

Quantum Model for Sensory Representations

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	4
1.1	Overall View About TGD Inspired Theory Of Consciousness	4
1.2	The Quantum Hardware	6
1.3	Me As A Computer Sitting At Its Own Terminal?	8
2	General Ideas About Hardware Of Consciousness	9
2.1	Brain As A Computer	10
2.1.1	Brain as a computer sitting at its own terminal	10
2.1.2	Brain as a motor and sensory organ of higher level selves	12
2.1.3	Boolean mind and memetic code	12
2.2	Brain, MEs, And Quantum Holograms	13
2.2.1	A possible vision about how MEs act as communication links between mag- netic body and biological body	14
2.2.2	The notion of neural window	14
2.2.3	The experiments of Mark Germine	15
2.2.4	MEs and long term memory	15
2.3	Generalized Notions Of Sensory Experiencing And Motor Activity	16
2.4	The Paradigm Of Four-Dimensional Brain	16
2.5	Music Metaphor And The Function Of The Nerve Pulses And EEG	17
2.6	Connection With The Functionalistic View About Brain	18
2.7	Brain As An Associative Net	19

3	Quantum Tools For Biocontrol And -Coordination	20
3.1	Massless Extremals, Magnetic Flux Tubes, And Electrets	20
3.1.1	Massless extremals	20
3.1.2	Magnetic flux tubes and the notion of magnetic body	24
3.1.3	Electrets	27
3.2	Homeostasis As Many-Sheeted Ionic Flow Equilibrium?	28
3.3	Quantum Model For Pattern Recognition	29
3.4	General Mechanism Making Possible Biological Clocks And Alarm Clocks, Comparison Circuits And Novelty Detectors	29
4	Sensory Representations	31
4.1	Where Me Is?	31
4.1.1	Are higher level sensory representations realized at the magnetic body? . .	31
4.1.2	Could the sensory representations about position of the object be realized in the perceptive field?	32
4.2	Concrete Realization Of Sensory Representations	32
4.2.1	Qualia as quantum phase transitions and as discharges of quantum capacitor	33
4.2.2	Zero energy ontology and geometric qualia	34
4.2.3	Place coding by cyclotron frequency scale	35
4.2.4	Cortex as a collection of attributes assigned to the objects of perceptive field represented at magnetic canvas	35
4.2.5	Anomalous visual percepts and sensory canvas hypothesis	37
4.2.6	Place coding of features inside brain	38
4.2.7	The relation of mental imagery to sensory experiences	39
4.2.8	Are the space-time sheets and sub-CDs representing objects of the perceptive field generated automatically?	41
4.2.9	Spectroscopy of consciousness	41
4.3	Is The Pain In The Toe In The Toe, In Brain, Or Somewhere Else?	44
4.3.1	Back projections and cross projections	46
4.3.2	Projected pain and phantom leg	46
4.3.3	Color constancy and sensory organs as primary experiencers	47
4.3.4	Blind sight and Anton's syndrome	48
4.3.5	Woman without body	49

Abstract

One of the toughest challenges of quantum theories of consciousness is to understand how sensory representations are constructed at quantum level. It became as a surprise that the vision about sensory representation which resulted from a long lasting thought experimentation is actually very much what the original experience about myself as a computer sitting at its own terminal, when taken very literally in some aspects, actually suggests. This vision adds to the standard view about brain an additional layer responsible for the sensory representations and brings in the quantum level of control so that nerve pulse patterns are only part of the control loop. In fact, it has turned out that the same basic theory applies to both geometric memories, precognition, sensory perception, and motor actions. The vision goes as follows.

1. As far as our consciousness is considered, primary sensory organs are the seats of sensory qualia and brain only constructs cognitive and symbolic representations. Various objections against this hypothesis can be circumvented by assuming that sensory organs entangle with the brain. The question how imagination differs from the sensory experience becomes trivial, and dreams and hallucinations can be understood as resulting via the back-projection of the imagined mental images to the primary sensory organs.
2. Libet's findings about passive aspects of consciousness lead to the view that sensory percept can be regarded as a geometric memory in time scale of .5 seconds involving entanglement with the geometric past mediated by negative energy MEs. Libet's experiments about the active aspects of consciousness in turn lead to realization that motor actions and sensory perceptions are in a well-defined sense time-reversals of each other: pre-cognition is a definite aspect of motor action. One can say that motor action at the level of negative energy MEs is initiated from the level of muscles rather than brain and motor imagination is just a motor action starting from some level higher than muscles. The transformation of a p-adic ME to negative energy ME realizes the transformation of intention to action in a precisely targeted manner and the emission of negative energy makes possible extreme flexibility by buy now-let others pay mechanism of remote metabolism. This process is the basic step initiating motor action, neural activity leading to imagery, and active memory recall. This picture also explains why geometric memories occur more or less spontaneously whereas precognition is a rare phenomenon (pre-cognizer must *receive* negative energy MEs). Zero energy ontology (ZEO) provides a firm theoretical justification for the notion of negative energy signal to past obeying reversed arrow of time.
3. In TGD framework one can assign to any material structure a magnetic body having much large size. The closed flux loops composing magnetic bodies allow an elegant realization of the long term memories in terms of negative and positive energy MEs. A stronger hypothesis is that various magnetic bodies define sensory canvases at which various sensory representations are realized. Motor action can be seen as a geometric time reversal of sensory perception. Cortex can be seen as a collection of pre-existing symbolic and cognitive features possibly entangled with sensory mental images at sensory organs, and activated when they appear in the perceptive field or form a part of motor action. The basic task of the central nervous system is to identify these features from the sensory input. The mental images associated with various parts of the physical body are entangled with the points of the correspondin magnetic bodies representing objects of the perceptive field by sharing of mental images and in this manner define attributes of these objects. There is an entire hierarchy of representations corresponding to the hierarchy of magnetic bodies, and also sensory perception involves active selections by entangling a sequences of mental images defining paths along the tree-like structure defined by the hierarchy of magnetic bodies beginning from the personal magnetic body and ending at the roots defined by magnetic bodies of sensory organs. This explains phenomena like sensory rivalry.
4. The decomposition of the perceptive field to objects is one of the basic aspects of sensory experiencing and TGD provides a mechanism generating these objects as space-time sheets: the boundaries of these objects correspond to regions of strong Kähler electric field whose strength is assumed to correlate with the intensity of the neural input. It might be that even the objects of perceptive field or thoughts could be regarded as features. In zero energy ontology causal diamonds become the imbedding space correlates of mental images and one can ask whether Negentropy Maximization Principle -perhaps suitably generalized- could force their generation.

5. The computational activities associated with the construction of the sensory representations (say estimating distances and directions of the objects of perceptive field) and virtual sensory representations representing the goals of motor action are presumably realized as iterated processes in which virtual sensory inputs characterizing the expected experiences are compared with the real world sensory input. In a similar manner the goal of the motor action is compared with the sensory representation resulting from effect of a virtual motor action on the representation of the recent state of world and body. This comparison does not necessarily require sensory representation at any level of the self hierarchy and could be based on comparison circuits defined by parallel supra currents in which the inputs which are sufficiently near to each other generate constructive interference giving rise to a large Josephson current.
6. Zero energy ontology together with the notion of causal diamond (CD) identified as imbedding space correlate of self and the moduli space of CD s, the description of dark matter in terms of a hierarchy of Planck constants implying a generalization of the notion of the imbedding space, and the vision about living matter as something residing in the intersection of real and p-adic worlds and carrying positive entanglement negentropy allow to make this vision more detailed and lead to surprisingly precise quantitative predictions and connect the basic biological time scales to those assignable to elementary particles in zero energy ontology. The notion of spectroscopy of consciousness can be formulated for the geometric aspects of conscious experience in terms of the moduli space of causal diamonds and the frequencies of the generalized EEG.

1 Introduction

This - as also the other chapters of “TGD Inspired Theory of Consciousness” - was written for the first time for more than a decade ago. The recent version is an outcome of an updating motivated by the progress taken place in quantum TGD proper during the period 2005-2010. Several new elements are involved. The improved understanding of the quantum TGD itself at the fundamental level; zero energy ontology including the notion of causal diamond (CD) defined as the intersection of future and past directed light-cones; the hierarchy of Planck constants requiring a generalization of the notion of imbedding space and involving the identification of dark matter as phases with non-standard values of Planck constant; and the progress in the understanding of p-adic physics- especially the realization that life could be seen as something residing in the intersection of real and p-adic worlds. The fact that number theoretic entanglement negentropy has a positive value in the intersection has profound implications for the TGD inspired theory of consciousness and quantum biology since the quantum measurement theory is modified profoundly.

1.1 Overall View About TGD Inspired Theory Of Consciousness

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

1. The original view was that notion of quantum jump defines “microscopic” theory of consciousness whereas the notions of self and self hierarchy allow to understand “macroscopic” aspects of consciousness absolutely essential for brain consciousness. It however seems that zero energy ontology and the hierarchy of Planck constants allow to identify these notions by replacing the quantum jump as a fractal structure consisting of quantum jumps within quantum jumps. Despite this I will prefer to talk about these notions as separate ones in the sequel. The assumptions about how the contents of consciousness of self is determined allow to understand the basic structure of conscious experience at general level. One can understand intentionality and volition as closely related to the p-adic nondeterminism. Negentropic quantum entanglement is stable under state function reduction if governed by Negentropy Maximization Principle (NMP) so that state function reduction is not a random process anymore. The implications are obvious for understanding how conscious intelligence emerges. Theory leads to a very general model of sensory experience - including a vision about qualia - and the so called whole-body consciousness involving in an essential manner negentropic entanglement explains the basic characteristics of altered states of consciousness.

2. The understanding of the relationship between subjective and geometric time has evolved via several proposals and leads to the notion of psychological time involving in an essential manner the new view about space-time. Symbolic representations at space-time level required by quantum classical correspondence are made possible by the classical nondeterminism of Kähler action. All space-time sheets are assigned to CDs in zero energy ontology and correspond to mind-like space-time sheets in the earlier terminology. They serve as geometric correlates of selves. The notion of psychological time forces to view the entire many-sheeted space-time surface as a living system so that the standard notion of linear time is illusory and reflects the restricted information content of our conscious experience rather than fundamental 4-dimensional reality.

The paradigm of 4-dimensional brain provides a completely new understanding of the long term memory: no memory storage mechanisms are needed and one avoids the basic difficulties of neural net models. There are two kinds of memories: subjective and geometric. Also geometric memories come in two types: episodal and declarative. Time-like negentropic entanglement make possible episodal memories as a direct re-experiencing in the intersection of real and p-adic worlds, and state function reduction trivializing time-like entropic entanglement gives rise to declarative, verbal memories mediated by classical communications. Massless extremals (MEs) are proposed to serve as space-time correlates for both kinds of memories. The fact that the temporal duration of the light-like self associated with ME can be arbitrarily long, is very probably of significance. The hierarchy of Planck constants allows to overcome the objection due to the fact that the photons with the required extremely low frequencies are below the thermal threshold in living matter and therefore should not have any role for consciousness. Emotions might be understood as resulting from the comparison of geometric memories (the expectation) with the subjective memories (what really happened). The positive-negative coloring of the emotions could relate directly to whether the mental images corresponds to a system with negentropic or entropic entanglement.

3. An essential element is macro-temporal quantum coherence accompanying the formation of bound and negentropically entangled states. Already zero energy ontology assigns macroscopic time scales of coherence to elementary particles and the hierarchy of Planck constants and the stability of negentropic entanglement against state function reduction bring in additional elements. Quantum spin glass degeneracy lengthens the lifetimes of the resulting bound states.
4. Subjective time development by quantum jumps implies quantum self-organization which can be regarded as a sequence of quantum jumps between quantum histories. This evolution corresponds to a sequence of superposition of macroscopic space-time surfaces associated with the final state quantum histories assignable to the hierarchy of CDs. Quantum jumps imply dissipation at fundamental level. As in standard approach dissipation serves as a Darwinian selector of self-organization patterns, which can represent both genes and memes. Jumping from the bottom of a valley of the 4-D quantum spin glass energy landscape to the bottom of another valley by a temporary de-localization in zero modes explains phase transition like processes ranging from a change of protein conformation to the replacement of a habit routine by a new one. Further new elements to the standard view about self-organization are brought by zero energy ontology, negentropic entanglement, and hierarchy of Planck constants implying that second law does not hold true in the standard form anymore. An especially interesting prediction is that the CDs assignable to elementary particles correspond to macroscopic time scales. For instance, electron corresponds to the fundamental.1 second bio-rhythm.

