{pmatrix} \leftrightarrow black \\ \begin{pmatrix} 1 \\ 1/2 \end{pmatrix} \leftrightarrow red & \begin{pmatrix} -1 \\ -1/2 \end{pmatrix} \leftrightarrow green \\ \begin{pmatrix} 1 \\ -1/2 \end{pmatrix} \leftrightarrow blue & \begin{pmatrix} -1 \\ +1/2 \end{pmatrix} \leftrightarrow yellow \end{array} \tag{3.1}$$

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 [J36] 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 [J36].

   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-symplectic 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-symplectic qualia labelled by color and spin quantum numbers. The general objections against assigning other than visual colors and polarization sense to super-symplectic 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 flux tubes 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 [I12]. 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 [I12].

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 [J2], 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 [J2].

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-symplectic 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-symplectic transitions, integer multiples of the fundamental frequency generate maximum response. Good sensory acuity requires that fundamental frequency of the super-symplectic 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-symplectic 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 [J35]. 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 [I12] 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 [K24] 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 r 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.

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 [J20]. 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 averagings 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-symplectic level.

If p-adic length scales define preferred lengths for MEs, then there is a difference between magnetic and super-symplectic 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.

3.4 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 quantum phase transitions as well as super-symplectic transitions could give rise to similar kinesthetic qualia. Since super-symplectic 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 WCW 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 perhaps formal and one must compare it with alternative possibilities.

The quantum model of hearing [K22] has evolved through painful steps. At this moment it however seems that basic auditory quale could correspond to an increment of electroweak spin at the level of cell membrane (see the discussion towards the end of the chapter). The increment of electroweak spin can be assigned to either quark pair assignable to a lipid of receptor membrane or a pair of quark pairs assignable to separate receptor membranes and joined by flux tube during sensory reception. The experienced pitch in turn seems to correspond to a quale of magnetic body and correspond to a frequency modulation of Josephson frequency by the frequency of the sound [K8] .

The modulation of Josephson frequencies would provide a completely general representation of sensory and other information at the magnetic body. Music metaphor allows to see this representation as analogous to that produced by a choir of of whales. Both neurons and astrocytes are expected to sing and the value of Planck constant for a given neuron or astrocyte characterizes the octave associated with this particular singer. Speech and song would be direct motor expressions of this representation. Also ordinary speech involves frequency modulation as becomes clear by playing a recorded speech with abnormally slow rate.

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 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 [J40].

"Push-or-twist" metaphor would allow to assign figure-background separation also to super-symplectic spin flips. For super-symplectic 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.

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 flux tubes 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 flux tubes 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.

flux tubes 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 flux tubes inside cortex and this requires that the energy for the generation of flux tube is extremely small, of order of 10^{-14} eV for 10 Hz frequency for ordinary value of $\hbar$: for $k_d = 40$ level of dark matter hierarchy energy is above thermal threshold. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}.

The flux tubes 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 bonds/flux tubes 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-symplectic 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 by replacing second law with NMP 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 [J15]. 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 [J15]. 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 [J22] 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 [J15]. 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-symplectic 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 [J15].

According to Damasio [J15], 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 [J15]. 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 [J17] 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 biomolecules 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 transition frequencies of peptides (short proteins acting as hormones) correspond to

geometric aspects of emotional qualia. The cyclotron frequencies of singly charged amino-acids 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 WCW 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-symplectic 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 [K24] 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 metaphorical 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 [K27] 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 [J7]. 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 ask how the structural and functional hierarchy of CNS and the hierarchy of emotions relates to the dark matter hierarchy. The basic picture wherefrom one can start is following.

1. The emergence of nervous system corresponds to the emergence of $k_{eff} < 205$ levels of dark matter hierarchy above $k_{eff} < 167$. For instance, worms and insects would correspond to this level.

2. Vertebrates have EEG and thus the most primitive vertebrates (reptiles) should correspond to $k_{eff} \geq 205$.

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_{eff}. Also the maximum span of memories at given level should be characterized by the value of k_{eff} 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 $k_{eff} \leq 205$ most naturally.

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 one can as whether they could be assigned to organs consisting of ordinary cells and correspond to $k_{eff} \leq 205$.

1. The time scale of planned behavior and of long term memories makes possible to estimate upper bounds for the values of k_{eff} assuming Josephson frequency hypothesis. $k_{eff} \leq 205$ would give the upper bound of 6 ms which corresponds to cerebellar resonance frequency 160 Hz. This time scale looks too short even for the simplest vertebrates and one must be very cautious here.

2. An alternative interpretation is as the shortest possible span for short term memory whose time scale is known to vary.

3. Cerebellar rhythm could be analogous to hippocampal theta rhythm and involved with the cebellar memory storage and therefore would not tell anything about the span of the memory but would characterize the time resolution of memories and planned actions. The role of cerebellum in the fine coordination of motor actions indeed requires high time resolution.

Brain has anatomic division into midbrain, hindbrain, and forebrain [J4]. Midbrain and hindbrain (sometimes both are included in brain stem) is possessed by even the most primitive vertebrates and its emergence could therefore correspond to the emergence of $k_{eff} \geq 205$ levels and EEG. The emergence of these 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 the Gaussian Mersenne defined by $k_{eff} = 239$ containing dark electron condensates 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 $k_{eff} \leq 205$ system?

Reptilian brain contains only the structures corresponding to brain stem (midbrain and hind brain, in particular cerebellum) and as far structures are considered would correspond to $k_{eff} \leq 205$ levels of the hierarchy. Cerebellum is not believed to contribute directly to our consciousness. The absence of higher looks however an unrealistic assumption since reptiles certainly have long term memories.

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 [J10]. 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 [J10] 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 $205 < k_{eff} < 239$.

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. The time scale of memories would be shorter than 3.4 at this level.

3. Frontal lobes [J6] 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. The Gaussian Mersenne levels $k_{eff} = (239, 241)$ could be assigned as lowest level in this hierarchy. The time scale of long term memories would be longer than 3.4 years at these levels.

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 lobes.

These levels would naturally 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 a crucial prerequisite of a 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 $k_{eff} \geq 239$ (defining Gaussian Mersenne) as a whole. The decomposition of sensory areas to layers is consistent with the presence of lower levels 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 consistent with $k_{eff} \leq 205$. 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 $k_{eff} < 239$ would 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 [J6] 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 first thing to ask is of course whether the notions of short and long term memory make sense in TGD framework. Indeed, it would seem that it is more natural to speak about hierarchy of memories with characteristic time scales coming as selected powers of two.

1. According to [J13], the span of other than visual short term memories is 30-45 seconds. This requires $k_{eff} \in \{217, 218\}$.
2. Visual short term memories [J1] representing selected features of visual field are reported to have time span of few seconds. This suggests $k_{eff} \in \{213, 214, 215\}$.
3. Iconic visual memories representing entire visual field have much shorter time span of order 1 s: $k_{eff} \in \{211, 212\}$ would be appropriate for them,
4. Long term memories would correspond to $k_{eff} > 218$.

Hippocampus and mammillary bodies involved with long term memory recall are part of the limbic system. The hippocampal theta rhythm 4-12 Hz, which could corresponds roughly to $k_{eff} \in \{163, 162, 161\}$ has nothing to do with the span of long term memories but would define the time resolution of the memories: the moment of sensory experience indeed corresponds to 10 Hz frequency. The frequencies responsible for memory storage need not have anything to do with the ultralow frequencies characterizing the temporal distance of the past event associated with the memory recall and hippocampus could just build a 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 faster rhythms of the 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?

$k_{eff} > 245$ levels of dark matter hierarchy correspond to time span longer than 109 years and cannot relate to the biological body alone. They could relate to higher collective levels of the dark matter hierarchy and evolution of social structures. The memories extending over personal life span claimed by meditators could have interpretation in terms of $k_{eff} > 245$ transpersonal levels of consciousness. Also the "god module" located to temporal lobes could correspond to this kind of levels of dark matter hierarchy. If it corresponds to Gaussian Mersenne with $k_{eff} = 283$ the time scale of memories becomes huge: about 10^{14} years so that the notion of "god module" is indeed appropriate.

3.8.6 Boolean qualia, fermions, and memetic code

The original proposal for the realization of Boolean mind was in terms of sequences cognitive neutrino pairs. These can be interpreted as wormhole contacts carrying neutrino and antineutrino at the light-like wormhole throats and would thus represent boson like entities. In the framework of the standard model the proposal looks of course completely non-sensical. TGD however predicts the existence of long range classical electro-weak fields, and one might imagine that inside neutrino- whose Compton length corresponds to length scale of cell- intermediate gauge bosons behave like massless fields. Although neutrinos could be important, the time scale of corresponding CD - about 10^4 years - suggests that cognitive neutrinos might be important in much longer time scale than the.1 second time scale assignable to the memetic code.

The recent view about TGD allows a much more general view. Zero energy ontology allows to interpret the fermionic parts of zero energy states as quantum superpositions of Boolean statements of form $a \rightarrow b$ with a and b represented in terms of positive and negative energy parts of the zero energy state. If one has negentropic entanglement this kind of state has interpretation as an

abstraction - a "law of physics" - representing as a quantum superposition various instances of a more general law.

The simplest situation corresponds to a CD having only single positive energy fermion and negative energy fermion at its light-like boundaries. The fermion number or spin or isospin of the fermion could represent qubit. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, led to a prediction of order .1 seconds for the duration of the "wake-up" period of sub-self corresponding to the codeword of the memetic code. Since the CD assignable to electron has time scale.1 seconds and the CD assignable to u and d quarks has time scale 1/1.28 milliseconds there is a temptation to proposed that the quark-like sub-CDs of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub-CDs. u and d quarks would be assigned to the magnetic flux tubes connecting DNA and the lipids of the cell membrane in the model of DNA as topological quantum computer. Clearly, beautiful connection between new elementary particle physics, genetic code, nerve pulse activity, DNA as topological quantum computer, logical thought, and the basic time scales of speech are suggestive.

This codeword consists of 126 bits represented by quarks such that the two possible magnetization directions correspond to the two values of Boolean statement. This implies that the duration of single bit should 1/1260 seconds. The duration of the nerve pulse is slightly longer than this which might mean that the full memetic code is realized as membrane oscillations rather than nerve pulse patterns. Both hearing and vision have .1 second time scale as a fundamental time scale and sounds are indeed coded to membrane oscillations in ear.

One can consider also the realization of genetic code with six bits of the codon represented by various scaled up versions of quark CD coming as size powers of 2. In this case the ordering of the bits would come from the size of sub-CD whereas in previous example temporal ordering would define the ordering. It is not however clear whether the powers of two can be realized physically.