The role of energy feed in self-organization becomes more complex in TGD framework. Learning becomes a fundamental process since state function reduction for negentropically entangled states is not random process anymore and in the first approximation the powers of unitary process define an iterative self-organization process. In this framework one can in principle understand how habits, skills and behavioral patterns are gradually learned. The possibility of the reversal of the arrow of the geometric time below p-adic time scale characterizing the system brings in time reversed dissipation identifiable as a healing. Bio-rhythms could quite generally correspond to dissipation-healing cycles. Motor action could be under-

stood as geometric time reversal for the build-up of sensory representation in an appropriate time scale.

This process gives deep insight to a repertoire of widely different phenomena.

1. The formation of bound and negentropically entangled states implies subjecto-temporal fractality of consciousness meaning that the basic anatomy of quantum jump is replicated in various time scales, even that of human life cycle.
2. Both kinds of entanglements mean fusion of mental images. In entropic fusion sub-selves lose their consciousness whereas negentropic fusion accompanies the experience about expansion of consciousness. Depending on the character of entangling selves (real or p-adic for some p), one can assign to the negentropic entanglement some positively colored experience, say experience of understanding or experience of love. Telepathic sharing of mental images and remote mental interactions become possible. Sexual and spiritual experiences can be seen manifestations of the same basic process of fusion of selves and sex would be present even at the molecular level. For instance, information molecules and receptors entangling negentropically could be seen as having opposite molecular sexes with the binding of the information molecule to receptor giving rise to the experience of “oneness” and favoring co-operation instead of competition.
3. If the randomness of the outcome of the ordinary state function reduction means free choice, then self can choose to some degree whether sub-self ends up to a state in which it can decompose to sub-selves by state function reduction or becomes a entropic or negentropic sub-self stable against state function reduction. Maybe this choice could be seen as a choice between good and evil.
4. For negentropically bound states the powers of unitary process U define a sequence quantum computer type processes. More concretely, the combination of the notions of magnetic body and hierarchy of Planck constants leads to a model of DNA as topological quantum computer [K4]. Zero energy ontology and 4-dimensionality of the ensemble of computations assignable to sub-CDs mean deviations from the standard model for quantum computation.
5. The binding energy liberated in the formation of bound state entanglement is usable energy: this means quantum metabolism based on buy now-pay later mechanism. Negentropic entanglement in turn can carry positive energy and there is a large temptation to assume that metabolic energy is transferred in this manner so that the somewhat nebulous notion of high energy phosphate bond would involve new physics.

The general vision about different types of conscious experiences and about qualia was discussed in [K11]. In this chapter a general model of personal sensory representations is considered: in [K5] a more detailed model for these representations is discussed. The so called magnetospheric sensory and memory representations possibly responsible for the third person aspect of consciousness are discussed in [K10].

1.2 The Quantum Hardware

The model involves the following basic notions and ideas about the quantal hardware of consciousness.

1. TGD universe is quantum spin glass and the plasticity of the brain is in accordance with a model of brain as point moving in an infinite-dimensional spin glass energy landscape. Inhibitory and excitatory nerve pulses induce motion in the energy landscape and justify the notion of frustration characterizing spin glass. The picture differs from ordinary neural net in that spin glass energy landscape has also time as one dimension in a well defined sense (this is due to the failure of the classical determinism in standard sense for the Kähler action defining the dynamics of the system). This allows a new view about what happens in learning.

2. The general model of sensory experience relies on the music metaphor. Axons are like strings of a music instrument. What this metaphor means is however not obvious. Frequency coding relates only the intensity of the sensory quale. Nerve pulses induce dropping of various ions to magnetic flux tubes in magnetic fields of $\simeq .2$ Gauss (Earth's magnetic field has nominal value .5 Gauss) and this generates EEG MEs at EEG frequencies serving as entanglers to the sensory magnetic canvas, and the variation of these frequencies could code for the distance to the object of the perceptive field.

A stronger interpretation of the metaphor should be that sensory pathways are like strings of a musical instrument such that the sound produced by the string corresponds to a particular sensory modality and corresponding higher level cognitive representations associated with it. Primary sensory qualia can be associated with sensory receptors or primary sensory organ if brain and sensory organs are quantum entangled with each other. Nerve pulse patterns would build up what could be regarded as notes representing the music whereas the music (primary sensory qualia) is produced by the primary sensory organs. This leads to a generalization of the idea about brain as an associative, cognitive net.

3. The notion of self hierarchy is central for the model and allows to understand quantum correlates of the sensory qualia.
 - (a) Self hierarchy is very much analogous to the hierarchy of subprograms of a computer program and defines a hierarchy of increasingly abstract experiences. Self hierarchy allows to understand computational aspects of brain although connectionistic picture realized as quantum association network seems to work at various levels of the hierarchy.
 - (b) The empirical results [J7] about the effects of oscillating em fields on brain suggest that cyclotron frequencies, and more generally magnetic transition frequencies, of biologically important ions in magnetic field $B \simeq .2$ Gauss, which is by a factor $2/5$ weaker than the magnetic field of Earth, correspond to important oscillation frequencies of Josephson currents or some other perturbations acting on the system. Also the magnetic transition frequencies of electronic Cooper pairs seem to be important as perhaps also Z^0 magnetic transition frequencies of neutrino and various ions and atoms and even molecules. Classically cyclotron frequency for Josephson current corresponds to resonance.
 - (c) The role of massless extremals (MEs) have become more and more central in TGD inspired theory of consciousness as I have gradually understood their properties. Very briefly, MEs are ideal for both classical and quantum communications, they give rise to quantum holograms both in quantum gravitational and "technological" sense. MEs make also possible the realization of long term memories as communications between future and past. The notion of conscious hologram makes these ideas very concrete.
 - (d) The strange findings challenging the notions of ionic channels and pumps lead to the view about biosystem as a symbiosis of MEs, superconducting magnetic flux tube structures, and atomic space-time sheets. The latter two are in many-sheeted ionic flow equilibrium controlled by MEs and very elegant control mechanisms based on the classical em interaction between MEs and flux tubes inducing supra currents emerges.
 - (e) Self hierarchy has as its geometric correlate the hierarchy of CDs the level of imbedding space and the hierarchy of space-time sheets at space-time level. The fact that Josephson currents associated with ELF frequencies generate photons with wavelengths of size of Earth which by uncertainty principle correspond to topological field quanta with size of Earth. The only possible conclusion seems to be that our sub-selves correspond to (at least) these topological field quanta so that we are much more than our neurons.
 - (f) It took years to arrive to the conclusion that also magnetic flux tube structures associated with various parts of brain could have same size as EEG MEs and serve as sensory canvas in the sense that the positions of objects of perceptive field are represented as sub-selves at the magnetic flux tubes of varying thickness woken-up by MEs generating magnetic transition frequencies. Obviously MEs and magnetic flux tubes associated with the sensory projectors must be very closely related (perhaps they are parallel to achieve Alfvén wave resonance). Various attributes associated with the object of the perceptive field are associated with these magnetic sub-selves and brain, or rather entire

central nervous system, can be seen as a collection of pre-existing features of perceptive field which can be activated. Also long term memory recall can be understood in this framework as a communication between geometric now and geometric past made possible by MEs (which correspond to light-like selves) and magnetic flux tube structures associated with brain, both having astrophysical sizes.

1.3 Me As A Computer Sitting At Its Own Terminal?

It became as a surprise that the vision resulting from a long lasting thought experimentation is actually very much what the original, now twenty five year old, altered state of consciousness experience about myself as a computer sitting at its own terminal, when taken very literally in some aspects, actually suggests. This vision adds to the standard view about brain an additional layer responsible for the sensory representations and brings in the quantum level of control (possibly from magnetic body) so that nerve pulse patterns are only part of the control loop.

1. Magnetic flux tube structures serve as a sensory canvas analogous to the computer screen. The control commands realized by activating MEs, in which state they create coherent states of photons and possibly also other gauge bosons, generate magnetic quantum phase transitions, and induce supra currents, Josephson currents and Ohmic currents, provide a realization for the keyboard of this computer. Brain serves as central processing unit: the computations carried out are parallel computations and program modules are replaced by various self-organization patterns.
2. Motor actions and sensory representations differ in that they are time reversals of each other in a relevant p-adic time scale.
3. What imagined motor actions and sensory experience mean is not quite clear.
 - (a) The first view is that for imagined motor actions and sensory experiences the first (rather than last as one might think!) step in the sequence of commands is simply not realized. For sensory experiences the first step means sensory input assuming that primary sensory qualia are at the level of sensory receptors. A real motor action proceeds like a geometric time reversal of the sensory input and starts from motor organs if it is real, and from some higher level if it is imagined. p-Adic-to-real phase transition is the basic step initiating neural activity leading to imagery.
 - (b) A more quantal view about imagination is based on the notion zero energy states with time-like negentropic entanglement. In this case qubits and more general states are always fuzzy so that Schrödinger cat is never completely alive or completely dead. Suppose one takes a zero energy for which nothing happens and adds to it a little bit of state for which the imagined event happens. The higher the probability of the imagined event is, the nearer the imagined event is to a real event.
4. Cortex can be seen as a collection of pre-existing cognitive features which are activated when they appear in the perceptive field or form a part of motor action. The basic task of cortex is to identify these features from the sensory input, entangle them with sensory input, and project to the magnetic body.
5. The decomposition of the perceptive field into objects is one of the basic aspects of sensory experiencing and TGD provides a mechanism generating these objects as mind-like space-time sheets: the boundaries of these objects correspond to regions of strong Kähler electric field whose strength is assumed to correlate with the intensity of the neural input. It might be that even the objects of perceptive field or thoughts could be regarded as features. At the neuronal level one ends up to a model in which neurotransmitters at the ends of magnetic flux tubes attach to receptors at the ends of magnetic flux tubes connecting cell membrane and DNA and give in this manner rise to a fusion of the pre- and post-synaptic mental images. In contrast to standard neuroscience view, gene level would be involved in an essential manner in the information processing. U process could be described as a generalized Feynman diagram in which synaptic transmissions replace particle exchanges and for negentropically entangled states learning would correspond to a sequence of powers of U .

6. The computational activities associated with the construction of the sensory representations (say estimating distances and directions of the objects of perceptive field) and virtual sensory representations representing the goals of motor action are presumably realized as iterated processes in which virtual sensory inputs characterizing the expected experiences are compared with the real world sensory input. In a similar manner the goal of the motor action is compared with the sensory representation resulting from effect of a virtual motor action on the representation of the recent state of world and body. This comparison does not necessarily require sensory representation at any level of the self hierarchy and could be based on comparison circuits defined by parallel supra currents in which the inputs which are sufficiently near to each other generate constructive interference giving rise to a large Josephson current. The fractal hierarchy of CDs coming as octaves of CD size and the hierarchy of Planck constants in principles makes possible zooming up and down possible so that simulations can be carried out in time scales smaller than that characterizing self.
7. The neural realization of long term memories has remained to a high extent a mystery and TGD suggests that the fundamental realization is not in fact neural. TGD allows the geometric memory storage in the geometric past, where the things happened and still happen. MEs suggest several candidates for the memory recall mechanisms and the quantum communication between geometric future and past is one of the most promising ones. Active memory recall might involve a question sent to the geometric past as a classical signal, perhaps MEs are involved at this stage. In the case of episodal memory the answer would involve the generation of time-like negentropic quantum entanglement: the recalled experience is shared by the experiencer now and in the geometric past. For declarative memories outside the intersection of real and p-adic worlds the communication of the memory would be classical.
8. The model of intentionality is mirror image of the model of long term memories obtained by real \rightarrow p-adic and geometric past \rightarrow geometric future replacements.

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> [L2]. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L3]. The topics relevant to this chapter are given by the following list.

- TGD inspired theory of consciousness [L5]
- The notion of self [L6]
- Quantum model of qualia [L4]

2 General Ideas About Hardware Of Consciousness

In this section general ideas and metaphors about what quantum brain and quantum brain functioning might be, are summarized. These ideas have developed gradually during last decade and continue to do so. The recent view about brain conforms with the great sixteen years old vision about self as a computer sitting at its own terminal.

This vision, if taken completely seriously, means that the ultimate sensory representation conscious-to-us is outside the brain: that this is the case became clear quite recently (the geometric now when I am writing this is October, 2001). The title of this section is “General ideas about hardware of consciousness”. rather than “General ideas about brain”. The reason is that brain and body in TGD Universe form only a tiny part of a system involving hierarchy of MEs and magnetic flux tube structures having astrophysical sizes controlling the matter at the atomic space-time sheets defining brain and body in the usual sense of the world.

I defend this radical deviation from the standard wisdom by the fact that the world “consciousness” has ceased to be a taboo only during the last decade. It would be really astonishing if the materialistic view about consciousness as an illusion and brain as a computer would

generalize to a general theory of consciousness just by adding one candle to the birthday cake of one century of brain science. Just like the creation of physics at the times of Kepler meant revolution in Earth centered world picture, also the creation of the general theory of consciousness is bound to mean thoroughgoing changes in the basic prejudices about human consciousness.

2.1 Brain As A Computer

Brain as a computer metaphor in sense of Turing machine has been one of the dominating metaphors about brain functioning. In TGD this metaphor makes sense as far as general functional architecture of modern computer is considered. Programs must be however replaced by self-organization patterns.

2.1.1 Brain as a computer sitting at its own terminal

My personal great experience involved the realization that I am in some sense a computer sitting at its own terminal. It took more than one and half decades to realize what this self-referential idea having deep mystic coloring in it might mean in practice. Actually I realized the connection only after having ended up to this kind of view about brain by quite different routes.

To be precise, “computer” does not mean in the recent context the abstract Turing machine, but a real world personal computer. The concrete functional and geometric architecture seems to be mimicked by personal computers, not the detailed data processing. the deterministic computer programs are replaced by much more flexible self-organization patterns.

1. Brain corresponds to the central processing unit of this computer. The data in computer memory are typically represented at computer monitor which is outside the central unit, can have much larger size and be located arbitrary far away. In the case of brain this means that the ultimate, conscious-to-me sensory representations are realized outside brain at superconducting magnetic flux tube structures associated with various parts of brain. This view is inspired by very simple observation: when my eyes or my head move, I do not experience that the sensory image of external world moves although its physical representation in brain moves. As if I were an external observed looking the projection of sensory data on canvas inside brain so that the motion of canvas does not matter.

The standard argument is that the fact that brain constructs sensory representations about the motion of eyes, head, and body, is enough to generate the experience that the world is not moving. At least in TGD framework it is extremely difficult to understand how the sensory image of the external world in motion would not give rise to the experience that the world is in motion. I see the failure to realize this point as one of the fatal consequences of computationalism decoupled from physics: the ability to calculate what really happens does not simply give rise to the experience what really happens in the world of physics.

2. In computer the representation of the data on monitor, printing of data, and even various control actions such as the control of a robot reduces to sending of files to various kinds of receivers: the data is just expressed in various manners. In case of brain this means that that the processes leading to sensory experience or motor action differ only in their last steps. If the last step is not present, imagined motor action or sensory experience is in question.

This picture leads to a very general view about sensory representations and motor actions. In this picture also “features” reduce to MEs and this might be too strong an assumption.

1. Brain can be regarded as a collection of standard feature records represented by MEs. These features represent basic features of objects of perceptive field and primitive elements of motor actions. The set of feature MEs is pre-existing and realization of the

sensory image or motor action only activates a subset of these MEs. In principle the locations of feature MEs could be more or less random which means extreme flexibility and ability to adapt to new situations.

2. The basic frequency associated with a particular sensory ME codes for the distance of the object of the perceptive field and the direction of ME codes for its direction. Sensory MEs are naturally organized in radial bundles, files, representing various directions for the objects of perceptive field at given distance. Feature MEs with nearly the same frequency generate magnetic quantum phase transitions waking up magnetic self in the desired distance on the magnetic sensory canvas and thus assign to the object of the perceptive field various kinds of attributes. This means nothing but frequency binding and leads to what might be called spectroscopy of consciousness: EEG acts like a spectrogram allowing to deduce information about the functional state of brain.
3. Support for the view that sensory input and motor activities are very similar comes from motor synesthesia in which person can represent the sensory input by dancing it! More concretely, the realization of intention as motor action reduces to generation of MEs propagating along axons and generating desired membrane oscillation and nerve pulse patterns. There might be however a crucial difference also: motor action could be a geometric time reversal for the construction of a sensory representation and start from a rough sketch in the geometric now and develop quantum jump by quantum jump to a detailed plan in the geometric past. Time reversed dissipation would polish a sketch to a precise plan. Motor action would start from the motor organs and proceed to the level of brain.
4. Brain can be said to contain a collection of passive sensory and motor features which it activates selectively. This brings in mind computer game containing large number of extremely simple files, for instance sound files producing *Aaaargh*'s and *Auuuch*'s. The activation of ME record could mean ME is color rotated by coherent state of WCW photons to electromagnetic ME which in turn generates coherent state of photons and WCW photons acting as a control command; activates magnetic quantum phase transitions; induces supra currents; or something else. Similar mechanism works even at the level of DNA where genes can be coded to various kinds of control commands by activating the associated MEs.

What this view implies that there is no need to worry about how brain realizes ultimate sensory representations inside brain as neural activities. What remains to be understood how brain develops into a collection of the standard features; how brain recognizes the standard features from the incoming sensory input; how brain evaluates the distances and orientations and other data related to the objects of the perceptive field; how brain decomposes the perceptive field into objects; and many other things not listed here.

1. Feature recognition might be based on comparison circuits based on supra current circuits. Expected features would be represented as standard patterns of supra currents. When the pattern of supra currents associated with the sensory input and running parallel to those of expected sensory input is sufficiently near to the expected one, a resonant generation of Josephson currents occurs and gives rise to a recognition of the feature.
2. The positions and other geometric data about the objects of perceptive field are presumably estimated by an iterative process in which the sensory input from the virtual world construct of the perceptive field is compared with the real sensory input which could be sustained in the sensory circuits. Cortico-thalamic communications might relate to this iteration. The comparison takes place by comparison circuits and when the two inputs resemble each other sufficiently, a sensory output at the magnetic canvas is generated. The consistency of these two representations should be gained gradually through learning and by the requirement of consistency between different sensory inputs. Similar comparisons are involved with the development of motor action to yield the final action giving rise to the desired goal.

2.1.2 Brain as a motor and sensory organ of higher level selves

Certainly the most dramatic deviation from the standard neuroscience implied by this view is the prediction of an entire hierarchy of MEs and magnetic selves using brain as a generalized sensory and motor organ. We correspond to only one level in this hierarchy making decisions and controlling the behavior of our body in certain time scale. For instance, long term goals and socially acceptable behavior could be seen as forced by selves at the higher levels of the hierarchy. Drives could perhaps seen as activities forced by lower level selves in the hierarchy (amygdala and other parts of paleobrain contra neocortex). What makes this so dramatic is that the sizes of our magnetic bodies could be astrophysical (here one must of course be very cautious: the realization of long term memories however encourages strongly this view). For instance, EEG ME and corresponding magnetic flux tube structures would both have sizes measured using Earth size as a unit.

A possible mechanism for the motor control from our own sensory canvas as well as from the sensory canvases of higher level selves is provided by MEs. The classical gauge fields entering to brain and body would represent very high level commands, and might be transformed to endogenous sounds by piezoelectric effect identifiable as internal speech (internal speech could also correspond to p-adic MEs). This is only one possibility. The construction of the model of nerve pulse and EEG leads to quite general model for the interaction of MEs as bridges between two space-time sheets characterized by different p-adic primes, and inducing a flow of charge between the two space-time sheets, inducing in turn a flow of em charge, and in case of cell membrane a change of membrane potential leading to the triggering of the nerve pulse. The reduction of the effective phase velocity of ME to the conduction velocity of nerve pulse or of some other excitation involves the shift of entire ME to future occurring in each quantum jump. If the shift occurs in the direction of geometric past, a super-luminal effective phase velocity results. Both cases might be involved, and would correspond naturally to propagating and standing EEG waves and to the space-like and time-like soliton sequences predicted by the model for Josephson junctions.

2.1.3 Boolean mind 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 of 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 [K6, K16, K17, K18].

2.2 Brain, MEs, And Quantum Holograms

MEs represent a communication link in the control hierarchy formed by the magnetic body having onion like structure consisting of superconducting magnetic flux tube structures and flux sheets carrying dark matter, and space-time sheets carrying visible matter, and would be thus involved with the fundamental control operations. EEG MEs and they fractal variants could mediate classical signals and act as time-like entanglers assigning mental images to the points of the magnetic body with distance to the magnetic body being coded by the length

of ME and the direction of the point by the direction of ME. Of course, also the deformations of magnetic flux tubes could mediate classical signals as counterparts of Alfvén waves, and magnetic flux tubes are natural space-like entanglers - the model of DNA as topological quantum computer as an example about this function.

2.2.1 A possible vision about how MEs act as communication links between magnetic body and biological body

One can imagine large number of options for how the MEs are concretely involved with biology and I have done so. The recent view about TGD inspired biology allows to consider a highly unique model for how MEs could perform their role as a communication link.

1. The most plausible one is that MEs associate with the communications between biological body and magnetic body are generated by genome acting as a kind of relay station. For this option MEs attached to the flux tube going through the passive DNA strand would mediate sensory data from the cellular environment to the magnetic body. The sensory data from environment would arrive through magnetic flux tubes connecting biomolecules and lipids of cell membrane to the passive DNA strand analogous to sensory areas of cortex.
2. Magnetic body could induce nerve pulse activity as one particular form of gene expression by ME attached to the flux sheet going through the active DNA strand. Rapid signalling along flux tubes connecting DNA nucleotides and lipids would make this gene expression much faster than the ordinary one. Also nerve pulse activity would be communicated to the magnetic body from the lipid layers of neuron membrane via genome and magnetic body could generate it. It is of course possible that also reflex like nerve pulse activity which does not involve magnetic body is present. From the time scale of the nerve pulse the size scale of the layer of the magnetic body involved with nerve pulse activity must correspond to quark CDs and would be about 10^{-5} meters. This fits nicely with the vision about DNA as topological quantum computer.
3. EEG MEs could be automatically generated as an outcome of nerve pulse activity, when ions drop to the flux quanta of magnetic field $B \simeq .2$ Gauss (Earth's magnetic field has nominal value .5 Gauss), and entangle mental images with the points of the sensory magnetic canvas.

This vision is of course not the only one that one can imagine. As discussed in [K17], genetic/memetic code could also have translation to control commands represented by pairs of MEs orthogonal to DNA strand/axon. In latter case orthogonal pairs of MEs must move along axon with the same velocity as nerve pulse pattern. Stationary EEG MEs translate the nerve pulse patterns to the patterns of light-like vacuum currents. TGD based model of EEG and nerve pulse [K17] predicts two kinds of EEG waves: moving and stationary, and it might be that they correspond to these two kinds of codings. The properties of moving/stationary EEG waves suggest their association to left/right brain hemisphere. Left brain might favour the coding of memetic codons to moving EEG ME pairs whereas right brain might favour the coding of nerve pulse patterns to stationary EEG MEs.

2.2.2 The notion of neural window

The notion of neural window, which was the original form of the hologram idea, allows to see information processing in brain from a slightly different point of view.

1. Massless extremals act as quantum antennae and generate coherent light and also provide waveguides along which BE condensed photons can propagate like Cooper pairs in superconductor. The photons radiated by the space-time sheets representing objects of the perceptive field and propagating along microtubules could provide neurons with a neuronal window. This picture would abstract just the bare essentials of the idea of holographic brain: small piece of hologram is like a small window yielding the same picture as larger window but in blurred form.

2. Massless extremals associated with neural activity could also represent or be accompanied by association sequences making possible geometric memories representing simulations of future and past. What is mysterious from the point of view of the standard neuroscience is that left part of the body sends sensory stimuli to the right brain hemisphere and vice versa. In TGD framework the mystery disappears: the maximization of the axonal lengths maximizes the durations of the association sequences and hence optimizes geometric memory.
3. Neuronal window idea would perhaps make it possible to realize the idea about iterative computation of conscious experiences involving guesses and comparisons. Neuronal windows would generate representations of various perceptive landscapes in disjoint parts of thalamus (sensory organs feed their input in separate parts of thalamus) and mental imagery would construct guesses for the cognitive representations for the objects of the external world realized in the cortex as mind-like space-time sheets radiating coherent light. The neural pathways from cortex to thalamus would provide thalamus with a neural window to cortex and comparison of the landscapes from cortex and sensory organ would be possible. Simple comparison circuits might be at work: neuron would fire when its neural windows to the cortex and sensory organ give sufficiently similar views.
4. One can sharpen the neuronal window idea by combining it with the music metaphor. This would mean that the massless extremal associated with a given axon would correspond to a Bose-Einstein condensate of photons (or WCW photons) with one particular frequency. This would mean vision at neuronal level (nothing to do with our vision realized in EEG frequency scale). Thus one can say that each neuronal window is either covered by curtains or provides a view to single sensory landscape at single frequency.

2.2.3 The experiments of Mark Germaine

MEs could also serve as a communication link between living matter and magnetic bodies representing levels of collective consciousness responsible for the cultural aspects of our consciousness.