One can understand the number 126 as related to the total number of separately experienced frequencies in the interval $20 - 20.000$ Hz spanning 10 octaves. $10 \times 12 = 120$ is not far from 126: here 12 corresponds to 12 tones of basic music scale. Also speech has 10 Hz frequency as fundamental frequency. In visual primary cortex replicating triplets, 4-, 5- and 6-plets of spikes with highly regular intervals between spikes have been detected. The triplets are accompanied by ghost doublets. This would suggest a coding of some features of visual experience to reverberating mental images. The time scale for various patterns is.1 seconds. This could be seen as a support for the realization of some degenerate version of the memetic code as nerve pulse patterns.

The model for the memetic code encourages the following conclusions.

1. Membrane oscillation/nerve pulse patterns correspond to temporal sequences of magnetization directions for quarks representing yes/no Boolean statements.

2. The spin polarization of quarks is changed from the standard direction fixed by the spontaneous magnetization in the direction of axon by a ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses could correspond to a degenerate memetic code resulting by frequency coding for which the number of distinguishable code words is 64, and would thus naturally correspond to the reduction of the memetic code to the genetic code.

A very precise correspondence with the basic structures of the genetic code results. mRNA $\rightarrow$ protein translation corresponds to the translation of temporal sequences o magnetization directions to conscious cognitive experiences. Under very natural constraints the mapping to cognitive experiences is not one-to-one and the predicted degeneracy (2^{126} sequences correspond to $(2^{126} - 1)/63$ cognitive experiences) can be understood.

One might think that the full memetic code is an evolutionary newcomer and involved only with the logical thought: this would explain the completely exceptional characteristics of human brain. The full memetic code could be realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech.

4 Constraints On The Fermionic Realization Of Genetic Code From The Model For Color Qualia

The original model for DNA as topological quantum computer assigns to DNA nucleotides quarks at ends of flux tubes or quark pairs at the ends of wormhole flux tubes. This is only the realization that came first to my mind in TGD Universe where dark variants of quarks can define QCD like physics even in cellular length scales. One can actually imagine several realizations of the genetic code and the first realization is far from being the simplest one. It is enough to have four different particles or many-particle quantum states to build at least formally a map from A, T, C, G to four states. It is obvious that the number of possible formal realizations is limited only by the imagination of the theoretician. Additional conditions are required to fix the model.

4.1 Fermionic Representation

Consider first the fermionic representations in the general case without specifying what fermions are.

1. The original proposal was that DNA nucleotides correspond to flux tubes with quark q and antiquark $\overline{q}$ at the ends of the parallel flux sheets extremely near to each other. Second options relies on wormhole magnetic flux tubes in which case quark pair $q\overline{q}$ is at both ends. Quarks u, d and their antiquarks would code for A, T, C, G. The spin of quarks is not taken into account at all in this coding: why not restrict the consideration to single quark. The total quark charge at given end of flux tube pair vanishes and flux tube ends carry opposite quark charges.

   The nice feature of this option is that one could understand the generation of color qualia in the model of sensory receptor in simple manner to be discussed below. Even if one accepts the arguments supporting the view that dark quarks in cell scale are natural outcome of the hierarchy of Planck constants, one could argue that the presence of both quarks and antiquarks does not conform with matter antimatter asymmetry (not that one can however identify the analog of matter antimatter asymmetry at DNA level).

2. Spin states for fermion pairs assigned with two parallel magnetic flux tubes with the magnetic field generated by spin provide much simpler representation for nucleotides. Similar fermion pair would reside at the second end of flux tube pair.

   (a) It is is essential that rotational symmetry is broken and reduces to rotational symmetry around the direction of flux tubes so that spin singlet and spin 0 state of triplet mix to form states for which each fermion is in spin eigenstate. The states must be antisymmetric under exchange of the protons and spin 1/0 states are antisymmetric/symmetric in spatial degrees of freedom (wave functions located to the ends of flux tubes). The states with definite spin for given flux tube are mixtures of s=1 states with vanishing spin projection and s=0 state.

   (b) It is not quite clear whether one should treat fermion pairs as identical bosons with 3+1 spin states since in TGD framework one considers disjoint partonic 2-surfaces and the situation is not that of QFT in M^4. This interpretation would require totally symmetry of the states under permutations of bosonic states defined by the 3+1 spin states. Coding by spin requires that each nucleotide corresponds to a state with a well defined spin. In field theory language the state would be obtained by applying bosonic oscillator operators generating states of given spin localized to a given nucleotide position.

   (c) The classical correlate for the permutations of coordinates of fermions has interpretation as braiding for the flux tubes of the flux tube pair. In the similar manner the permutation of the flux tube pairs associated with nucleotides has interpretation as braiding of the 3-braids formed form from flux tube pairs. Braiding therefore gives a representation of spin analogous to the well-known orientation entanglement relation invented by Dirac and providing geometric representation of spin 1/2 property.

4.2 Various Options For The Fermionic Representation Of A, T, C, G

Fermionic representations allows several options since fermion can be electron, u or d quark, or proton. Wormhole magnetic fields would not be needed in this case.

1. The problem of electron and proton options is that it does not allow realization of color qualia. There is also the well-known problem related to the stability of DNA caused by the phosphate charge of -2 units per nucleotide. Somehow this charge should be screened. In any case, the charge -2 should correspond to the electron pair at the DNA end of the flux tube for electron option. For proton option the charge would be screened completely. One could of course consider also the large $\hbar$ color excitations of ordinary protons instead of quark at its nucleotide ends. This option would however require the modification of quark wave functions inside proton and this option will not be discussed here.

2. Quark option would give rise to both color and allow also to reduce the electronic charge of -2 units by 4/3 units to -2/3 units in the case of u quark pair. This would help to stabilize DNA. In the case of d quarks the charge would increase to -10/3 units and is not favored by stability argument. Flux tube pairs assigned to single nucleotide define diquarks with spin 1 or spin 0.

   (a) Diquarks behave ass identical bosons with 3+1 spin states and 3×3 color states. They form formally super-multiplet of $\mathcal{N} = 2$ SUSY. The states with well defined symmetry properties in spin degrees of freedom have such properties in spatial degrees of freedom. This means that one obtains a superposition of flux tube pairs with are either braided or unbraided. Triplet/singlet state is symmetric/antisymmetric and total asymmetry could be guaranteed by assuming symmetry/antisymmetry in spatial degrees of freedom and antisymmetry/symmetry in color degrees of freedom. This would give anti-triplet/6-plet in color degrees of freedom. Spatial symmetry would favor antitriplet and diquark would behave like antiquark with respect to color. Let us assume antitriplet state for definiteness.

   (b) DNA codon corresponds to three-di-quark state. This state must be totally symmetric under the exchange of bosons. One can have total symmetry in both spatial and color degrees of freedom or total antisymmetry/symmetry in spatial and total antisymmetry/symmetry in color degrees of freedom.The first option gives 10-dimensional color multiplet and the second one color singlet. Braiding is maximal and symmetric/antisymmetric in these case. One can consider also mixed symmetries. In this case one has color octet which is antisymmetric with respect to the first nucleotide pair and symmetric with respect to first nucleotide pair and third nucleotide. The braiding of the first two nucleotides must be antisymmetric and the braiding of this pair with third nucleotide. The conclusion would be that color multiplets correspond to well defined braidings and one would therefore have directed connection with topological quantum computation. Color octet is especially interesting concerning the representation of color qualia.

The challenge of all these options (note that the representability of color selects quark option) is to find a good justification for why the assignment of A, T, C, G to quark states or spin states is unique dynamically. Stability argument is expected to help here.

4.3 Realization Of Color Qualia For Quark Option

Consider now how one could understand the generation of qualia for quark option.

1. The generation of qualia involves interaction with external world giving rise to a sensory percept. In the case of visual colors it should correspond to a measurement of quark color and should give rise to eigenstages of color at the ends of flux tubes at DNA nucleotides for a nucleus or cell of photoreceptor. A modification of capacitor model is needed. Color polarization is still essential but now polarization in nucleus or cell scale is transformed in the generation of color quale to a polarization in longer length scale by the reconnection of

flux tubes so that their ends attach to "external world". The nucleus/cell becomes color and state function reduction selects well defined quantum numbers. It is natural to assume that the entanglement in other degrees of freedom after color measurement is negentropic.

2. Does the "external world" corresponds to another cell or to the inner lipid layers of the cell membrane containing the nucleus. In the first case flux tubes would end to another cell. If the nuclei of receptor cells are integrate to a larger structure by magnetic flux sheets traversing through them one can also consider the possibility that the polarization in the scale of cell nucleus (recall that the nucleus has also double lipid layer) is transformed to a polarization in cell scale so that similar process in cell scale gives rise to qualia.

   The entire receptor unit must have net color charge before the state function reduction. This requires that there are flux tubes connecting the receptor unit to a unit representing "external world" and having vanishing color charge. If second cell is the "external world" these flux tubes must go through the pair of lipid layers of both cell membrane and end up to the nucleus of cell in the environment. If external world correspond to the complement of nucleus inside cell the inner layers of cell membrane represents external world. Cell membrane indeed serves as sensory receptor in cell length scale. One can of course have sensory qualia in various length scales so that both options are probably correct and a kind of fractal hierarchy is very natural giving rise also to our qualia at some higher level. Living matter as conscious hologram metaphor suggests a fractal hierarchy of qualia.

   After state function reduction reducing the entanglement the flux tubes split and the receptor becomes un-entangled with external world and has vanishing color charges. At the level of conscious experience this means that there can be only memory about the quale experience. The sensation of quale lasts with respect to subjective time as long as the negentropic entanglement prevails. There is an obvious analogy with Orch OR proposal of Hameroff and Penrose in which also conscious experience ends with state function reduction.

3. Consider now how the color qualia are generated.

   (a) There must be two flux tube states. In the first state there are two flux tube beginning from cell nucleus A and ending to the inner lipid layer a_1 and flux tube beginning from the outer lipid layer a_2 and ending cell nucleus B. Both flux tubes have vanishing net color so that cells have vanishing net colors. This could be regarded as the resting state of the receptor. The lipids in layers a_1 and a_2 are connected by another short flux tube. Same for b_1 and b_2.

   (b) The second flux tube state corresponds to long flux tubes connecting the nuclei of cells A and B. The ends carry opposite color charges. In this case the net color of both A and B is non-vanishing. This state would be an outcome of a reconnection process in which the flux tubes from A to a_1 and B to a_2 re-connect with the short flux tube connecting lipid layers a_1 and a_2.

   (c) When these flux tubes carry opposite colors numbers at their ends, the cell possess net color charge and can represent color quale. Or rather, creation of this kind of flux tube connections would give rise to the color charging of the receptor cell with external world carrying opposite color charge.