The experiments of Mark Germaine [J11] provide evidence for the notion of ELF self and associated collective memory. What was studied was the evoked EEG response to a series of random quantum stimuli, which consisted of series of identical stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved, the first one experienced stimuli as pictures in computer monitor, the second one as sounds. In case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for collective “ELF ME” at this frequency interacting with brains of both A and B. When ELF ME had already heard the stimulus once, it did not react to it in similar manner. Rather interestingly, 11 Hz corresponds to the 10.7 Hz cyclotron frequency associated with Fe_{++} ion in a magnetic field of .2 Gauss (Earth’s magnetic field has nominal value of .5 Gauss). Ca^{++} cyclotron frequency in this field is equal to 15 Hz and would explain the effects of ELF fields on vertebrate brain occurring at harmonics of this frequency.

2.2.4 MEs and long term memory

MEs provide a mechanism of long term memory which differs from ordinary sensory perception only in that the ME giving rise to a geometric memory has much longer duration with respect to the geometric time than the ME giving rise to ordinary sensory perception. To remember classically is to look at a mirror located at a distance of light years. The ends and branching points of magnetic flux tubes are good candidates for the mirrors where MEs are reflected.

In TGD framework synaptic strengths code only cognitive representations and learned associations, not genuine information about events of the geometric past. Long term memory is

coded in the classical em field and in coherent light generated by ME in hologram like manner. Any finite space-time region receiving the classical em field of coherent light generated by it gets hologram like picture containing info about entire geometric time interval spanned by ME. If vacuum current is localized to some restricted space-time region (it can be!), the holographic information is about this region and receiver anywhere along the ME gets more or less the same information since hologram is in question. ELF selves can perhaps control this localization. Note also that the light-likeness of the boundary of ME implies that ME selves have temporal extension defined by the length of ME.

The fact that memory is stored to the moment of geometric time at which event occurred explains why we know that mental image is memory. It is quite possible that MEs are involved with sensory perception, say vision and auditory experience, and make possible to develop time-like entanglement (possibly negentropic) with the sources of light as belonging to the external world. Geometric memory allows also understand identification experiences and transpersonal experiences in which person can experience events of the distant past not related to the personal history. Anticipation of future in turn could be also understood as particular kind of geometric memory, the MEs involved are now p-adic representation intentions, plans, and expectations. Later a more detailed model of long term memories will be developed.

2.3 Generalized Notions Of Sensory Experiencing And Motor Activity

The general view about brain is as a system moving of a fractal energy landscape of quantum spin glass containing valleys inside valleys inside... Brain is not only an on observer of the external world but also of its own position in the spin glass landscape. Brain is not only activator of ordinary motor programs but generates also movements in the spin glass energy landscape. Thus the general functional division sensory experience-motor action generalizes and provides completely new insights to the brain circuitry and functioning. For instance, one could perhaps understand why neural loops are bi-directional. The first loop provides sensory information about the position of brain region in its spin glass landscape and the second loop mediates the motor action: just like in case of the spinal chord.

The sensory experiences giving information about spin glass landscape can be interpreted as giving rise to a generalized sensory and emotional input. Emotions correspond to entropy gradients of various types for selves. A mental image with a positive/negative emotional color results from negentropy/entropy feed to sub-self. If the sign of entropy feed to mental images correlates with the entropy gradient of the system represented by sub-self, emotions become sensory qualia. Emotions provide perhaps the most important "Is it going well" type information about the state of brain and body. Entropy gradients can be also used as an active control tool: sub-selves are rewarded by negentropy feed and punished by a entropy feed. Note that the generalized motor action inducing motion in the spin glass landscape is identifiable as emotional expression and generates entropy gradients and thus emotions.

2.4 The Paradigm Of Four-Dimensional Brain

Four-dimensionality of brain is crucial for the understanding long term memories as multitime experiences receiving contributions from several moments of geometric time. This identification makes it unnecessary to have any memory storage mechanisms. Rather, the activities of the memory circuits can be seen as increasing the probability that memory recall occurs. Reverberating memory circuits in which experience is echoed indeed do this by extending the deep memory valley in spin glass landscape to a long canyon in time direction. This increases the probability that mind-like space-time sheets enter in the region of four-dimensional spin glass landscape representing the memory. The deepness of the spin glass valley correlates with the emotionality of the memory. Childhood memories are especially emotional and therefore stable. Memories are result of creative action and memory circuit involving hippocampus seem to be active in carving out the art works representing geometric memories

worth of remembering. TGD based approach solves the basic problems of the neural net approach resulting from the fact that the formation of new memories destroys old memories and from the fact that it is difficult to understand how the component of experience is known to be a memory.

Four-dimensional brain provides a completely new view about how generalized sensory experiences are generated, how generalized motor actions are planned and how memories are constructed. This process is like creating an artwork. *Four*-dimensional spin glass landscape representing a rough scetch is gradually refined by adding details and corrections in increasingly shorter time scales: this corresponds to neural activities of four-dimensional brain generating motion leading to the desired part of spin glass energy landscape. This picture is consistent with the observed $1/f$ noise and fractality of nerve pulse patterns. Absolutely essential is self-organization and related dissipation forcing the Darwinian selection leading to end product which is charicature rather than photo.

2.5 Music Metaphor And The Function Of The Nerve Pulses And EEG

Music metaphor allowing to see brain as a music instrument. gradually changed from a guiding principle to a prediction of TGD inspired theory. In case of brain the music played is EEG and ZEG spectra. EEG frequencies serve as resonant frequencies at which various quantum phase transitions occur resonantly. Various sensory qualia correlate with EEG frequencies and place coding and possibly also temporal coding by cyclotron frequency scale is possible. Stochastic resonance and pendulum metaphor, which are discussed in [K17], allow to understand the mechanisms for the transformation of EEG waves to nerve pulse patterns and vice versa.

The picture about brain as self-organizing system suggests that neurons are subject to strong selective pressures and specialize to produce highly specialized fixed components of our experience so that music metaphor holds true. If music metaphor holds true generally, the nerve pulses involving fast transmitters can be said to pick the strings of the sensory instrument represented by axons and spatio-temporal patterns of nerve pulses determine the overall pattern of the sensory experience. Nerve pulses inducing motor action in sensory landscape represent pushes and pulls in spin glass energy landscape. These pushes and pulls induce motion in the spin glass landscape and generate both neuronal and our emotions. It seems that simplest emotions with no association telling the cause or object of emotion, are determined by the nerve pulse pattern only.

This picture suggests for neurotransmitters two obvious basic functions: they mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of synapse and postsynaptic neuron. Fast neurotransmitters controlling directly ion channels are involved with mediation and the relevant time scale is one millisecond: no long term change of the postsynaptic neuron is involved. Sensory experiences and motor actions are mediated by direct neurotransmitters. Slow neurotransmitters involving second messenger action are involved with modulation of the response of the postsynaptic neuron and the time scales can be of order minutes. In this case the properties of the postsynaptic neuron are changed.

Emotional reactions involve typically slow transmitters and the effect of them can be regarded as a generalized motor action inducing motion of neuron in the spin glass energy landscape of the neuron. The large information flows associated with neurotransmitters imply entropic gradients and thus also emotions. Some neurotransmitters such as serotonin and dopamine, which generate sensations of pleasure, should reduce entropy and thus fight against the second law of thermodynamics. This presumably occurs at the neuronal level and could be only represented at the level of the sensory selves, where some other mechanisms of the entropy reduction and generation could be at work. An interesting question relates to the warriors in the war against second law. Could glial cells play key role here as is suggested by the observations that depression (in which mental images becomes very entropic and emotional flatness and emptiness results) involves abnormally small amount of glial cells in forebrain and abnormally strong emotional reactions of amygdala.

One can see associations at neuronal level as formed by the pairs of input and output. Input corresponds to the sensory experiences associated with active presynaptic neurons and output to the activity in the axons. The postsynaptic receptors serve as sensory receptors and each neuron could be specialized to its own sensory modalities which are same for the entire sensory pathway. Alternatively, primary qualia are associated with the sensory receptors or sensory organs: this option provides very elegant understanding of what imagination and dreams are. Boolean axons give rise to “Boolean modality” representing thoughts. Typically sensory-Boolean associations are associated with the associative regions of brain and are realized as a fusion of mental images. The formation of an association corresponds to the fusion of space-time sheets representing pre- and post-synaptic neurons to single space-time sheet. The space-time sheets formed by the orbits of synaptic vesicles form the 4-dimensional flux tube. Fusion to single space-time sheet makes possible conscious association containing both inputs and output as a single experience. This picture also explains the time directedness of association. “Our” associations are superpositions of neuronal associations associated with various neuronal circuits.

2.6 Connection With The Functionalistic View About Brain

The basic counter argument against quantum theories of consciousness is that the so called classical theories of brain can quite well explain all the relevant aspects of brain functioning whereas quantum theories of consciousness seem to add very little if anything to this understanding. It seems that huge misunderstandings are involved on both camps.

The notion of self is fundamental for consciousness. For some reason the proponents of quantum consciousness (including me hitherto) have however failed to realize that they should perhaps try to formulate this notion as a quantum-physical concept. Indeed, “What is the quantum counterpart of self” was the bottleneck question in TGD approach and led to the final breakthrough.

Neuroscientists (and also many quantum physicists) in turn seem to have wrong view about what the term “classical” means. This wrong view reflects the wrong view about time and dissipation, which in TGD framework can be understood elegantly in terms of the subjective time development identified as a sequence of quantum jumps between quantum histories. It is of crucial importance that this development can occur only inside selves! Dissipation is the basic correlate of consciousness and consciousness is the basic prerequisite of “classicality” understood in the erratic manner. Thus, from the TGD point of view, Hodgkin-Huxley equations have nothing to do with genuinely classical world. Rather, they model phenomenologically the development of neurons by quantum jumps between quantum histories. Quantum jumps (and dissipation) inside neurons is possible only because neurons act as sub-selves and dissipate. Our self can be regarded as a system making something like 10^{38} quantum jumps per second. This implies macrotemporality but this macrotemporality has absolutely nothing to do with classicality in the sense as it appears in the field equations of say General Relativity.

The notion of self as quantum self-organizing system justifies the use of cybernetic notions such as circuits, loops, feedback, feedforward, inhibition and excitation. The general neuroscientist’s view about brain as a complex neuronal circuitry finds justification and one ends up with rather concrete identifications for what kind of conscious (not necessary conscious to us –) experiences are associated with various brain circuits. The essentially new elements are 4-dimensionality of brain and realization of qualia and Boolean mind in terms of macroscopic quantum phases and these additional elements lead to genuine understanding of what happens in brain.

The randomness of the quantum jump is certainly a strong argument against quantum theories of consciousness and for me it took quite a long time to realize how serious this objection actually is. One can quite well claim that it leaves only one option: standard non-equilibrium thermodynamics in which dissipation in the presence of external energy feed selects the self-organization patterns. The possibility of negentropic entanglement (see **Fig. <http://tgdtheory.fi/appfigures/cat.jpg>** or **Fig. ??** in the appendix of this book) in the intersection of real and p-adic worlds is what changes the situation and removes the

randomness of quantum jump so that unitary process U and its powers define an iterative self-organization process leading to generation of fractal structures and quantum computation like processes possible. This makes also possible conscious goal directed actions and the existence of genuine information rather than only lack of dis-information is what makes possible also learning at the fundamental level.

2.7 Brain As An Associative Net

Brain can be regarded as an associative net. At neural level association is a pair of incoming axons and outgoing axon: during synaptic transfer the space-time sheets of pre- and postsynaptic neuron fuse to form a larger space-time sheets and the corresponding conscious experience is association formed by the experiences determined by pre- and postsynaptic neurons. Neurons have their own sensory qualia associated with transmitter-receptor combinations: also neuronal seeing and hearing is possible. These qualia are probably not ours. From the point of view of our consciousness, nerve pulse patterns are most important and give rise to symbolic representations of sensory input. Frequency coding is involved and memetic code is reduced to genetic code. Membrane oscillations correspond to full memetic code and higher level cognition. Emission of at least slow neural transmitter gives rise to neuronal emotion. During synaptic firing the association pair becomes conscious. The most elegant option is that sensory qualia are at the level of primary sensory organs.

Also motor actions, in particular the transformation of Boolean statements to speech, can be regarded as associations of this kind. Motor action would be time reversal of sensory perception in appropriate time scales, and the motor actions initiated from some level higher than muscle cells correspond to motor imagination. Speech represents translation of memes to motor actions analogous to the translation of genes to proteins. For instance, logical reasoning develops as associations respecting basic rules of logic. This could explain why we are so poor in performing conscious logical deduction. On the other hand, rules of logic could be unconsciously inherited at the level of experience pairs from the physical world which obeys logic.

The most general possibility is that the output of a complex neuron is some function of the inputs. Music metaphor however suggests much simpler possibility: output is the same always and represented by nerve pulse pattern inducing postsynaptic qualia which depend on the receptor-transmitter combinations involved. This assumption has very strong consequences. Especially interesting are the sequences of associations associated with closed neural loops. The assumption that projections are topographically organized and that given axon is always in the same state mean that all closed circuits are reverberatory. Thus elementary single neuron association sequences associated with various brain circuits would be fixed and nerve pulse patterns should be determined the content of various conscious experiences constructed from these elementary experiences: the analogy with music would be very close. This would have quite strong consequences as far as the general structure of the brain circuits are considered.

1. Memories could quite correspond to asymptotic nerve pulse patterns reverberating in memory circuits. Nerve pulse patterns in closed would determine the content of memory and memories would result as fixed point patterns of self-organization. Very probably also microtubular representations of long term memories are important.
2. Motor plans would be represented by nerve pulse patterns reverberating in motor circuits and selected by self organization and realized as genuine motor actions only in case that the geometrically time reversed process starts from the muscle cells.
3. In case of Boolean thoughts reverberating circuits correspond to tautologies so that one can question the hypothesis that axons are permanently in the same state. Of course, there is no need to assume that thoughts correspond to closed circuits.

Negentropic space-like quantum entanglement between neurons, neuronal membranes and DNA strands, and DNA strands and magnetic body adds to this picture a further element necessary if one wants to speak about conscious brain able to learn. Synaptic transmission

becomes the molecular counterpart of enlightenment experience in which neuronal sub-selves experience an expansion of consciousness. Learning as gradual evolution of synaptic strengths can be understood as the space-time correlate for the evolution defined by the unitary process U and its powers in the space of zero energy states representing M -matrices allowing an interpretation as abstractions describing the “laws of physics” as experienced by brain.

3 Quantum Tools For Biocontrol And -Coordination

Coordination and control are the two fundamental aspects in the functioning of the living matter. TGD suggests that at quantum level deterministic unitary time evolution of Dirac equation corresponds to coordination whereas time evolution by quantum jumps corresponds to quantum control. More precisely, the non-dissipative Josephson currents associated with weakly coupled super conductors would be the key element in coordination whereas resonant dissipative currents between weakly coupled super conductors would make possible quantum control.

This view allows to consider more detailed mechanisms. What is certainly needed in the coordination of the grown up organism are biological clocks, which are oscillators coupled to the biological activity of the organ. Good examples are the clocks coordinating the brain activity, respiration and heart beat [I10]. For example, in the heart beat the muscle contractions in various parts of heart occur in synchronized manner with well defined phase differences. Various functional disorders, say heart fibrillation, result from the loss of this spatial coherence. For a control also biological alarm clocks are needed. An alarm clock is needed to tell when the time is ripe for the cell to replicate during morphogenesis. Some signal must tell that is time to begin differentiation to substructures during morphogenesis: for example, in case of the vertebrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

3.1 Massless Extremals, Magnetic Flux Tubes, And Electrets

Massless extremals (MEs), magnetic flux tubes and magnetic body, and electrets define the basic new notions of TGD inspired theory of consciousness and quantum biology and it is good to introduce them first before discussing the quantum tools.

3.1.1 Massless extremals

The identification of mind-like space-time sheets as “massless extremals” (MEs) together with the notion of magnetic body leads to a very general vision about bio-consciousness and an explanation for the fact that the effects of ELF em fields on biomatter occur only for certain amplitude windows [J6] (these effects are discussed in detail in [K1, K2])

1. What MEs are?

Massless extremals (MEs) define a very general solution set of field equations associated with Kähler action [K8] and representing various gauge fields and gravitational [A2] [K13]. Being scale invariant, MEs come in all size scales. The geometry has axial symmetry in the sense that CP_2 coordinates are arbitrary functions of two variables constructed from Minkowski coordinates: light-like coordinate $t - z$ and arbitrary function of the coordinates of the plane orthogonal to the z -axis defining the direction of propagation. The polarization of the electromagnetic field depends on the point of the plane but is temporally constant. MEs represent waves propagating with velocity of light in single direction so that there is no dispersion: preservation of the pulse shape makes MEs ideal for classical communications.

Electric and magnetic parts of various gauge fields are orthogonal to each other and to the direction of propagation. Classical gauge has as its source light-like vacuum current. The time dependence of the vacuum current is arbitrary, this is only possible by its light-likeness.

This makes it possible to code all kinds of physical information to the time dependence of the vacuum current. MEs can have finite spatial size and in this case they are classical counterparts of virtual photons exchanged between charged particles and represent classical communication between material space-time sheets. MEs carry gravitational waves and various classical color and electroweak gauge fields propagating with light velocity.

MEs can also carry constant electric and magnetic fields but in this case the boundaries of ME contain necessarily the sources of this field. Light-like vacuum currents or elementary particles in massless phase could serve as sources MEs could also form double-sheeted structures with wormhole contacts serving as effective sources. It took quite a time to realize that the wormhole contacts have interpretation as gauge bosons and their super partners. Therefore quantum classical correspondence between classical fields and field quanta emerges automatically. In the case of single-sheeted MEs the interpretation is as a space-time correlate for fermion or a super-partner of fermion.

TGD allows the possibility that the two sheets have opposite time orientations and therefore also opposite classical energies. In zero energy ontology this might be always the case for the double sheeted MEs assigned to bosons and their super-partners. The opposite sign of the energy makes it possible to realize virtual particles as pairs of on mass shell particles of opposite sign of energy and this of utmost importance in the recent formulation of quantum TGD [K22]. A natural guess would be that pairs of positive (negative) energy MEs correspond to massless on mass shell particles and pairs of MEs with opposite energies represent naturally virtual particles. The objection is that it is difficult to understand how the spin of on mass shell gauge boson could be represented in terms of fermion and anti-fermion spins associate with the throats of the wormhole contact. Massless Dirac equation seems to allow only longitudinal net polarization for the resulting gauge bosons. The resolution of the problem is based on Kähler-Dirac action which mixes M^4 chiralities. This mixing is also behind the massivation of elementary particles. Quite generally, the exchange of a double-sheeted ME between material space-time sheets can correspond to arbitrary value of the exchanged momentum. Also fermions and their superpartners are assumed to topological condense in in the interaction region and become temporarily double-sheeted but the other sheet need not be ME anymore.

This kind of structures are obvious candidates for cognitive structures since classical non-determinism is localized in a finite space-time volume and direct connection with the notion of virtual particle characterizing the non-determinism of quantum theories emerges. World should be full of MEs with all possible sizes since they have vanishing action: addition of ME with finite time duration yields new absolute minimum of Kähler action since Kähler action does not change in this operation. This suggests that MEs should be of crucial importance in TGD Universe.

2. Interaction of MEs with matter

The basic interaction mechanisms of MEs with superconducting flux tubes are magnetic induction generating supercurrents, the action of MEs as Josephson junctions between magnetic flux tubes, and magnetic quantum phase transitions stimulating radiation of coherent light which in turn BE-condenses on MEs and defines a feedback loop.

Many-sheeted ionic flow equilibrium defines the basic control mechanism with superconducting magnetic flux tubes taking the role of master and atomic space-time sheets taking the role of slave. Magnetic phase transitions could make possible chemical senses based on an endogenous NMR type spectroscopy. Also other than magnetic quantum transitions, such as changes of protein (in particular enzyme-) conformations, could occur coherently at superconducting space-time sheets, so that superconducting space-time sheets could allow an extremely effective high precision quantum control of the biochemistry. Magnetic quantum phase transitions make possible place coding by if the thickness of magnetic flux tube varies and this coding is crucial in the model for how various features are associated with objects of perceptive field at a given position.

MEs allow at their light-like boundaries representations of super conformal- and super-symplectic algebras with gigantic almost-degeneracies of states due to the almost-commutativity

of Poincare algebra and super-symplectic algebra. Super-symplectic states define genuine quantum gravitational state functionals in the space of three-surfaces, the “world of classical worlds”, and correspond to a higher abstraction level than ordinary quantum states defined in the “world” (space-time). This “world of classical worlds” aspect of quantum gravitational states explains why quantum gravity is crucial for consciousness.

3. Possible functions of MEs

MEs serve as receiving and sending quantum antennae [K13]. Light-like vacuum current generates coherent light. Also coherent gravitons are generated. MEs serve also as templates for BE condensation of photons and gravitons with momenta parallel to the light-like vacuum current. Linear structures, say DNA and microtubules, are natural but not the only candidates for structures accompanied by MEs. Since MEs are massless, they carry maximal possible momentum. This makes exchange of ME ideal mechanism for locomotion. The possibility of negative energy MEs is especially fascinating since it suggests “buy now, pay later” mechanism of energy production: perhaps living matter uses MEs to generate coherent motions [K14, K15].

Perhaps the most important function of MEs in living matter is communication and control. MEs can connect different parts of biological body at various levels. For instance, they can be attached to magnetic flux tubes. MEs would be also involved with the communications between magnetic body and biological body and EEG would represent one particular example of this kind of communication. MEs would be also ideal quantum entanglers in time direction and could serve as correlates for the mediators of negentropic quantum entanglement. The communication of sensory data to magnetic body could take via MEs and also the control actions of magnetic body could be mediated by MEs to biological body via MEs.

The original idea was that MEs could induce Josephson junctions and more general current carrying bridges between bio-structures. This is possible but magnetic flux tubes are more natural looking structures in this respect because they can be stationary.

1. Since the electric field of ME is orthogonal to the direction of the propagation of vacuum current, the Josephson junction with potential difference is formed most naturally when super conductors are joined by flux tubes to ME in the direction of the electric field associated with ME. MEs can in principle be arbitrary thin so that the thickness of Josephson junction can be much smaller than the dominating wavelength of ME.
2. The electric field of ME can contain also a constant component. This is possible if there is a vacuum charge density or ordinary elementary particles in a massless phase in the time scale considered (Higgs field vanishes) at the boundaries of ME generating the field. If this charge density is absent, ME is necessary double sheeted with the constant electric and magnetic fields created by the wormhole throats at the boundaries of ME serving as effective charges. Both single and double sheeted MEs could give rise to the Josephson junctions with a constant potential difference. The coding of the transversal potential difference associated with ME to Josephson frequency could be a fundamental information coding mechanism in living matter. ME can contain also oscillating electric field over Josephson junction at magnetic or some other transition frequency so that MEs are ideal for control purposes.

4. MEs and the interaction of the classical em fields with biomatter

MEs acting as Josephson junctions and containing oscillating em field at ELF frequency give rise to a harmonic perturbation inducing quantum jumps of the magnetic states of ions and explains the effect of ELF em fields on biomatter. Also the presence of the mysterious intensity windows [J8, J5] can be understood. Josephson current paradigm allows to understand this effect if radio frequency or microwave MEs associated with the external field act as Josephson junctions.

1. The external electric field oscillating with frequency ω (now radio frequency) defines slowly varying potential difference over Josephson junction of length d acting as Josephson junction provided that the condition

$$\omega \ll \omega_J(max) = ZeV = ZeEd$$

holds true. This gives

$$d \gg \frac{\omega}{ZeE} .$$

For $E \sim .1$ V/m and $\omega \sim GHz$ which are typical values used in experiments [J6], this condition gives $d \gg 10^{-6}$ meters which is satisfied if Josephson junctions have size not smaller than cell length scale.

2. For fixed length of Josephson junction amplitude window results if the maximal Josephson frequency $\omega_J(max)$ is slightly above some transition frequency since in this case the stationary maxima and minima of amplitude lead to long lasting resonant excitation of quantum transitions. Denoting the relative width of the resonance by $\Delta\omega/\omega = P$, the ratio of the time spent in resonance at $\Omega_J(max)$ to the time spent off resonance at Ω_J is of order

$$\frac{t(max)}{t} \sim \sqrt{1 - \frac{\Omega_J^2}{\Omega_J^2(max)}} \times \frac{1}{\sqrt{P}} .$$

For a narrow resonance width this ratio can be very large so that amplitude window results for fixed value of d .

3. Amplitude window results if there is a correlation between the thickness of ME and transversal electric field so that $\omega_J(max) = ZeEd(E)$ satisfies resonance condition for some values of E only, if any. In absence of this correlation Josephson junctions must have discrete spectrum of effective lengths for amplitude window to result.
4. For electric fields in the range .1 V/m the frequencies ω_J are above GHz for d larger than 3×10^{-5} meters and correspond to the frequencies for the conformational dynamics of proteins. There are obviously a large number of frequencies of this kind and several intensity windows. EM fields with these strengths should have special effects on living matter: it could be even that some kind of feature recognition process involving self-organization occurs at these field strengths. Note that the minimal size of Josephson junctions corresponds to the p-adic length scale $L(173) \simeq 1.6 \times 10^{-5}$ meters characterizing structures next to cells in the p-adic length scale hierarchy.

5. MEs and quantum holography

Sokolov and collaborators [B1] have proposed a model of quantum holographic teleportation in which the *classical* photocurrents from the sender to receiver take the role of a dynamical hologram. The connection with MEs is obvious.