One can argue that this mechanism is not quite in spirit with color capacitor model. Polarization is still essential but now polarization in receptor scale is transformed to polarization in longer length scale by the reconnection of flux tubes. The analog of di-electric breakdown however still applies in the sense that its analog induces large polarization. Several mechanisms generating larger polarization are of course possible. One can ask how essential the electromagnetic polarization of cell membrane is for the generation of qualia at cell level. Note also that biomolecules are quite generally polar molecules.

The unexpected prediction of the model is that braiding would correlate directly with qualia. This would mean also a connection between quantum computation and qualia. This condition emerges from Fermi/Bose-Einstein statistics correlating braiding with symmetric properties of color states and spin states. Quite generally, the correlation of braiding with the symmetries of wave

functions as functions of points of braid end points would allow to have direct geometric correlate between induced entanglement and braiding as naive intuitive expectations have suggested.

This model is not consistent with the naive expectation that the quale is generated after state function reduction. Rather, the beginning of sensation of quale means beginning of negentropic entanglement and fusion with external world and state function usually associated with the quantum measurement would mean the end of the sensation and separation from the external world! Maybe one can say that state function reduction means that experience is replaced with a memory "I had the sensation of quale" ! Krishnamurti would certainly agree!

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 [A3]. 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-symplectic algebra and the findings of the Barbara Shipman will be discussed in TGD framework.

5.1 Basic Structure Of WCW

The basic mathematical structure of quantum TGD is the infinite-dimensional space of 3-surfaces. If Kähler action were deterministic, WCW 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.

WCW 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 WCW 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-symplectic 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 [A3] [A3] emerges naturally for MEs.

5.2 Quantum Honeybee

Barbara Shipman [A3] 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" [J43].

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 [A3] 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 [A3] 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 [A2, A1]. 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. The simplest extremals of Kähler action have 2-dimensional CP_2 at a geodesic sphere of CP_2, which can be homologically non-trivial or trivial. For the first option classical electromagnetic and W fields are non-vanishing. For the latter option electromagnetic and Z^0 fields are non-vanishing and proportional to each other. Almost vacuum extremals provide a detailed model for both sensory receptor and basic sensory qualia and will tbe discussed at the end of the chapter whereas far from vacuum extremals seem to provide a model for magnetic bodies. Also the simplest MEs can be classified to these two types.

2. The holonomy algebra of color group is Abelian and one 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.

3. 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. How flag-manifolds emerge from first principles?

A deeper explanation for flag-manifold emerges in zero energy ontology combined with the hierarchy of Planck constants.

1. Zero energy states correspond to entangled pairs of positive and negative energy states located at the opposite light-like boundaries of a given causal diamond (CD) defined as the intersection of future and past directed light-cones. Strictly speaking a Cartesian product of CD with CP_2 is in question. CDs form a fractal hierarchy. In the ordinary ontology zero energy state corresponds to a physical event. The time-like entanglement between positive and negative energy states defines M-matrix generalizing the notion of S-matrix. Time-like entanglement must be fundamental also from the point of view of consciousness as a reduction of quantum state to a state with well defined values of observables for the initial (positive energy) and final (negative energy) states. The Cartesian product of causal diamond CD defined as the intersection of future and past directed light cones with CP_2. CD is characterized by the positions of its tips so that one has M^4 valued cm coordinate plus relative coordinate between the tips. p-Adic length cale hypothesis follows if the proper time distance is quantized in powers of two. This suggests that also the of the tip at the hyperboloid with constant proper time is discrete and that discrete lattice like structure defined by some discrete subgroup of SL(2, C) acting as boosts on given reference CD.

2. The hierarchy of Planck constants forces a generalization of the imbedding space to a book like structure [K11, K9, K7, K2, K3]. The pages of the Big Book are characterized by two numbers x_a and x_b assignable to M^4 and CP_2 degrees of freedom. The values of these numbers are either integers of their inverses depending on whether the page of the book is a singular covering or factor space defined by a discrete subgroup of SU(2). For a given CD the sectors characterized by different integers are glued together along $M^2 \subset M^4$ defining quantization axis of energy and spin. In CP_2 degrees of freedom the gluing is along a homologically trivial geodesic sphere of CP_2 and also now a fixing of the quantization axes is involved. The positions of the tips of CD and preferred points of CP_2 at the two light-like boundaries of CD fix the quantization axis and moduli space for CDs. An attractive

hypothesis is that the relative positions of tips and corresponding preferred points of CP_2 form discrete spaces. The quantization of the temporal distance between tips in powers of two implies p-adic length scale hypothesis.

3. The tips of CD define a preferred time coordinate, which together with M^2 defines the quantization axes of energy and spin. In the case of CP_2 has also a choice of color and isospin quantization axes implied by the choice of a pair of CP_2 points and the choice of S^2. This means that one has a flag-manifold defined by the choices of quantization axes for energy and momentum one one hand and for color quantum numbers on the other hand. Therefore the model for the honeybee dance finds a justification from the first principles of quantum TGD.

4. 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 sequence summarizing 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 [B1] 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

$$H = \sum_{a=1}^{n} \left[\frac{1}{2}(P^a)^2 + exp(-Q^{a+1} + Q^a) \right] \ . \tag{5.1}$$

Toda equations allow group theoretical interpretation [B1] . 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

$$L = \frac{1}{2} \sum_{a,b=1}^{n-1} \frac{dq^a}{dt} K^{-1}_{ab} \frac{dq^b}{dt} - \sum_{a=1}^{n-1} exp(-q_a) \ . \tag{5.2}$$

The equations of motion for S read as

$$\frac{dS}{dt} - [S,U] = \frac{1}{2} \sum_{a,b=1}^{n-1} H_a K^{-1}_{ab} \left[\frac{d^2 q^b}{dt^2} - \sum_{c=1}^{n-1} K_{bc} exp(-q_c) \right] = 0 \ , \tag{5.3}$$

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 [A2, A1]). 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

$$\begin{aligned} \frac{dS}{dt} &= i[H,S] \ , \\ S &= b_- + \varepsilon \ , \\ H &= \Pi_{N_-} S \ . \end{aligned} \tag{5.4}$$

$H = \prod_{N_-} S$ is the strictly lower triangular part of S, which is nilpotent, and acts as a non-hermitian 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 $H = \frac{1}{2}Tr(S^2)$ [A1]. 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 non-vacuum 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.

"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 [K5]. 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 [K26, K20, K11]. 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 [K1, K8]. 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 [K5, K4]. 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 [K29, K11] play a fundamental role in the formulation of quantum TGD [K5, K4]. 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. Finite measurement resolution [K4] 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 [I8]. 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 [K23] and EEG [K8] emerge. One of the most fascinating applications is the model of DNA - cell membrane system as a topological quantum computer (TQC) [K10]: this model leads to a further insights about findings of Shipman.

1. The model for DNA as topological quantum computer [K10] 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) [K30]. 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 nth 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 [L3], [L3] 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 $F = SU(3)/U(1) \times U(1)$. The original belief was that -in contrast to standard model- color rotations in general do not leave classical electromagnetic field invariant. There are however good arguments based on the Abelian holonomy of the classical gluon fields showing that color rotation only induces an Abelian gauge transformation so that the induced gauge field remains a superposition of gauge transformed em field and W boson field *resp.* em field and Z^0 field corresponding to the two kinds of geodesic spheres. This also conforms with the general vision about electro-weak symmetry breaking taking place already at the level of CP_2 geometry. Hence color rotations are not visible at the level of classical interactions as was the original belief inspiring the idea that color rotation would affect the resting potential of cell membrane and have thus a direct neuronal correlate.

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 topological quantum computation (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.

6 A General Model For Qualia And 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.

6.1 A General Model Of Qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could corresponds to some kind of quale- perhaps "a feeling of existence". This could make sense for the qualia of the magnetic body.

2. Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Käjhler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could would represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boots of sub-CD representing mental image about the object.

3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

6.2 Detailed Model For The Qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K10].

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement beween positive energy parts of the states associated with the sub-CD assignable to the cell membrane and sub-CD at the magnetic body is expected to be an important factor.

2. For the standard value of $\hbar$ the basic prediction would be 1 ms second time scale of d quark, 6.5 ms time scale of u quark, and.1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates $m(u) = 2$ MeV and $m(d) = 5$ MeV for the quark masses [C1]. These time scales correspond to 10 Hz, 160 Hz, and 1280 Hz

frequencies, which all characterize neural activity (for the identification of 160 Hz frequency as cerebellar resonance frequency see [J24]). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.

3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the u and d quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.

4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.

   (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K25]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.

   (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.

   (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.

5. Two identification of primary qualia are therefore possible.

   (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.

   (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.

6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.

7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neutron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.

8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large $\hbar$ for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.

2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order 10^7 longer than the d quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of d quark CD by a factor of 10^{14} to about 10^4 years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.

3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding d quark CDs would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-CDs could define what might be called memetic codon representation of the nerve pulse sequence.

4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$ define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with $k = 120$ would be replaced with $k = 163$ (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and.5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with $k = 123$ $k = 163$ (167) one would give masses.8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

   In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

6.2.1 Overall view about qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has 3×7 *resp.* 6×8 combinations of colorless *resp.* colored qualia.

2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with $9 \times 16 - 1$ points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.

3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualia and and electroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for "quantum synesthesia" cross association works in both directions and this distinguishes it from the ordinary synesthesia.

4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.

5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the

magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

6.2.2 Guesses about detailed identification of the qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K23]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide an manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.

2. Also tastes and odours define qualia with "colors". Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give c 3×4 basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J35] would conform with this picture.

3. Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

   The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggests that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nocireceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

6.2.3 Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated

to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary a sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the "feeling of existence" type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. One the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the "feeling of existence" at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.

2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of $\hbar$ must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons and EEG. One expects that only high level qualia can correspond to a very large values of $\hbar$ needed.

   For the sake of completeness it should be noticed that one might do without large values of $\hbar$ if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

6.3 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.

6.4 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.

6.4.1 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 WCW photons.

6.4.2 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.

6.4.3 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 [K7, K8] 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.

6.4.4 WCW photons?

TGD predicts also WCW color degrees of freedom. What is remarkable is that these states do not carry any energy and momentum. Actually infinite-dimensional super-symplectic 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.

6.5 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 characterstic 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.

6.5.1 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 [I6] 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 [I10]. 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 [J27] 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 generated. 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 [J37] and this could be crucial for the generation of the macro-temporal quantum coherence, which quite generally relies on the generation of flux tubes 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.

6.5.2 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 [J25] 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 [I13] 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.

6.5.3 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 [I1] [K14] 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 sticking 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 [K15] 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 [J33] 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) [J33] 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 [I7] 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 feasibility 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 [I7]) 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 [I7]. 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.

6.5.4 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 [I13].

2. In vertebrates *resp.* invertebrates incoming color generates hyper-polarization *resp.* polarization of the receptor membrane [I13]. 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 [A4], [I4]. 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 [A4], [I4] 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. Endoderm 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. Ectoderm 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 [A4] , [I4]. 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 psychokinetic 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 [J34] 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 [I12].

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 [I5].

6.5.5 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 [J26]. 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) [J30]. 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 [J28] 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 [J28] 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 [J34] 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.

6.6 Some Examples About Deficits Of Color Vision As A Test Of The Model For Cognitive Representations

The article "Quining the Qualia" by Daniel Dennett gives [J21] a good view about the difficulties encountered as one tries to understand qualia as a philosopher. Dennett's reaction to the problems is to give up the notion of qualia altogether. To me this is like denying the causal role of consciousness just because we do not have mathematical and conceptual tools to describe it. This is however not the main point now. Dennett lists some fascinating empirical findings related to deficits in color vision, which serve as excellent tests for any theory of qualia.

It is instructive to consider these examples in the framework provided by the model of cognitive representations just discussed. For this purposes let us list the basic general assumptions of the model in the case of color vision.

1. The paradoxical fact that receptor cells hyper-polarize rather than depolarize as they receive light is consistent with the requirement that incoming light must increase the color voltages between cone system and its magnetic body in order to generate color discharge. Rods would

differ from cones in that the full color algebra SU(3) to its sub-algebra SU(2) so that only the increments of color isospin I_3 would be perceived and would give rise to black and white as primary qualia. Thus only charged SU(2) gluons are exchanged between the magnetic body associated with the rod system.

In the case of cones the most natural assumption is that all 3+3 colors (black and white are counted as colors) are perceived and correspond to increments of color isospin and two generators carrying hyper charge. Single cone could be specialized to produce up the increment of color quantum numbers corresponding to a particular primary color. The increment of color quantum numbers should always have the same sign in the ideal situation (only quale which is red or green, blue or yellow, black or white is produced if the highest weight or lowest weight states of the representation of color algebra (or color Kac-Moody algebra) define the ground state of the system.

2. Cortex is assumed to participate actively to the coloring of the sensory map by using back projections to retina and the experienced color map is an outcome of a complex information processing.

3. The magnetic bodies of retina would contain regions where colors are cognitively represented as an analog of color circle so that the over all color sensation generates cognitive and emotional representations as a "somatosensory" experience at the magnetic body realized as cyclotron phase transition patterns. Pure colors would correspond to patterns localized at single point of the magnetic body whereas mixed colors would correspond to de-localized patterns.

6.6.1 First example

Objects to the right of the vertical meridian appeared to be of normal hue, while to the left they were perceived only in shades of gray, though without distortions of form... He was unable to recognize or name any color in any portion of the left field of either eye, including bright reds, blues, greens and yellows. As soon as any portion of the colored object crossed the vertical meridian, he was able to instantly recognize and accurately name its color.

This finding could reduce the plausibility of the hypothesis that sensory organs are seats of sensory qualia and of primary cognitive and emotional representations. The hypothesis passes the test. Retina decomposes to nasal and temporal retina. This corresponds to the decomposition of the visual field of retina to right and left hemifields [J5]. The inability to recognize and name colors in the left visual could be simply due to the fact that cones sensitive to color are not functioning properly or at all in the left temporal and right nasal retina. A more complex situation would results if parts of cortex responsible for the back projections to the left visual field want to "see the world as grey" and actively reduce the color map to the shades of grey.

6.6.2 Second example

The patient failed in all tasks in which he was required to match the seen color with its spoken name. Thus, the patient failed to give the names of colors and failed to choose a color in response to its name. By contrast, he succeeded on all tasks where the matching was either purely verbal or purely nonverbal. Thus, he could give verbally the names of colors corresponding to named objects and vice versa. He could match seen colors to each other and to pictures of objects and could sort colors without error.

What was remarkable that the patient was not aware of any deficit.

There is an obvious analogy with the phenomenon of absolute ear. Almost anyone can tell whether two notes have the same pitch but only people with absolute ear learn to name the heard note. In the case of color vision almost all of us have "absolute eye" in the sense that we can recognize the perceived color and name it but in the above described case this ability would be lost. The analogy is weakened by the fact that musicians not possessing absolute ear are quite well aware of their "deficit".

Accepting the analogy, the TGD based model for absolute ear generalizes as such to the recent situation. The model of absolute ear is based on a comparison in which reference dark photon signal is sent from the temporal planum [J32] to the magnetic body assignable to the cochlea.

Recognition relies on the constructive interference of the dark photon signals from cochlea and temporal planum enhancing the rate for the cyclotron phase transition. This model generalizes to a general model for how conscious pattern recognition occurs at the level of the magnetic body and applies in the case of vision too.

1. There should exists a region of visual or associative cortex analogous to the temporal planum sending a dark photon signal to the magnetic body of retina.

2. That the patient is not aware of the syndrome suggests that the reference signal representing given name of color as actual color is sent but goes to a "wrong address" at the magnetic body and is not compared with the real signal. If the cognitive "color circle" correspond to a small portion of the magnetic body as the general model for cognitive representations suggests, the resonance could indeed occur at wrong position of the magnetic body receiving different kind of cognitive input.

6.6.3 Third example

One morning in November 1977, upon awakening, she noted that although she was able to see details of objects and people, colors appeared "drained out" and "not true." She had no other complaint... her vision was good, 20/20 in each eye... The difficulty in color perception persisted, and she had to seek the advice of her husband to choose what to wear. Eight weeks later she noted that she could no longer recognize the faces of her husband and daughter... [So in] addition to achromatopsia, the patient had prosopagnosia, but her linguistic and cognitive performances were otherwise unaffected. The patient was able to tell her story cogently and to have remarkable insight about her defects.

This case could be understood as the failure of the back projection mechanisms making possible coloring of the percept and the generation of the caricature like percept allowing recognition of faces. Also the recognition of faces could rely on the resonance mechanism in which signal is sent from cortex to an appropriate magnetic body.

These examples should demonstrate that the TGD based notion of qualia combined with the general model for cognitive and emotional representations can easily explain the findings discussed in [J21].

6.7 Odor Perception And Quantum Coherence

In Discover magazine there is an article titled *Is Quantum Mechanics Controlling Your Thoughts?* [I11] telling among other things about the latest direct evidence of quantum effects provided by experiments related to odor perception. The article discusses the work of the biophysicist Luca Turin [J38] about odor perception as an additional support for quantum brain. Before going to the article it is good to summarize the basic ideas about sensory qualia (colors, odors, ...) in TGD inspired theory of consciousness.

1. In TGD framework the the identification of qualia follows from the identification of quantum jump as a moment of consciousness. Just as quantum numbers characterize the physical state, the increments of quantum numbers characterize the quantum jump between two states. This leads to a capacitor model of the sensory receptor in which the sensory perception corresponds to a generalized di-electric breakdown in which various particles carrying some quantum numbers flow between electrodes and the change of the quantum numbers at second electrodes gives rise to the sensory quale in question.

2. It is important that sensory qualia are assigned to the sensory receptors rather than to the neural circuitry of brain as in standard neuroscience. This leads to objections (phantom leg for instance) which are circumvented in TGD based vision about 4-D brain. For instance, phantom leg would correspond to sensory memory resulting by sharing the mental image about pain residing in the geometric past when the leg still existed. A massive back-projection generating virtual sensory input from brain (or from the magnetic body via brain) is needed to build the actual perception as a kind of art-work by filtrating from the actual sensory input a lot of unessential stuff and amplifying the essential features.

3. The discovery of Callahan [I12] that odor perception of insects seems to be based on IR light inspired my own the proposal that photons at IR frequencies could be involved with the odor perception so that odor perception would be at molecular level seeing by IR light. Even hearing could involve similar "seeing" in appropriate frequency range. Massless extremals (topological light rays) would serve as kind of wave guides parallel to axons along which light would propagate as kind of laser beams between receptor and brain. This would also explain why the mediation of auditory input takes so rapidly.

4. I have also proposed frequency coding for the sensory qualia. The first proposal which I dubbed as "Spectroscopy of Consciousness" stated that cyclotron frequencies assignable to various biologically important ions -much below IR range- associated with as such correspond to sensory qualia. Later I gave up this idea and proposed that frequencies code provide only a symbolic representations- define their names- as one might say. The information about qualia and more general sensory data would be represented in terms of cyclotron frequencies inducing dynamical patterns of the cyclotron Bose-Einstein condensates of biologically important ions residing at the magnetic body receiving the sensory information.

6.7.1 Vibrational theory of odor perception

I attach a small piece of the article here to give a popular summary about the work of Luca Turin [J39].

Quantum physics may explain the mysterious biological process of smell, too, says biophysicist Luca Turin, who first published his controversial hypothesis in 1996 while teaching at University College London. Then, as now, the prevailing notion was that the sensation of different smells is triggered when molecules called odorants fit into receptors in our nostrils like three-dimensional puzzle pieces snapping into place. The glitch here, for Turin, was that molecules with similar shapes do not necessarily smell anything like one another. Pinanethiol [C10H18S] has a strong grapefruit odor, for instance, while its near-twin pinanol [C10H18O] smells of pine needles. Smell must be triggered, he concluded, by some criteria other than an odorant's shape alone.

What is really happening, Turin posited, is that the approximately 350 types of human smell receptors perform an act of quantum tunnelling when a new odorant enters the nostril and reaches the olfactory nerve. After the odorant attaches to one of the nerve's receptors, electrons from that receptor tunnel through the odorant, jiggling it back and forth. In this view, the odorant's unique pattern of vibration is what makes a rose smell rosy and a wet dog smell wet-doggy.

The article "A spectroscopic mechanism for primary olfactory perception" [J39] by Turin explains in detail his theory and various experimental tests. Here are the core ideas in more quantitative terms.

1. The theory originates from the proposal of Dyson proposed already 1938 that odor perception might rely on the vibrational spectrum of the odorant rather than its shape alone. The spectrum would be in the wave length range 2.5-10 μm corresponding to photon energies in the range.5 eV -.125 eV. This vibrational spectrum would be excited by the current of electrons tunnelling from the receptor to the odorant molecule.

2. The proposal is that odor receptor can be regarded as a pair formed by a source and sink of electrons. If there is nothing between source and sink, tunnelling can occur if there is electronic energy state with same energy in both source and sink. If there is an odorant molecule between source and sink with vibrational energy E, tunnelling can occur indirectly: the electron can excite a vibrational state with this energy and tunnelling can occur only if the difference of electron energies in source and sink is E. Therefore the presence of odor molecule would be detected from the occurrence of the tunnelling and vibrational energy spectrum would characterize the odor molecule.