1. MEs are carriers of classical light-like vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Light-like current would be like a dynamical (four-dimensional) diffraction grating. Light-like vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons and their generalizations to colored WCW photons should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.
2. The proposal of [B1] generalizes to the case of MEs provided one can devise a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix in which each pixel gives rise to a photocurrent [B1], is replaced

with ME or set of parallel MEs. The neural window hypothesis states that neuronal axons are accompanied by parallel MEs carrying information between sensory organs and brain and various parts of brain. This is only a less standard manner to say that ME represents classical dynamical hologram. The possibility of local light-cone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

The concrete realization of holographic teleportation proposed in [B1] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is performing internal teleportation of photonic quantum states with spike patterns being directly coded to the pattern of the vacuum currents flowing along MEs. If spike patterns code the dynamical hologram, a surprisingly close relationship with Pribram's views about holographic brain results. Nerve pulse patterns could be seen as specifying the necessary classical aspects of the quantum teleportation (in TGD classical physics is essential part of quantum physics, rather than some effective theory).

3. The light-like vacuum current at a 3-dimensional time-like section of ME as a function of time defines a dynamical 3-dimensional hologram. This is consistent with the fact that our visual experience is two-dimensional: the information is always about outer boundaries of the objects of the perceptive field. The values of the vacuum current at a given point are non-deterministic which means that vacuum current is ideal for coding information. Classical data also propagate without dispersion with light velocity obeying the laws of geometric optics and MEs imply channelling so that MEs are tailor-made for classical information transfer.
4. Space-time sheets can have both positive and negative time orientations and the sign of energy depends on time orientation in TGD framework. This means that classical communication can occur both in the direction of the geometric future and past: this is essential for the classical model of the long term memories as a question communicated to the geometric past followed by answer. The dynamical nature of the holograms means that there is no need to combine 2- or 3-dimensional holograms associated with several moments of geometric time to single hologram. To remember is to perceive an object located in the geometric past. Of course, fractality might make possible temporally scaled down versions of the geometric past but the principle would remain the same.
5. Quantum hologram view suggests that the super-symplectic representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K5] this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling super-symplectic generators in the complement of Cartan algebra. In this view superconducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.
6. The model for visual qualia leads to the hypothesis that, besides ordinary photons, also colored WCW photons are possible and characterized by WCW Hamiltonian which is labelled by orbital spin quantum number J (in two-dimensional sense) and by color quantum numbers. The coherent states of these massless WCW photons would be responsible for visual colors and polarization sense and the corresponding holograms might be the crux of quantum control in living matter.

3.1.2 Magnetic flux tubes and the notion of magnetic body

The notion of magnetic/field body is one of the features of TGD inspired biology challenging the standard views about living matter.

1. Magnetic body has a fractal onion like structure with decreasing magnetic field strengths and the highest layers can have astrophysical sizes. Cyclotron wave length gives an estimate for the size of particular layer of magnetic body. $B = .2$ Gauss is the field strength associated with a particular layer of the magnetic body assignable to vertebrates and EEG. This value is not the same as the nominal value of the Earth's magnetic field equal

to 5 Gauss. It is quite possible that the flux quanta of the magnetic body correspond to those of wormhole magnetic field and thus consist of two parallel flux quanta which have opposite time orientation. This is true for flux tubes assigned to DNA in the model of DNA as a topological quantum computer.

2. The layers of the magnetic body are characterized by the values of Planck constant and the matter at the flux quanta can be interpreted as macroscopically quantum coherent dark matter. This picture makes sense only if one accepts the generalization of the notion of imbedding space.
3. In the case of wormhole magnetic fields it is natural to assign a definite temporal duration to the flux quanta and the time scales defined by EEG frequencies are natural. In particular, the inherent time scale of 1 second assignable to electron as a duration of zero energy space-time sheet having positive and negative energy electron at its ends would correspond to 10 Hz cyclotron frequency for ordinary value of Planck constant. For larger values of Planck constants the time scale scales as \hbar . Quite generally, a connection between p-adic time scales of EEG and those of electron and lightest quarks is highly suggestive since light quarks play key role in the model of DNA as topological quantum computer.
4. TGD predicts also hierarchy of scaled variants of electro-weak and color physics so that ZXG, QXG, and GXG corresponding to Z^0 boson, W boson, and gluons appearing effectively as massless particles below some biologically relevant length scale suggest themselves. In this phase quarks and gluons are unconfined and electroweak symmetries are unbroken so that gluons, weak bosons, quarks and even neutrinos might be relevant to the understanding of living matter. In particular, long ranged entanglement in charge and color degrees of freedom becomes possible. For instance, TGD based model of atomic nucleus as nuclear string suggests that biologically important fermionic could be actually chemically equivalent bosons and form cyclotron Bose-Einstein condensates.

The list of possible functions of the magnetic body is rather impressive.

1. Magnetic body controls biological body and receives sensory data from it. Together with zero energy ontology and new view about time explains Libet's strange findings about time lapses of consciousness. EEG, or actually fractal hierarchy of EXGs assignable to various body parts makes possible communications to and control by the various layers of the magnetic body. WXG could induce charge density gradients by the exchange of W boson.
2. The flux sheets of the magnetic body traverse through DNA strands. The hierarchy of Planck constants and quantization of magnetic flux predicts that the flux sheets can have arbitrarily large width. This leads to the idea that there is hierarchy of genomes corresponding to ordinary genome, supergenome consisting of genomes of several cell nuclei arranged along flux sheet like lines of text, and hypergenomes involving genomes of several organisms arranged in a similar manner. The prediction is coherent gene expression at the level of organ, and even of population. In this picture the big jumps in evolution, in particular, the emergence of EEG, could be seen as the emergence of a new larger layer of magnetic body characterized by a larger value of Planck constant. For instance, this would allow to understand why the quantal effects of ELF em fields requiring so large value of Planck constant that cyclotron energies are above thermal energy at body temperature are observed for vertebrates only.
3. The strands of DNA could serve as intermediation structure analogous to brain hemispheres with active strand analogous to motor areas and passive strand analogous to sensory areas of cortex. The passive strand would serve as a relay station through which sensory data about the cellular environment is transferred to the magnetic body. Here MEs topologically condensed to the flux sheets could be in key role. The flux tubes connecting DNA nucleotides and cell membrane and various biomolecules would mediate the sensory data to the passive DNA strand.
4. Magnetic body makes possible information process in a manner highly analogous to topological quantum computation. The model of DNA as topological quantum computer

assumes that flux tubes of wormhole magnetic field connect DNA nucleotides with the lipids of the lipid layer of nuclear or cell membrane. The flux tubes would continue through the membrane and split during topological quantum computation. The time-like braiding of flux tubes makes possible topological quantum computation via time-like braiding and space-like braiding makes possible the representation of memories. The model allows general vision about the deeper meaning of the structure of cell and makes testable predictions about DNA.

One prediction is the coloring of braid strands realized by an association of quark or antiquark to nucleotide. Color and spin of quarks and antiquarks would thus correspond to the quantum numbers assignable to braid ends. Color isospin could replace ordinary spin as a representation of qubit and quarks would naturally give rise to qutrit, with third quark would have interpretation as unspecified truth value. Fractionization of these quantum numbers takes place which increases the number of degrees of freedom. This prediction would relate closely to the discovery of topologist Barbara Shipman that the model for the honeybee dance suggests that quarks are in some manner involved with cognition. Also microtubules associated with axons connected to a space-time sheet outside axonal membrane via lipids could be involved with topological quantum computation and actually define an analog of a higher level programming language.

5. The strange findings about the behavior of cell membrane, in particular the finding that metabolic deprivation does not lead to the death of cell, the discovery that ionic currents through the cell membrane are quantal, and that these currents are essentially similar than those through an artificial membrane, suggest that the ionic currents are dark ionic Josephson currents along magnetic flux tubes. A high percent of biological ions would be dark and ionic channels and pumps would be responsible only for the control of the flow of ordinary ions through cell membrane.
6. These findings together with the discovery that also nerve pulse seems to involve only low dissipation lead to a model of nerve pulse in which dark ionic currents automatically return back as Josephson currents without any need for pumping. This does not exclude the possibility that ionic channels might be involved with the generation of nerve pulse so that the original view about quantal currents as controllers of the generation of nerve pulse would be turned upside down. Nerve pulse would result as a perturbation of kHz soliton sequence mathematically equivalent to a situation in which a sequence of gravitational penduli rotates with constant phase difference between neighbors except for one pendulum which oscillates and oscillation moves along the sequence with the same velocity as the kHz wave. The oscillation would be induced by a “kick” for which one can imagine several mechanisms.

The model explains features of nerve pulse not explained by Hodgkin-Huxley model. These include the mechanical changes associated with axon during nerve pulse, the outwards force generated by nerve pulse with a correct prediction for its order of magnitude, the adiabatic character of nerve pulse, and the small rise of temperature of membrane during pulse followed by a reduction slightly below the original temperature.

The model predicts that the time taken to travel along any axon is a multiple of time dictated by the resting potential so that synchronization is an automatic prediction. Not only kHz waves but also a fractal hierarchy of EEG (and EXG) waves are induced as Josephson radiation by voltage waves along axons and microtubules and by standing waves assignable to neuronal (cell) soma. The value of Planck constant involved with flux tubes determines the frequency scale of EXG so that a fractal hierarchy results.

The model forces to challenge the existing interpretation of nerve pulse patterns and the function of neural transmitters. Neural transmitters need not represent actual/only signal but could be more analogous to links in quantum web. The transmitter would coding the address of the receiver, which could be gene inside neuronal nucleus. Nerve pulses would build a connection line between sender and receiver of nerve pulse along which actual signals would propagate. Also quantum entanglement between receiver and sender can be considered.

7. Acupuncture points, meridians, and Chi are key notions of Eastern medicine and find a natural identification in terms of magnetic body lacking from the western medicine.

Also a connection with well established notions of DC currents and potentials discovered by Becker and with TGD based view about universal metabolic currencies as differences of zero point energies for pairs of space-time sheets with different p-adic length scale emerges.

Chi would correspond to these fundamental metabolic energy quanta to which ordinary chemically stored metabolic energy would be transformed. Meridians would most naturally correspond to flux tubes with large \hbar along which dark supra currents flow without dissipation and transfer the metabolic energy between distant cells. Acupuncture points would correspond to points between which metabolic energy is transferred and their high conductivity and semiconductor like behavior would conform with the interpretation in terms of metabolic energy storages. The energy gained in the potential difference between the points would help to kick the charge carrier to a smaller space-time sheet. It is possible that the main contribution to the of charge at magnetic flux tube is magnetic energy and slightly below the metabolic energy quantum and that the voltage difference gives only the lacking small energy increment making the transfer possible. Also direct kicking of charge carriers to smaller space-time sheets by photons is possible and the observed action spectrum for IR and red photons corresponds to the predicted increments of zero point kinetic energies.

8. Magnetic flux tubes could also play key role in bio-catalysis and explain the magic ability of biomolecules to find each other. The model of DNA as topological quantum computer [K4] suggest that not only DNA and its conjugate but also some amino-acid sequences acting as catalysts could be connected to DNA and other amino-acids sequences or more general biomolecules by flux tubes acting as colored braid strands. The shortening of the flux tubes in a phase transition reducing the value of Planck constant would make possible extremely selective mechanisms of catalysis allowing precisely defined locations of reacting molecules to attach to each other. With recently discovered mechanism for programming sequences of biochemical reactions this would make possible to understand the miraculous looking feats of bio-catalysis.
9. The ability to construct “stories”, temporally scaled down or possible also scaled up representations about the dynamical processes of external world, might be one of the key aspects of intelligence. There is direct empirical evidence for this activity in hippocampus. The phase transitions reducing or increasing the value of Planck constant would indeed allow to achieve this by scaling the time duration of the zero energy space-time sheets providing cognitive representations.

The list of nice things made possible by the magnetic body is impressive and one can ask whether there is any experimental support for this notion. The findings of Peter Gariaev and collaborators give evidence for the representation of DNA sequences based on the coding of nucleotide to a rotation angle of the polarization direction as photon travels through the flux tube and for the decoding of this representation to gene activation [I4], for the transformation of laser light to light at various radio-wave frequencies having interpretation in terms of phase transitions increasing \hbar [I3, I1], and even for the possibility to photograph magnetic flux tubes containing dark matter by using ordinary light in UV-IR range scattered from DNA [K20], [I6].

3.1.3 Electrets

Electrets are by definition spontaneously electrically polarized structures. Living matter is full of electrets. Practically all important biomolecules are electrets. Cell membrane is an electret and liquid crystal. Microtubules are electrets as are also various larger structures such as collagens.