6.7.2 Comparison of Turin's model with TGD and Callahan's theory

One can compare the model of Turin with TGD based ideas.

1. The theory of Turin conforms at the general level with the receptor model. The "electrodes" of the sensory capacitor would correspond to the source and sink of electrons and the presence

of the odorant molecule between the "electrodes" would induce the current. The current of electrons from the source to the sink should induce the change of total quantum numbers defining the odor quale.

2. The first thing to notice is that the upper bound.5 eV for IR energies corresponds to the nominal value of the metabolic energy quantum identified as the energy liberated as proton drops from the atomic space-time sheet with $k = 137$ to a very large space-time sheet or the same process for electron Cooper at $k = 149$ space-time sheet. If Cooper pairs are involved, the latter process would occur in the length scale defined by the thickness of the lipid layer of the cell membrane (5 nm). The lower bound corresponds to a metabolic energy quantum assignable to $k = 139$ for protons and $k = 151$ transition for electrons (thickness of cell membrane).

3. Second point to notice is that TGD predicts a fractal hierarchy of spectra of metabolic energy quanta [K1] coming as $E(\Delta k, n) = 2^{-\Delta k} E_0(1 - 2^{-n})$, $n = 1, 2, ...$, converging to $E(\Delta k, \infty) = 2^{-\Delta k} E_0$ for given p-adic length scale characterized by the difference $\Delta k = k - k_0$. E_0 denotes the zero point kinetic energy of particle at space-time sheet with p-adic length scale $k = k_0$ and is inversely proportional to the mass of the particle. The transfer of electrons and/or protons between different space-time sheets with any perception for purely metabolic reasons. The simplest option is that since the electrons at the side of the source receive their energy in this manner, their energy spectrum is given by $E(\Delta k, n)$ (there is of course some resolution meaning a cutoff in n). The specificity of the receptor would require preference of some specific metabolic energy quanta $E(\Delta k, n)$. If this spectrum characterizes the receptor independently of its chemistry, then not only metabolic energy quanta but also the mechanism of sensory perception is universal. This proposal fails if the receptor has always same spectrum of $E(\Delta k, n)$ since all receptors would detect all odors.

It is interesting to relate the theory of Turin with the hypothesis of Callahan that the odor perception of insects uses IR light.

1. Callahan's work [I12] suggests that the IR photons emitted by the odorant in the transitions between the vibrational states and received by the odor receptor are basically responsible for the odor perception. Turin in turn proposes that the pattern of vibrational excitations in the odor molecule characterizes the perception. These views are consistent if the pattern of vibrational excitations is in 1-1 correspondence with the flow pattern of electrons between different space-time sheets at the receptors if a kind of self-organization pattern results: this is expected to take place in presence of a metabolic energy feed.

2. In Callahan's model for the odor perception of insects the simplest odor receptor would "see" the IR light emitted by the odor molecules. Also Turin explains -with different assumptions- that the situation is analogous to that prevailing in retina in that there are receptors sensitive to characteristic energy ranges of photons. One would expect that the odor perception of insects is something very simple. The so called vomeronasal organ [J2] is known to be responsible for the perception of socially important odors not generating conscious experience at our level of self hierarchy but having important effect on behavior (perfume industry has long ago realized this!). Vomeronasal organ could utilize this kind of primitive odor receptors.

3. The rate for the spontaneous transitions emitting IR light could be rather low. A more advanced receptor would induce more transitions by using tunnelling electrons to excite vibrational energy levels in the odorant. This would be like using lamp to see better! The analogy with the transistor is also suggestive: the small base current induced by IR radiation generated by the odor molecule would be amplified in the process. Since the source contains electrons in excited states (at smaller space-time sheets), odor molecules could send negative energy photons dropping electrons to the large space-time sheet along which tunnelling is possible. Induced emission would cause a domino like flow of electrons and excitations of the vibrational states of the odor molecule as the counterpart of di-electric breakdown would take place.

4. What could then the physical correlates for the primary odor qualia? The increments of some quantum numbers assignable to electrons at the source should be in question. Could the energies $E(k,n)$ characterizing the receptor define the primary odors? Odors and tastes are indeed very intimately related to metabolic activities. A natural consequence would be that besides the radiation generated by the transfer of electrons between space-time sheets would induce odor and perhaps also taste sensation. Organisms serve as food for other organisms so that an optimal detection of nutrients would be the outcome. The objection is that similar "metabolic qualia" would result in all receptors. This is not a problem if these qualia are qualia not conscious to us but conscious to neuronal selves. For instance, in TGD based model for visual colors color the increments of quantum numbers define the basic colors.

Could one assume that also other receptors use metabolic energy quanta as basic excitation energies?

1. The first objection is that similar "metabolic qualia" would result in all receptors. This is not a problem if these qualia are qualia not conscious to us but conscious to neuronal selves. For instance, in the TGD based model for visual colors the increments of color quantum numbers (in QCD sense!) define the basic colors, which means that colored particles must be in question (TGD variant of quark color implies the existence of scaled variants of QCD like physics and predicts that also electrons have colored excitations for which there is indeed a growing experimental evidence [K28]).

2. Second objection is that it does not seem possible to identify $E(k,n)$ as excitation energies in the case of vision. The relevant range of photon energies is [1.65, 3.3] eV. By scaling the metabolic energy quantum by a power of 2, the nominal values of relevant maximal metabolic energy quanta $E(k,n=\infty)$ are 2 eV and 4 eV. The series of energies approaching 2 eV below 2 eV is 1, 1.5, 1.75, ..., 2 eV so that the range below 2 eV representing red light would be covered. Above 2 eV the series is 2, 3, 3.50, ..., 4 eV so that the region above 2 eV (orange, yellow, green, blue, indigo, violet) would contain only single line at 3 eV (violet). If the incoming photon can kick the electron to an excited state with energy E_0 at the smaller space-time sheet the spectrum contains also the energies $E(k,n)+E_0$. For $E_0 = 1.3$ eV these excitation energies would come as 2.3, 2.8, 3.05, ... 3.3 eV and cover this range.

6.7.3 Isotope effect of olfaction as an additional guideline

The above considerations are still rather speculative and leave a loot of room for alternatives. The additional guideline leading to a surprisingly simple TGD inspired model of odor perception comes from the observation that flies can smell the difference between normal hydrogen and deuterium [J41]. This is not in accordance with the standard theory of olfaction which says that olfaction relies on the shape of the molecule but conforms with the vibration theory of Luca Turin [J38, J39], who is one of the co-authors of the article [J31] reporting the discovery. The theory assumes that olfaction relies on molecular vibrational frequencies depending on the mass of the isotope.

1. Turin's theory

From Turin's video lecture and Wikipedia article [J14] about vbration theory of olfaction one learns why reductionism is so nice when it can be applied.

1. If the molecular vibrations in a reasonable approximation reduce to independent vibrations assignable to various chemical bonds, the problem of predicting the odor of the molecule reduces to the calculation or measurement of the oscillation frequencies associated with the chemical bonds of between two atoms or between two molecules forming a bigger molecule as a composite. Near IR frequencies in.8-2.5 μm wavelength range associated with vibrational spectrum are inversely proportional to the reduced mass of the pair of atoms or molecules connected by the chemical bond and the IR frequencies related to rotational-vibrational transitions depending on more complex manner on the molecular mass are good candidates for inducing the olfactory qualia at least in the case of insects.

2. Situation is also simplified by the fact that only a finite range of frequencies is expected to induce odor sensation just as only finite range of frequencies induces visual percept. Hence the engineering of odors becomes possible by considering only some basic bonds. One can test the model by replacing the hydrogen with deuterium in some constituent of the molecule and this was done in the article referred above.

3. The odor of the molecule should be a superposition of the basic odors assignable to the basic chemical bonds just like visual color is a superposition of primary colors. One must however remember that the quantum phase transition inducing the odor sensation itself need not have anything to do with the IR photons and many frequencies could induce the same quantum phase transition. The innocent novice is also allowed to ask whether the harmonics of the fundamental oscillation frequency could give rise to the olfactory analogy of timbre distinguishing between different musical instruments and whether octaves correspond to more or less similar odor sensation. The following considerations suggest that the answer to these questions is negative.

In Turin's theory vibrational frequencies are interpreted in terms of a model of receptor based on the idea that electron tunnelling occurs between odor molecule and receptor and generates odor sensation if the energies of the electron states at the both sides are same. In general the ground state energies of the electron at the two sides are different but it can happen that the condition is satisfied for some excited state of electron of the acceptor so that odor perception is due to a tunnelling to an excited state. The model requires the fusion of the odorant molecule to the receptor so that there is a close relationship with the standard theory assuming lock-and-key mechanism.

2. Callahan's theory

The finding conforms also with the old discovery of Callahan that the olfaction of insects is analogous to seeing at IR frequencies. This hypothesis explains among other things the finding that insects seem to love candles [I12].

If I have understood Callahan's theory correctly, the IR photons emitted by the odorant would induce transitions of electrons or Cooper pairs of the odor receptor. This would allow "radiative smelling" without a direct contact between odor molecules and olfactory receptors and at the first glance this seems like an unrealistic prediction. However, since the average power of radiation is proportional to $1/r^2$, where r is the distance between the receptor and molecule, radiative smelling would in practice be limited to rather short distances unless the radiation is guided. Maybe this could be tested experimentally by using coherent beam of IR light as a candidate for an artificial odorant.

3. TGD based theory

In TGD inspired theory of qualia one must distinguish between the sensory input inducing the quale and its secondary representation in terms of Josephson and cyclotron frequencies.

1. All qualia are coded (but not necessarily induced!) by various frequencies and communication using dark photons with various values of Planck constant meaning scaling down of visible basic frequencies is an essential element of communications at the level of biological body and between magnetic body and biological body. Josephson frequencies and cyclotron frequencies with so large Planck constant that energies are above thermal energy play a key role in the these communications. Note that cyclotron frequencies are inversely proportional to the mass of the ion so that isotope effect also at this level is predicted.

   Josephson frequencies are assignable to cell membrane and one ends up with a nice model for the visual qualia assuming some new physics predicted by TGD. Josephson frequencies and their modulation (as in the case of hearing) should be highly relevant for all qualia.

2. The capacitor model for sensory qualia assumes that all qualia are generated via the quantum analog of dielectric breakdown in which particles with given quantum numbers characterizing the quale flow between the plates of the capacitor. For sensory receptors the capacitor is obtained by a multi-layered structure obtained by a multiple folding of the cell membrane so that the efficiency of the sensory receptor increases.

3. In Turin's model the second plate of the capacitor model would correspond to the odorant molecule. This does not however allow anything resembling di-electric breakdown. It is difficult to imagine how to achieve a quantum phase transition involving simultaneous tunnelling of a large number of electrons unless the receptor binds a large number of odorant molecules. Odor molecules should also form a quantum coherent state: a molecular analog of atomic Bose-Einstein condensate would be required. This would mean that only very special odor molecules could be smelled.

4. For the Callahan's variant of the theory the IR photons could excite the Cooper pairs of the other plate of the capacitor so that the tunnelling becomes possible and quantum variant of di-electric breakdown can take place. This model is consistent also with the assumption that cell membrane acts as a Josephson junction and fundamental sensory capacitor. The energy of electron gained in the electric field of the cell membrane is in the range.04-.08 eV which indeed corresponds to IR frequencies. The variation of the membrane potential would give rise to the spectrum of basic odors. Roughly one octave of frequencies could be smelled if the cell membrane defines the fundamental nose smelling the energy of electron.

   This option allows also the coding of odors by IR frequencies themselves so that brain could generate virtual odors by sending quantum coherent IR light to the odor receptors. This would explain odor hallucinations (and also other sensory hallucinations) as virtual percepts generated by brain itself. This sensory feedback would be absolutely essential for building up of standardized sensory percepts.

5. The difference between visual and odour receptors would be that the ground states of the cell membrane would correspond to near to vacuum extremals *resp.* far from vacuum extremals and therefore Josephson frequencies would be in visible *resp.* IR range respectively.

6.8 Is It Possible To See Without Brain?

Science News [J8] tells about a finding that transplanted eyes located far outside the head of vertebrate can see without a direct connection to brain. The connection to spine is however present.

The experimenters surgically removed donor embryo eye primordia, marked them with fluorescent proteins, and grafted them into the posterior region of recipient embryos. This induced the growth of the ectopic eyes. The natural eyes of recipients were removed. Fluorescent spectroscopy revealed the natural innervation patterns but none of the animals developed connections to brain.

To determine whether the animals having only ectopic eyes could see the training system was divided to quadrants of water illuminated by either red or blue LED light, and experimenters gave slight electric shocks in a particular quadrant. What was found that about 19 per cent of animals with optic nerves connected to the spine learned to avoid the quadrant in which they received electric shocks.

What experiments show that it is possible to see without neural connections to brain. The question is whether only the spinal cord or also the brain was involved with the learning. Probably neuroscientist could immediately answer this question but for an innocent layman like me the answer is far from obvious. Experimenters seem to think that brain is involved. As Douglas J. Blackinston, the first author of the paper "Ectopic Eyes Outside the Head in Xenopus Tadpoles Provide Sensory Data For Light-Mediated Learning, " in the February 27 issue of the Journal of Experimental Biology [J16], states "Here, our research reveals the brain's remarkable ability, or plasticity, to process visual data coming from misplaced eyes, even when they are located far from the head."

If brain is involved and the learned response is not a mere reflex involving only the spine, there must be information transfer to brain - perhaps along spine - but not as nerve pulses.

In TGD framework these findings inspire several questions.

1. Does the ability to see colors mean that visual colors are perceived at the level of retina rather than brain? The phenomenon of phantom limb supports strongly the standard view that various qualia emerge at the level of brain. On the other hand, the almost-prediction of TGD inspired theory of consciousness is that the primary sensory percept - and therefore

also color qualia - can be assigned with the sensory organs. In TGD framework brain and body are 4-dimensional so that the pain in non-existing limb would be pain in the real limb of the geometric past.

Brain would build cognitive representations - standardized mental images - about the sensory input by decomposing the perceptive field to objects. Brain would of course induce also motor response by associating to these standardized mental images motor actions.

2. In order to build standardized mental images brain would generate feedback as a virtual sensory input to the sensory receptors. Virtual sensory input would be realized using what I have called dark photons having "topological light rays" as space-time correlates and assignable to the magnetic flux tubes connecting body parts together. Two new notions are involved: magnetic body - the primary intentional agent - and the signalling using photons, which are dark in the sense that they are characterized by a large effective value $\hbar_{eff}$ of Planck constant coming as an integer multiple of $\hbar$ so that for say energy of visible photon the wavelength can be much longer than micrometer.

3. It has of course been known for a long time that EEG carries precise information about the state of brain, and the natural question is why so? Magnetic body must receive data from biological body and the hypothesis is that EEG and its variants and possible scaled variants of EEG involving dark photons with large enough value of Planck constant to make their energies higher than thermal energy make this communications possible. Dark photons would be assigned to what I have used to call "topological light rays" assignable to magnetic flux tubes. The basic functions of EEG would therefore be communication to and control by magnetic body.

   For instance, quite recent experiment [J29, J9] involved two rats as model animals. The first rat learned to press one of the two levers in response to a light signal over the correct level to get the reward. Second rat received the EEG response of the first rat and learned to respond in the same manner on basis of this response only so that this sensory response served as a virtual sensory or cognitive input for it.

   Magnetic body would generate also motor response using brain as a control instrument. Is the motor response in the recent case a kind of reflex action using only spine? Or are brain and magnetic body involved? Certainly the magnetic body could use brain as an intermediate control instrument. How much of the plasticity usually assigned with brain is actually flexibility of the magnetic body? And who is learning: is it brain or the magnetic body?

4. The communication using dark photons and the presence of magnetic body would make possible the participation of also brain to the learning process. For instance, the communication from the ectopic eye to brain could utilize quantum coherent dark photons travelling along the route ectopic eye $\rightarrow$ appropriate layer of magnetic body $\rightarrow$ brain. One can imagine also a dark photon communication along magnetic flux tubes parallel to spine.

6.9 How Are The Visual Percepts Constructed?

How does visual system analyze the incoming visual information and reconstruct from it a (highly artistic) picture of the external world? I encountered this problem for the first time for about 35 years ago while listening some lecture about what happens in retina. I was working with my thesis as an unemployed in a job with the (hidden for me) purpose to make me capable of getting a job in a real world (as a person suffering from a tendency to use my brains to thinking I was (and still am) labelled as a kind of socially handicapped person: in former Soviet Union I would have been labelled as a paranoid). The job itself was a purely formal duty and I was allowed to prepare my thesis rather freely (this would not be possible nowadays). I had also opportunity to listen lectures and this particular lecture series about neuroscience by Kari Kaila has teased me since then.

1. In the primary visual cortex there are so called orientation columns `http://en.wikipedia.org/wiki/Orientation_column`. The are geometrically flat slabs parallel to each other and orthogonal to the surface of the cortex being arranged like slices of bread. The neurons inside

the columns are highly discriminatory for visual orientations and their motion. Wikipedia article also mentions pinwheels: orientation columns characterized by different orientation angles meet at singular points. This bring in mind radial lines emanating from origin and defining discretization of the azimutal angle.

This sounded very strange to me. Why not divide visual field to small cycles or squares and be sensitive to the light in a particular square defining the bit?

2. I learned that there are also simple and complex cells. Simple cells are sensitive to a particular line. Complex cells are sensitive to all lines with same direction.

3. I was also told that ganglions in retina have receptive fields. There are ganglions with on-center and off-center receptive fields. There is also a saccadic motion (`http://en.wikipedia.org/wiki/Saccade`), which is essential for visual consciousness: if it is prevented, subject persons first begins to see just darkness and eventually the visual consciousness fades away.

How to integrate these pieces to a coherent picture? During morning hours this problem popped up in my mind and I got some ideas and decided to check from Wikipedia what is known. I of course thought that this whole thing has been well-understood for decades and maybe it is! If so, I am making myself a fool: it does not however matter much at this age! I found an article about orientations columns (`http://en.wikipedia.org/wiki/Orientation_column` containing a brief mention about a model for how the orientation map is constructed.

So called Moire interference (see `http://en.wikipedia.org/wiki/Moir_pattern`) of identical or nearly identical patters rotated with respect to each other by an angle produces a non-localized representation of a definite orientation. By putting the visual representation associated with approximately hexagonal lattices formed by on-centre and off-centre ganglions, one would obtain a representation of orientation somehow. I must be honest: I did not understand the idea at all! Is this really so complex? There was a reference to an article in Nature: Paik, S., Ringach, D. L. (2011): Retinal origin of orientation maps in the visual cortex. Nature Neuroscience, 14(7), 919-925. I do not have access to this article so that I can continue making naive questions and stupid arguments.

1. Primary visual cortex performs the roughest processing of visual information. What are the simplest possible visual representations of the external world? Drawings of course. Painters make first a a sketch. We have cartoons. Visualizations are typically 2-D drawings. It would not be surprising if visual system would not obey the same strategy. In finite resolution they consist of pieces of lines forming what looks like continuous structures when the length of basic piece is short enough as anyone who has used drawing programs knows. Maybe brain and retina first build this kind of representation and add colours and other details later.

2. Could ganglia or possible linear structures formed from them effectively see through slits? They would be specialized to detect the presence of this kind of lines of some minimal length defining the resolution and going through through the centre of retina. When the line is parallel to the slit associated with the detector, the line detector sends nerve pulses to brain.

3. There is a problem. If the orientation of eye remains fixed, the line detector sees only the lines going through the normal of the retina at its centre and usually sees nothing. Most of visual field would remain unseen.

   Saccadic motion saves the situation. When the normal of the line detector intersects the line of visual field with a proper orientation, it detects a line. For a given light intensity the input is maximal if the line is longer than the maximal length of line source for which detector is sensitive. The total intensity of incoming light through the slit is enough to build the representation. The output is bit telling whether a piece of line is there or not.

4. These inputs from slit detectors would be the basic inputs fed to the complex cells forming representations of the lines. In visual cortex the information from the orientation of retina combined with the bits produced by slit detectors during a saccadic motion lasting so long a period that large enough number of orientations of normal are scanned, are combined to a drawing.

$T = .1$ seconds is the croon of time for sensory percepts. and is the natural guess for this period of integration. The maximal angular speed of saccadic motion is for humans about 900 degrees/second making 90 degrees per time interval T (see `http://en.wikipedia.org/wiki/Saccade`).

Certainly there must exist a feedback from brain favoring preferred saccades using already existing information about the distribution of lines so that for targets which are stationary saccades would go along the lines of the already existing picture and detect if changes have occurred. The signals from orientation columns of primary cortex might be important part of this feedback.

5. If the object remains in good approximation at rest during this period, a drawing about the external world is obtained as an outcome. The simplest guess is that orientation column at particular point of visual cortex corresponds to a point in the visual field and if there is line of defined direction going through that point of visual field, simple cell sensitive to that orientation receives input.

6. Could ganglia themselves see the world through a slit? One can argue that if this were the case, it would have been observed experimentally. I tend to agree. One can of course ask whether saccadic motion necessary for visual consciousness effective blurs the visual field of the ganglion so that it is disk of radius defined by the maximal length of line for which ganglion is sensitive.