The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I7]. This cohesion gives rise to liquid [F1] [D1] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of

the layers [I11, I9, I7] . For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K3]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I8] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

In TGD framework electrets could serve as sensory receptors. In capacitor model of sensory qualia the flow of quantum numbers between the plates of this kind of capacitor would give rise to sensory qualia. The process would be self-organization process with energy flow replaced with a more general flow of quantum numbers.

3.2 Homeostasis As Many-Sheeted Ionic Flow Equilibrium?

The experimental work of Ling, Sachs and Qin [I7, I12] and other pioneers [I5, I2] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the many-sheeted space-time. Ionic super currents from superconducting controlling space-time sheets flow to controlled atomic space-time sheets and back. Currents are of course ohmic at the atomic space-time sheets. One can understand how extremely small ionic densities and super currents at cellular space-time sheets can control ionic currents and much higher ionic densities at atomic space-time sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic space-time sheets flow through the cell membrane region containing the strong electric field along superconducting cell membrane space-time sheet (rather than atomic space-time sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Superconducting space-time sheets contain a plan of the biosystem coded to ion densities and magnetic quantum numbers characterizing the super currents. Biocontrol by em fields affects these super currents and one can understand the effects of ELF em fields on biosystem in this framework. The model relies crucially on the liquid crystal property of biomatter (hamburger mystery!) making possible ohmic current circuitry at the atomic space-time sheets as a part of the many-sheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [J4]: among other things the circuitry could explain how acupuncture works.

One can add several new elements to this picture.

1. The phase transition changing the value of Planck constant induces a change of the length of the magnetic flux tube scaling as \hbar . Therefore the reduction of the Planck constant for a flux tube connecting two biomolecules can bring them near to each other. This suggests that biomolecules form a kind of Indra's net and that these phase transitions together with the reconnection of magnetic flux tubes changing the topology of this net are the basic mechanisms explaining the miracles of bio-catalysis and induce various phases transitions typically accompanying contractions and expansions of the matter in the cell interior. One could actually see the phase transitions of living matter as being induced from the motor actions of the magnetic body.
2. Zero energy ontology predict is that the CDs assignable to elementary particles have temporal size scale given by the secondary p-adic time scale. For electron and quarks

(assigned to the ends of magnetic flux tubes in the model of topological quantum computation) these time scales are 100 milliseconds and 1 millisecond respectively and identifiable as fundamental biological time scales. A deep connection between biology and elementary particle physics seems to exist.

3. Negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) transforms the bio-molecules from dead matter to conscious entities so that the nano-scaled molecules are just what they seem to be in light of experimental nano-biology: intelligent conscious entities having intentions and plans and willing and able to collaborate.

3.3 Quantum ModelFor Pattern Recognition

The general neuroscience based model for recognition relies on learning made possible by synaptic plasticity. It is expected to have a TGD based quantum variant [K19]. The model of pattern recognition to be discussed below relies on supra currents and Josephson currents assignable to cell membrane and various other binary structures, and could define a building brick of the general model. For instance, the model of nerve pulse relies on Josephson currents [K17].

Time translation invariant pattern recognition circuit can be realized by using two coupled superconductors. The first superconductor contains the reference supra current and second superconductor contains the supra current determined by the sensory input. Supra currents are assumed to have same spatially and temporally constant intensity. If the supra currents have spatially constant phase difference, also Josephson currents are in the same phase and sum up to a large current facilitating synchronous firing. The temporal phase difference of supra currents does not matter since it affects only the overall phase of the Josephson current. Therefore patterns differing by time translations are treated as equivalent. Quite generally, the requirement of time translational invariance, favours the coding of the sensory qualia to transition frequencies.

The destructive interference of supra currents provides an tool of pattern cognition in situations when the precise timing is important. The pattern to be recognized can be represented as a reference current pattern in some neuronal circuit. Input pattern determined by sensory input in turn is represented by supra current interfering with the reference current. If the interference is destructive, synchronous generation of nerve pulses in the circuit occurs and leads to a conscious pattern recognition. Obviously the loss of time translation invariance makes this mechanism undesirable in the situations in which the precise timing of the sensory input does not matter. One can however imagine situations when timing is important: for instance, the deduction of the direction of the object of the auditory field from the phase difference associated with signals entering into right and left ears could correspond to this kind of situation.

In both cases one can worry about the regeneration of reference currents. The paradigm of four-dimensional quantum brain suggests that sensory input leads by self-organization to a stationary spatial patterns of supercurrents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

3.4 General Mechanism Making Possible Biological Clocks And Alarm Clocks, Comparison Circuits And Novelty Detectors

Weakly coupled superconductors and quantum self-organization make possible very general models of biological clocks and alarm clocks as well as comparison circuits and novelty detectors.

The Josephson junction between two superconductors provides a manner to realize a biological clock. Josephson current can be written in the form [D3]

$$\begin{aligned} J &= J_0 \sin(\Delta\Phi) = J_0 \sin(\Omega t) , \\ \Omega &= ZeV , \end{aligned} \tag{3.1}$$

where Ω is proportional to the potential difference over the Josephson junction. Josephson current flows without dissipation.

In BCS theory of superconductivity the value of the current J_0 can be expressed in terms of the energy gap Δ of the super conductor and the ordinary conductivity of the junction. When the temperature is much smaller than critical temperature, the current density for a junction is given by the expression [D3]

$$J_0 = \frac{\pi \sigma_s \Delta}{2e d} . \tag{3.2}$$

Here σ_s is the conductivity of the junction in the normal state assuming that all conduction electrons can become carriers of the supra current. d is the distance between the super conductors. The current in turn implies a position independent(!) oscillation of the Cooper pair density inside the two super conductors. By the previous arguments the density of the Cooper pairs is an ideal tool of biocontrol and a rhythmic change in biological activity expected to result in general. Josephson junctions are therefore good candidates for pacemakers not only in brain but also in heart and in respiratory system.

In the presence of several parallel Josephson junctions quantum interference effects become possible if supra currents flow in the super conductors. Supra current is proportional to the gradient of the phase angle associated with the order parameter, so that the phase angle Φ is not same for the Josephson junctions anymore and the total Josephson current reads as

$$J = \sum_n J_0(n) \sin(\Omega t + \Delta\Phi(n)) . \tag{3.3}$$

It is clear that destructive interference takes place. The degree of the destructive interference depends on the magnitude of the supra currents and on the number of Josephson junctions.

There are several options depending on whether both super conductors carry parallel supra currents or whether only second super conductor carries supra current.

1. If both super conductors carry supra currents of same magnitude but different velocity, the phases associated with the currents have different spatial dependence and destructive interference occurs unless the currents propagate with similar velocity. This mechanism makes possible comparison circuit serving as a feature detector. What is needed is to represent the feature to be detected by a fixed supra current in the second super conductor and the input as supra current with same charge density but difference velocity. The problem is how the system is able to generate and preserve the reference current. If case that feature detector “wakes-up” into self state when feature detection occurs, the subsequent quantum self-organization should lead to the generation of the reference current representing the feature to be detected.
2. If only second super conductor carries supra current and of this supra current for some reason decreases or becomes zero, constructive interference occurs for individual Josephson currents and net Josephson current increases: current causes large gradients of Cooper pair density and can lead to the instability of the structure. When the supra current in the circuit dissipates below a critical value, instability emerges. This provides a general mechanism of biological alarm clock.

Assume that the second super conductor carries a supra current. As the time passes the reference current dissipates by phase slippages [D2, D3]. If the reference current is large enough, the dissipation takes place with a constant rate. This in turn means that the

Josephson current increases in the course of time. When the amplitude of the Josephson current becomes large enough, the density gradients of the charge carriers implied by it lead to a non-stability of the controlled system: the clock rings. Since the dissipation of (a sufficiently large) Josephson current takes place at constant rate this alarm clock can be quite accurate. It will be found that a variant of this mechanism might be at work even in the replication of DNA. The instability itself can regenerate the reference current to the clock. If the alarm clock actually “wakes-up” the alarm clock to self state, self-organization by quantum jumps must lead to an asymptotic self-organization pattern in which the supra current in the circuit is the original one. Actually this should occur since asymptotic self-organization pattern depends only weakly on the initial values.

3. Novelty detector can be build by feeding the outputs of the feature detectors to an alarm clock circuit. In alarm clock circuit only the second super conductor carries supra current, which represents the sum of the outputs of the feature detectors. Since the output of a feature detector is non-vanishing only provided the input corresponds to the feature to be detected, the Josephson current in additional circuit becomes large only when the input does not correspond to any familiar pattern.

4 Sensory Representations

In this section concrete model for the sensory representations is developed on basis of the general vision already outlined. What is new as compared to the earlier vision is the role of zero energy ontology and CDs as imbedding space correlates for sub-selves.

4.1 Where Me Is?

The motion of eye or head does not induce the sensation that the world is moving although the sensory image moves around the cortex. Rather, brain acts like a (possibly moving) canvas at which the sensory input is projected and monitored by an external observer. This very simple observation is a strong objection against the idea that the ultimate sensory representations reside inside brain, and leads to the view that the magnetic flux tube structures associated with the primary and secondary sensory organs define a hierarchy of sensory representations outside brain. The question is where these representations are realized and one can imagine two alternatives.

4.1.1 Are higher level sensory representations realized at the magnetic body?

Magnetic flux tube structures would serve as the sensory canvas to which sensory images are projected from brain and possibly sensory organs and even neurons. MEs serve as projectors and place coding by magnetic transition frequency associated with ME wakes-up sensory sub-selves at various positions of magnetic flux tubes having varying thickness and associate thus various sensory qualia and even more complex attributes to the objects of the perceptive field.

This view can be defended also by the neat separation of the information processing from its representation occurring also in case of the ordinary computers as well as by Uncertainty Principle for EEG waves. If primary qualia are at the level of primary sensory organs and entangled with cortex, one can understand why imagination, which involves much the same neural processes as perception, does not give rise to sensory qualia.

EEG MEs correspond to our level in this hierarchy of projections. The simplest possibility is that the sizes of these sensory selves are of the order of EEG ME sizes ($L(EEG) = c/f(EEG)$) and thus can be of the order of Earth size! Thus the ultimate sensory representations are magnetic giants in TGD and diametrical opposites of the neurophysiological dwarfs of standard neuroscience populating also TGD brain.

The known strange effects of large scale perturbations of Earth’s magnetic field on consciousness (say, statistics about the effects of magnetic storms in mental state and tectonic activity

inducing UFO experiences) provide a rich palette of anomalies supporting this view. The conservation of magnetic flux makes the magnetic flux tube structures of Earth size (or even larger) very stable: thus physical death presumably means only that our magnetic body redirects its attention to something more interesting. Near death experiences discussed in more detail in [K3] indeed support this view.

Two requirements must be satisfied for this scenario to work.

1. The projectors to the magnetic body cannot rotate when head rotates so that a fixed direction of perceptive field corresponds to the fixed direct at the magnetic body. This can be achieved if the projectors are magnetic structures with a fixed orientation with respect to the Earth's magnetic field.
2. Retinae must act like windows for this scenario to work. This means that the primary qualia mental images (sub-selves) at retina are entangled with the corresponding cognitive mental images at cortex, keep their attention directed to that part of the perceptive field that they represent as the direction of the gaze changes. Perhaps the retinal mental images are stationary with respect to the liquid phase not comoving with the eye ball. The retina-external world entanglement would also keep retinal attention fixed. This applies also to the saccadic motion, and the loss of visual consciousness when saccadic motion is prevented, could mean simply that retinal mental images lose consciousness when their motor activity with respect to eye ball is prevented: just like we lose our consciousness if not allowed to move!

4.1.2 Could the sensory representations about position of the object be realized in the perceptive field?

There is also a more conservative realization of sensory representations (if I had invented it first, I would probably have never considered the representations at the magnetic body!).

1. If retina-external world entanglement is present as suggested by the argument above, sensory canvas for the primary sensory representations could be provided by the perceptive field itself. The series of quantum entanglements from sensory organs to brain to magnetic body would define the entire sensory-cognitive representation involving also the cognitive aspects. There would be no absolute need for topographic representations at the magnetic body although the appearance of a hierarchy of topographic representations in brain suggest that topographic representations continues. The magnetic representations could however be more abstract higher level representations: somewhat like the manual of an electronic instrument as compared with the photograph of the instrument.
2. One can also imagine that the magnetic body is not involved at all since also in this case the sensory representation would be organized topographically by the entanglement with the objects of the perceptive field. Now brain would entangle to the objects of the external world cognitive mental images. One could say, that me is the entire perceptive field plus physical body. In this case however the function of EEG remains unclear. Also the model of long term memories also suggests that EEG MEs in length scales of light life-time are involved.