   The simplest and probably the correct assumption is that ganglia indeed detect spots of light or absence of it. Line detectors would correspond to lines formed by ganglia or perhaps similar structures at higher levels of the neural hierarchy.

   Since I love magnetic flux tubes, I cannot resist the temptation to connect the ganglia by flux tubes to form these lines so that one would have a grid lines of ganglia analogous to a the radial lines of a coordinate grid of cylindrical coordinates with origin at the centre of retina. Peripheral regions would correspond to a poorer resolution if this is the case. Maybe macroscopic quantum coherence would enter the stage here and allow to bind the percepts about spots to a percept about line.

Of, course this idea is just a first guess reflecting my deep ignorance about how visual representations are formed, and certainly the details, if not the whole idea, are wrong.

7 TGD Based Models For Cell Membrane As Sensory Receptor

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of imbedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy lead to the breakthrough in TGD inspired quantum biology and also to the a view of qualia and sensory representations including hearing.

One of the basic challenge has been to construct a quantitative model for cell membrane.

1. The first model was based on the assumption that long range weak forces however play a key role [K1]. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for the standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive or Boolean representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role. The essential element is that the energies of the Josephson photons are in visible range. This would explain bio-photons and even why the frequencies assignable to visual receptors. Skeptic can of course argue that the energies at which receptors are most sensititive to incoming light need not have anything to do with the Josephson frequencies. Skeptic might be right but it is interesting to see if this hypothesis might work.

A possible problem is that Weinberg angle must be assumed to be much smaller in the near vacuum extremal phase than in standard model if one wants to explain the photon energies at which color receptors have maximum absorption assuming *same voltage* over the Josepshon junction defined by the receptor protein. A way out of problem is to assume that the voltage through the transmembrane protein depends on the ion (Na^+, K^+, Cl^- or Ca^{++}) characterizing the color receptor and is therefore different for the color receptors.

2. Second model is based on Gerald Pollack's findings about the fourth phase of water and exclusion zones [I3]. These zones inspire a model for pre-biotic cells. The outcome is a modification of the simplest model of Josephson junction. Besides resting potential also the difference between cyclotron energies between the two sides of the membrane plays a key role. This model allows to understand what happens in metabolism in terms of a quantum model replacing the thermodynamical model for cell membrane with its quantal "square root" inspired by Zero Energy Ontology. The model allows also to understand bio-photons as decay products of dark photons.

3. The success of the latter model does not of course mean that the weak forces could not be important in cell membrane scale and the realistic model could be a hybrid of these two models. The inclusion of Z^0 contribution to the effective magnetic field could also to the fact that the endogenous magnetic field deduced from Blackman's experiments is $B_{end} = 2B_E/5$ rather than B_E (Earth's magnetic field).

7.1 Could Cell Correspond To Almost Vacuum Extremal?

The question whether cell could correspond almost vacuum extremal of Kähler action was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value.23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. The assumption about the value of Weinberg angle can be used as the basic objection against the model. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K23].

7.1.1 Cell membrane as almost vacuum extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I9] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields.

This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts. In the recent view about TGD based on the weak form of electric-magnetic duality wormhole magnetic flux tubes having magnetically charged wormhole throats at their ends could be interpreted as scaled up variants of elementary particles having a large value of Planck constant.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general vision about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish and the vision has been that it is sensible to speak about two basic configurations.

   (a) Almost vacuum extremals (homologically trivial geodesic sphere).

   (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

   The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.

   (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.

   (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

(c) It might not be without importance that for any partonic 2-surface induced electroweak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.

4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.

5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field (see the appendix of any of the books about TGD)

$$\gamma = 3J - \tfrac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{7.1}$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7\hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

7.1.2 Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective restoring potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J11] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are

Table 1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting state for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{+2}	1.68	2.52	2.94

in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neuron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order.1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.

3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$\begin{aligned} (\frac{Z-N}{4} - pZ)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ . \end{aligned} \tag{7.2}$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 1** below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

7.1.3 Are photoreceptors nearly vacuum extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural

question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J11, J5]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ, which is largest for smallest λ. Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 1** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J11] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.

2. One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 2** below.

1. The resting potential for photoreceptors is $V = -40$ mV [J12]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This would conform with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{++}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of $\hbar$ the frequency scales is that of EEG).

4. In a very bright illumination the hyper-polarization is $V = -65$ mV [J12], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

Table 2: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and.0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

Ion	Na^+	Cl^-	K^+	Ca^{+2}
$E_J(.04\ \ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ \ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ \ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ \ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ \ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ \ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ \ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ \ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ \ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ \ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ \ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as**Table 1** shows.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

The basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences
$Na^+ \leftrightarrow$ 2.19 eV (R) and $eV = 86.8$ eV,
$Cl^- \leftrightarrow$ 2.32 eV (G) and $eV = 65.8$ eV,
$K^+ \leftrightarrow$ 2.49 eV (W) and $eV = 60.2$ eV,
$Ca^{++} \leftrightarrow$ 3.06 eV (B) and $eV = 67.3$ meV.
For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A} ,$$

   which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

   The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

7.2 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [I2] (`http://faculty.washington.edu/ghp/cv/`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

7.2.1 Pollack's findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [I3].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [**?**, **?**].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

4. In the splitting of water producing Brown's gas [**?**, **?**] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

7.2.2 Dark nuclei and Pollack's findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

1. Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K14, L3].

4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton

sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiplies of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J19].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

2. Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about.06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

   "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [**?**, **?**].

   (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

   (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

7.2.3 Fourth phase of water and pre-biotic life in TGD Universe

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism,

which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

1. Metabolism and fourth phase of water

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://www.en.wikipedia.org/wiki/Citric_acid_cycle`), which forms the basic element of both photosynthesis (`http://www.en.wikipedia.org/wiki/Photo-synthesis`) and cellular respiration `http://www.en.wikipedia.org/wiki/Cellular_respiration`, involves electron transport chain (`http://www.en.wikipedia.org/wiki/Electron_transport_chain`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://www.en.wikipedia.org/wiki/ATP_synthase`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

3. ATP is generated also in glycolysis (`http://www.en.wikipedia.org/wiki/Glycolysis`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://www.en.wikipedia.org/wiki/Pyruvate`)).

4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://www.en.wikipedia.org/wiki/Glycolysis`) the net reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield.86 eV per single ATP. The nominal value that I have used.5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range.1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

2. Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (`http://en.wikipedia.org/wiki/Osmotic`) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to

another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

   The phase transitions changing the value of h_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

Consider first the simplest model taking into account only membrane potential.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_2 \ .$$

   One can use the decomposition $\Psi_i = R_i exp(i\Phi(t)$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/h_{eff}$.

2. One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = sin(\Phi_0) + \frac{k_1}{\hbar_1} sin(\frac{eVt}{\hbar_1}) \ .$$

R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi 0$ taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = sin(\phi_0) = exp(\frac{ZeV(t)}{2T}) \ .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \rightarrow ZeV + \mu_I$. This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

   The earlier proposal [K12] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weingerg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: $(f_c(MB) = f_J$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $h_{eff} = n \times h$ to h.

   In the modified model the sum $f_c + f_{J,n}$ $(f_{J,n} = E_J/n \times h)$ of h_{eff}-independent cyclotron frequency and Josephson frequency proportional to $1/h_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \ .$$

   If dark photons correspond to biophotons the energy is of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibrium ion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

3. Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K31] explaining anomalously large gravimagnetic effect claimed by Tajmar et al [**?**, **?**] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle h_{gr} has the general form $\hbar_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For three inner planets one has $v_0/c \simeq 2^{-11}$.

2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.

2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2e^2/v_0$.

4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K16] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K21].

4. Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article [**?**]eporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K14, L3] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

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

Mathematics

[A1] Shipman B. A symmetry of order two in the full Kostant-Toda lattice. Available at: `http://www.math.rochester.edu:8080/u/shipman/symmetrypaper/`, 1998.

[A2] Shipman B. On the geometry of certain isospectral sets in the full Kostant-Toda lattice. Available at: `http://nyjm.albany.edu:8000/PacJ/1997/Shipman.html`, 1998.

[A3] Shipman B. The geometry of momentum mappings on generalized flag manifolds, connections with a dynamical system, quantum mechanics and the dance of honeybee. Available at: `http://math.cornell.edu/~oliver/Shipman.gif`, 1998.

[A4] Zeeman EC. *Catastrophe Theory.* Addison-Wessley Publishing Company, 1977.

Theoretical Physics

[B1] Das A. *Integrable Models.* World Scientific, 1989.

Particle and Nuclear Physics

[C1] Davies DT et al. Precise Charm to Strange Mass Ratio and Light Quark Masses from Full Lattice QCD. *Phys Rev* . Available at: `http://prl.aps.org/abstract/PRL/v104/i13/e132003`, 104, 2010.

Biology

[I1] Homeopathy. Available at: `http://en.wikipedia.org/wiki/Homeopathy`.

[I2] Pollack Laboratory- Biographical Sketch. Available at: `http://faculty.washington.edu/ghp/cv/`.

[I3] The Fourth Phase of Water : Dr. Gerald Pollack at TEDxGuelphU. Available at: `https://www.youtube.com/watch?v=i-T7tCMUDXU`, 2014.

[I4] Balinsky A. *An Introduction to Embryology.* Saunders, London, 1965.

[I5] Albrecht-Buehler G. Surface extensions of 3T3 cells towards distant infrared sources. *J Cell Biology*, 114:493–502, 1991.

[I6] Albrecht-Buehler G. Changes of cell behavior by near-infrared signals. *Cell Motility and the Cytoskeleton*, 32:43–50, 1995.

[I7] Albrecht-Buehler G. Reversible excitation light-induced enhancement of fluorescence of live mammalian mitochondria. *FASEB J* . Available at: `http://www.basic.northwestern.edu/g-buehler/relief.htm`, 2000.

[I8] Pollack G. *Cells, Gels and the Engines of Life.* Ebner and Sons, 2000.

[I9] Fröhlich H. The extraordinary dielectric properties of biological materials and the action of enzymes. *Nature*, 72(1968):641–649, 1975.

[I10] Gull K Lange BHH. Structure and function of the centriole in animal cells: Progress and questions. *Cell*, 6, 1996.

[I11] Anderson M. Is Quantum mechanics controlling your thoughts? *Discover Magazine.* Available at: `http://tinyurl.com/9nc2qx`, February 2009.

[I12] Callahan PS. Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent. *Appl Opt*, 16(12), 1977.

[I13] Dawkins R. *The Blind Watchmaker.* Penguin Books, 1986.

Neuroscience and Consciousness

[J1] Visual short term memory. Available at: `http://en.wikipedia.org/wiki/Visual_short-term_memory`.

[J2] A Secret Sense in The Human Nose? Available at: `http://www.hhmi.org/senses/`.

[J3] Action potential. Available at: `http://en.wikipedia.org/wiki/Action_potential`.

[J4] Brain . Available at: `http://en.wikipedia.org/wiki/Brain`.

[J5] Color vision. Available at: `http://en.wikipedia.org/wiki/Color_vision`.

[J6] Frontal lobes. Available at: `http://en.wikipedia.org/wiki/Frontal_lobes`.

[J7] How the mind senses the movement. *New Scientist* . Available at: `http://www.newscientist.com/channel/being-human/mg18925375.000.html`, 2537, February.

[J8] In a First, Experiment Links Brain s of Two Rats. Science News , Available at: `http://www.sciencedaily.com/releases/2013/02/130227183311.htm`.

[J9] In a First, Experiment Links Brain s of Two Rats. New York Times, Available at: `http://tinyurl.com/c2azg67`.

[J10] Limbic system. Available at: `http://en.wikipedia.org/wiki/Limbic_system`.

[J11] Photoreceptor cell. Available at: `http://en.wikipedia.org/wiki/Photoreceptor_cell`.

[J12] Retinal Transduction: Hyperpolarization of Primary Photoreceptors by Ligh. Available at: `http://www.acbrown.com/neuro/Lectures/NrVisn/NrVisnRtnlHprp.htm`.

[J13] Short term memory. Available at: `http://en.wikipedia.org/wiki/Short_term_memory`.

[J14] Vibration theory of olfaction. Available at: `http://en.wikipedia.org/wiki/Vibration_theory_of_olfaction`.

[J15] Damasio A. *The Feeling of What Happens.* Sane Töregard Agency, 1999.

[J16] Levin M Blackinston DJ. Ectopic Eyes Outside the Head in Xenopus Tadpoles Provide Sensory Data For Light-Mediated Learning. *J Exp Biol.* Available at: `http://jeb.biologists.org/content/216/6/1031.abstract`, 216((6)):1031–1040, 2013.

[J17] Pert CB. *Molecules of Emotion.* Simon & Schuster Inc., 1997.

[J18] Hiew CC. Hemi-Synch into creativity. *Hemi-Synch J*, (1):3–5, 1995.

[J19] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J20] Vanderwolf CH. Hippocampal electrical activity and voluntary movement in the rat. *Electroenceph & Clin Neurophysiol*, 26:407–18, 1969.

[J21] Dennett D. *Quining the Qualia*. MIT Press, Oxford, 1988.

[J22] Pouzzner D. The symphonic architecture of mind: the circulating wavetrain of consciousness. Available at: `http://www-douzzer.ai.mit.edu:8080/wavetrain.html`, 1999.

[J23] Ackerman E. *Biophys ical Science*. Prentice Hall, 1962.

[J24] Cheron G et al. Inactivation of Calcium-Binding Pr ein Genes Induces 160 Hz Oscillations in the Cerebellar Cortex of Alert Mice. *J Neurosci* Available at: `http://www.jneurosci.org/cgi/content/full/24/2/434`, 2004:434–441, January 2004.

[J25] Hodgkin AK et al. The ionic selectivity and calcium dependence of the light sensitive pathay in toad rods. *J Physiol*, 358:447–468, 1985.

[J26] Hunter JP et al. The effect of tactile and visual sensory inputs on phantom limb awareness. *Brain*, 126(3), March 2003.

[J27] Jibu M et al. Quantum optical coherence in cytosceletal microtubules: implications for brain function. *Biosystems*, 32, 1994.

[J28] Kosslyn SM et al. Hypnotic Visual Illusion Alters Color Processing in the Brain . *Am J Psychiatry*, 157:1279–1284, August 2000.

[J29] Pais-Vieira M et al. A Brain -to-Brain Interface for Real-Time Sharing of Sensorimotor Information. *Sci Rep* . Available at: `http://jeb.biologists.org/content/216/6/1031.abstract`, 3(Article number: 1319), 2013.

[J30] Paqueron X et al. The phenomenology of body image distortions induced by regional anaesthesia. *Brain*, 126(3), March 2003.

[J31] Turin L et al. *Proc Natl Acad Sci USA*, (2011).

[J32] Ernould F. The perfect pitch. Available at: `http://www.macmusic.org/articles/view.php/lang/EN/id/10/`, 2003.

[J33] Bolz J Hubener M. Relationships between dendritic morphology and cytochrome oxidase compartments in monkey striate cortex. *J Comp Neurol*, 324(1):67–80, 1992.

[J34] Jaynes J. *The origin of consciousness in the breakdown of the bicameral mind*. Princeton University Press, 1982.

[J35] Miller JP. Brain Waves Deciphered. *Nature*, 384:6605, 1996.

[J36] Jessel TM Kandel ER, Schwartz JH. *Principles of neural science*. Prentice-Hall International Inc., 1991.

[J37] Leibovic KN. *Sci of Vision*. Springer Verlag, New York, 1990.

[J38] Turin L. A spectroscopic mechanism for primary olfactory perception. *Chem Senses* . Available at: `http://www.flexitral.com/research/chemical_senses_complete.pdf`, pages 773–791, 1996.

[J39] Turin L. *The Secret of Scent: Adventures in Perfume and the Sci of Smell*. Ecco Available at: `http://en.wikipedia.org/wiki/Luca_Turin`, New York, 2006.

[J40] Noe A O'Regan JK. A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences*. Available at: `http://nivea.psycho.univ-paris5.fr`, July 2000.

[J41] Ball P. Flies can smell the difference between normal hydrogen and deuterium. *Nature News*.Available at: `http://tinyurl.com/6equps5`, 2011.

[J42] Palmer SE. Color, Consciousness, and the Isomorphism Constraint. *Behav & Brain Sci*, 22(6), 1999.

[J43] Frisch von K. *The Dance Language and Orientation of Bees*. Harward University Press, 1967.

Books related to TGD

[K1] Pitkänen M. About the New Physics Behind Qualia. In *Quantum Hardware of Living Matter*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/bioware/bioware.html#newphys`, 2006.

[K2] Pitkänen M. Bio-Systems as Super-Conductors: part I. In *Quantum Hardware of Living Matter*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/bioware/bioware.html#superc1`, 2006.

[K3] Pitkänen M. Bio-Systems as Super-Conductors: part II. In *Quantum Hardware of Living Matter*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/bioware/bioware.html#superc2`, 2006.

[K4] Pitkänen M. Construction of Quantum Theory: M-matrix. In *Towards M-Matrix*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/tgdquantum/tgdquantum.html#towards`, 2006.

[K5] Pitkänen M. Construction of Quantum Theory: Symmetries. In *Towards M-Matrix*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/tgdquantum/tgdquantum.html#quthe`, 2006.

[K6] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/tgdgeom/tgdgeom.html#compl1`, 2006.

[K7] Pitkänen M. Dark Forces and Living Matter. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#darkforces`, 2006.

[K8] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#eegdark`, 2006.

[K9] Pitkänen M. Dark Nuclear Physics and Condensed Matter. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#exonuclear`, 2006.

[K10] Pitkänen M. DNA as Topological Quantum Computer. In *Genes and Memes*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/genememe/genememe.html#dnatqc`, 2006.

[K11] Pitkänen M. Does TGD Predict the Spectrum of Planck Constants? In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#Planck`, 2006.

[K12] Pitkänen M. General Theory of Qualia. In *Bio-Systems as Conscious Holograms*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/hologram/hologram.html#qualia`, 2006.

[K13] Pitkänen M. Genes and Memes. In *Genes and Memes*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/genememe/genememe.html#genememec`, 2006.

[K14] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *Bio-Systems as Conscious Holograms*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/hologram/hologram.html#homeoc`, 2006.

[K15] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I. In *Bio-Systems as Conscious Holograms*. Onlinebook. Available at: http://tgdtheory.fi/public_html/hologram/hologram.html#metab, 2006.

[K16] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II. In *Bio-Systems as Conscious Holograms*. Onlinebook. Available at: http://tgdtheory.fi/public_html/hologram/hologram.html#molephoto, 2006.

[K17] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#mec, 2006.

[K18] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#nmpc, 2006.

[K19] Pitkänen M. Nuclear String Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#nuclstring, 2006.

[K20] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#qastro, 2006.

[K21] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#biosupercondII, 2006.

[K22] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#hearing, 2006.

[K23] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#pulse, 2006.

[K24] Pitkänen M. Quantum Model of EEG. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#eegII, 2006.

[K25] Pitkänen M. Self and Binding. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#selfbindc, 2006.

[K26] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#astro, 2006.

[K27] Pitkänen M. TGD Based Model for OBEs. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#OBE, 2006.

[K28] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#leptc, 2006.

[K29] Pitkänen M. Was von Neumann Right After All? In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#vNeumann, 2006.

[K30] Pitkänen M. Wormhole Magnetic Fields. In *Quantum Hardware of Living Matter*. Onlinebook. Available at: http://tgdtheory.fi/public_html/bioware/bioware.html#wormc, 2006.

[K31] Pitkänen M. TGD and Potential Anomalies of GRT. In *Physics in Many-Sheeted Space-Time*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#granomalies, 2013.

[K32] Pitkänen M. Criticality and dark matter. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#qcritdark, 2014.

[K33] Pitkänen M. TGD Inspired Comments about Integrated Information Theory of Consciousness. In *TGD based view about living matter and remote mental interactions*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdlian/tgdlian.html#tononikoch, 2016.

Articles about TGD

[L1] Pitkänen M. About identification of the quantum correlates of sensory qualia, 2000.

[L2] Pitkänen M. Spectroscopy of consciousness. *Int J Comp Anticip Systems*, 11, 2001.

[L3] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: http://tgdtheory.fi/articles/nuclstring.pdf, 2007.

[L4] Pitkänen M. CMAP representations about TGD. Available at: http://www.tgdtheory.fi/cmaphtml.html, 2014.

[L5] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: http://www.tgdtheory.fi/tgdglossary.pdf, 2014.

[L6] Pitkänen M. Quantum consciousness.Available at: http://www.tgdtheory.fi/webCMAPs/Quantumconsciousness.html. 2014.

[L7] Pitkänen M. Quantum model of qualia.Available at: http://www.tgdtheory.fi/webCMAPs/Quantummodelofqualia.html. 2014.

[L8] Pitkänen M. TGD inspired theory of consciousness.Available at: http://www.tgdtheory.fi/webCMAPs/TGDinspiredtheoryofconsciousness.html. 2014.

[L9] Pitkänen M. Two models for cell membrane.Available at: http://www.tgdtheory.fi/webCMAPs/Twomodelsforcellmembrane.html. 2014.