Of course, neither of these views about human consciousness is new. In particular, the first one is shared by all spiritual practices. What is new is the concrete physical model realizing this view physically. Here I cannot avoid the temptation to fall for a moment in manifesto mood: what makes me sad is that the materialistic neuroscience so strongly advocates the brain centered view about consciousness with physical death meaning the absolute end. The belief in this world view deprives life from its meaning and reduces it to a vulgar fight for survival or, depending on one's tastes, to a pre-determined performance of a robot. It is also deeply frustrating that the stubborn belief on materialism prevails despite the fact that this dogma contains so many internal contradictions that it would not even deserve to be called world view.

4.2 Concrete Realization Of Sensory Representations

The vision about the concrete realization of the sensory representations conscious-to-us has developed rather slowly. A good measure for the uncertainties involved is that the sizes of the primary sensory organs and EEG ME lengths $L(EEG) = c/f$ have represented the two extreme options for the size scale of the sensory representations conscious-to-us. It seems however more and more clear that TGD forces a dramatic deviation from the prevailing view about cortex as the seat of the ultimate sensory representations. The sensory representations conscious-to-us are outside the body and that the relevant length scale could be most naturally the length scale $L(EEG) = c/f$ defined by the EEG frequencies. In case of long term memories much longer length scales in the range of the light lifetime are necessarily involved and the realization of long term memories forces to conclude that human sensory consciousness is a cosmic phenomenon.

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

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

1. *Quantum phase transition produce qualia*

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

2. *Discharge of quantum capacitor produces primary qualia*

Quantum capacitor discharge provides an attractive model for how the primary sensory qualia at the level of sensory receptors emerge.

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 post-synaptic 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. *Higher level qualia at the level of brain and magnetic body*

Higher level sensory qualia at the level of magnetic body are expected to relate to the geometric aspects of sensory input such as shape or size of objects of the perceptive field.

The capacitor model in principle generalizes to the level of brain and magnetic body. What is needed is a phase transition transforming one Bose-Einstein condensate type phase with

definite quantum numbers to a second one. 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 frequencies characterizing CDs and the intensities of the Fourier components for various harmonics can affect self-organization process. Furthermore, qualia 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. Different values of Planck constant could define a hierarchy of representations.

4.2.2 Zero energy ontology and geometric qualia

Zero energy ontology is a new element of quantum TGD and states that all physical states have vanishing net values of conserved quantum numbers. Zero energy ontology provides a firm justification for the notion of negative energy signals consisting of (say) phase conjugate photons propagating to the geometric past. These negative energy signals are crucial element of the time mirror mechanism (see Fig. <http://tgdtheory.fi/appfigures/timemirror.jpg> or Fig. ?? in the appendix of this book) playing a central role in the general mechanism for intentional action, remote metabolism, and long term memory.

Causal diamond (CD) defined roughly as the intersection of future and past directed light-cones serves as an imbedding space correlate for zero energy state. Space-time sheets representing zero energy states are inside CD and the future *resp.* past boundaries of CD carry positive *resp.* negative energy parts of zero energy states. What is important from the point of view of consciousness theory is that CDs serve as imbedding space correlates of selves and sub-CDs as those for sub-selves (mental images). Sub-CDs are very much analogous to music instruments in the sense that the frequencies which come as harmonics of the fundamental frequency defined by the proper time distance between tips of CD (coming as powers of two) resonate with the geometry of CD and put it to “ring”. Sub-CDs could be seen as an analog of radio receiver as far as sensory representations are considered and sending antenna as far as the motor control of biological body is involved. This allows to communicate sensory data from brain to sub-CDs at magnetic body CD in a highly selective manner. MEs (massless extremals) mediating the communications between magnetic body and biological body are also very much like strings of a music instrument. This picture generalize the earlier music metaphor applied to axonal pathways.

A more precise definition of CD is as the Cartesian product of the intersection of future and past directed light-cone with CP_2 . The hierarchy of Planck constants brings in additional structure. There is identification of preferred $M^2 \subset M^4$ defining a preferred time direction (rest system/quantization axis for energy) and spin quantization axis. The preferred geodesically trivial sphere $S^2 \subset CP_2$ and the selection of point assigned with CP_2 at the future and past boundaries of CD gives rise to a selection of quantization axes of color isospin and hyper charge.

Sensory representations are a key element of the consciousness theory and the moduli space of CDs characterizing what kind of CDs are possible brings in new representational resources.

1. The moduli space of sub-CDs involves the position for the either tip of the sub-CD and the naive expectation is that this position could code for the position of the perceptive field. If so the representation would be very concrete and since the size of CD is already for electron with .1 lightseconds the representations is realized automatically in astrophysical scale.
2. The moduli space of sub-CDs assignable to the mental images with another tip fixed could represent geometric qualia. Without any further restrictions this space corresponds to proper time constant hyperboloid of future light cone. The values of time parameter come in powers of two. One can however quite well consider the possibility that only a discrete lattice of the hyperboloid is realized.
3. A Lorentz boost for sub-CD induces scaling of frequency and scaling of the object in the direction of the boost. Therefore boost coded to the fundamental frequency of CD

could code for various shapes of a figure obtained by scaling. Boost of sub- CD leaving the other tip of sub- CD invariant could also code for the velocity of object.

4. The moduli space of CDs contains also the choice of quantization axes of energy (preferred rest system) and spin as well as the choice of quantization axes of color isospin and hyper-charge identifiable as flag manifold $SU(3)/U(1) \times U(1)$. Mathematician Barbara Shipman has proposed that this flag manifold is involved with the representation of geometric data in honeybee dance [A1] and I have proposed a model for what might be involved [K5].

The moduli space of CDs is thus highly relevant for the representation of the geometric data associated with the objects of the perceptive field and the this data would be communicated using MEs with harmonics of the fundamental frequency of sub- CD so that sub- CD would act like radio receiver. This includes the position of the real object codable to the position of sub- CD s at magnetic body, the velocity of the object of the perceptive field codable to the Lorentz boost changing the shape of sub- CD and represented as scaling of the frequency assigned with the stationary object. Also the shape of perceptive field would represent this kind of geometric data. This picture supports the interpretation of sub- CD s as spotlights of attention giving information about many-sheeted space-time inside the regions defined by the sub- CD s. It would seem that sub- CD s are dynamical objects created, destroyed, and shifted in quantum jumps. This picture is also consistent with the explanation for the arrow of psychological time based on zero energy ontology [K21].

4.2.3 Place coding by cyclotron frequency scale

One of the basic aspects of conscious information processing is concrete geometric representation of even very abstract concepts and information as imagined objects of perceptive field. The observations about geometric qualia suggest to magnetic transition frequencies code for positions of sub-selves represented by magnetic flux tubes. Particular EEG frequency wakes-up particular sub-self in a specific position and orientation and gives rise to a “feeling of existence” in some part of the virtual world of brain of magnetic body. The sensation of motion of object of perceptive field could result automatically when sub-self moves inside self. Alternatively, Lorentz boost for the sub- CD could represent the velocity of motion of object represented by it. For instance, one could represent coordinate curves as magnetic flux tubes with varying thickness: by magnetic flux conservation thickness codes the coordinate to magnetic field strength to cyclotron frequency.

4.2.4 Cortex as a collection of attributes assigned to the objects of perceptive field represented at magnetic canvas

One of the basic problems related to the understanding of the information processing in brain is how various attributes are assigned to the object of the perceptive field. What is known that brain recognizes features and these features/attributes seem to be located in a more or less random looking manner all around cortex. This brings strongly in mind random access memory or computer game in which various little program modules realized as records in random access memory represent collection of standard sound effects. A strong hint is the empirical evidence for the view that the resonance frequencies associated with the autocorrelation functions of nerve pulse patterns, and thus presumably also coding EEG frequencies, are same for the features associated with a given object of the perceptive field. The challenge is to understand how the picture based on a collection of MEs projecting features to the magnetic canvas could allow to understand what is behind these observations.

The view about MEs associating attributes to the object of the perceptive field by waking up sub-selves in the magnetic flux tube structure serving as a sensory canvas suggests an elegant interpretation for these facts.

1. Cortex can be regarded as a collection of regions specialized to represent various kinds of standard features. Features need not be simple qualia: arbitrary complicated collections

of them, such as familiar faces are also possible features. Even entire dynamical processes (selves) could serve as features.

2. Basic feature-regions are like computer records. The information about the position of the feature in perceptive field could be represented by the entanglement of the feature with a particular part of, say, primary sensory area representing a point of the perceptive sphere.
3. The direction of the point of the perceptive field could be coded basically by the direction of the magnetic flux tube emerging from the particular position of the sensory area providing map for solid angles of the perceptive field. The mechanism would be based on resonance with Alfvén waves associated with the magnetic flux tubes of personal magnetic body amplifying MEs in the direction of magnetic flux tubes. The length (fundamental frequency) of ME would code for the distance of the point of the perceptive field to the distance of the point of the sensory magnetic canvas. Frequency coding could be achieved by varying the local value of the magnetic field responsible for generating the cyclotron frequency. This coding could be either dynamical or static in which case distance could be most naturally coded to linear structures, most naturally in direction orthogonal to the cortical surface.
4. Features would be basically associated with sensory organs, various neural pathways and brain areas and coded partially by nerve pulse patterns. Features could be practically all kinds of sub-selves generated by brain activity. Primary qualia could be realized at the level of sensory receptors if entire sensory pathways entangle with the magnetic body.
5. Projector MEs would be orthogonal to the sensory area where they emanate. The topographic mapping of the perceptive field to sensory areas would guarantee that sensory images would remain stationary under rotations of head: although sensory magnetic sensory canvas would move the image projected to it would be stationary. MEs and magnetic flux tubes must be parallel if Alfvén wave resonance is involved. In this manner the sensory experiences can be private and the contribution from the other brains remains negligible. Note however that people in very intimate contact could gradually share their magnetic sensory canvases: the anecdotes about gradually developing telepathic communications between the teachers and students of the meditative practices could involve this kind of sharing of computer screen between several users.
6. In this coding EEG MES would entangle with essentially all information about the perceptive field and the spectroscopy of consciousness to be discussed below would be realized in rather strong sense.
7. The model becomes even more predictive if it is assumed that DNA double strands act as a relay station. This encourages to think that also the decomposition of brain to motor and sensory areas has a counterpart at the level of the magnetic body so that the sensory input coming from the cell membrane is mediated through flux sheets going through the passive strand to the sensory magnetic body and motor actions of the motor magnetic body are mediated through the flux sheets going through active strand. One would have a closed loop in which the phase transition induced by the sensory input coming via the passive DNA strand to the sensory magnetic body generates cyclotron radiation inducing a phase transition in the motor part inducing cyclotron radiating inducing effect in the active DNA strand.

Of course, the extreme flexibility of the entanglement mechanism of binding means that one can imagine almost unlimited number of variants about this basic option and the proposed variant can be defended only as the simplest one found hitherto. One can also allow the possibility that the sequence of entanglements begins from the perceptive field with the primary mental images at the level of sensory organs being entangled with objects of perceptive field.

Fractality suggests that there is a hierarchy of sensory representations. In particular, cortex areas, brain nuclei and even cells could possess their own sensory representations. The inactivity of the primary sensory areas during REM sleep could mean that during dream state sensory representations are non-cortical lower level representations or realized at higher

sensory areas. Of course, lower level structures could define the projections to the magnetic sensory canvas also during wake-up consciousness. For instance, relay station like nuclei could act as relay stations for the projections realized at the magnetic body. Any brain area defining topographical map of sensory data is could candidate for defining a sensory representation.

The projector regions would serve as kind of central entanglers. Also the nuclei believed to somehow generate EEG resonance frequencies responsible for the binding of mental images are good candidates for the central entanglers. In standard neuroscience thalamus is believed to generate 40 Hz rhythm and is thus a good candidate for the central sensory entangler and projector. In TGD framework this rhythm would be more naturally generated by the magnetic body assignable to thalamus. Hippocampus -or more naturally its magnetic body- generates hippocampal theta and could be the central memory entangler and projector. Frontal lobes generate slow EEG waves during cognitive activities and could act as cognitive entanglers and projectors.

This kind of architecture is expected to be realized at various length scales. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my attempts to understand consciousness, conforms this picture. Computer screen would correspond to the sensory magnetic body. The one who sits there presumably could be identified as the motor part of the magnetic body (as far as conscious-to-me intentions are considered). The central unit corresponds to the brain and DNA double strands are the fundamental hardware responsible for communication and control and through which all information flows. They intronic parts of DNA strands would also provide the hardware for topological quantum computation programs. Sensory projector MEs are generated automatically by the nerve pulse activity and code the picture at the monitor. MEs would be active quantum holograms acting as control commands on the active DNA strand serving as the keyboard generating nerve pulse patterns. Thus it would seem that those aspects of the computer (monitor, keyboard, etc), which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the consciousness and computer programmers could be mimicking what happens inside (and outside) their own brain.

4.2.5 Anomalous visual percepts and sensory canvas hypothesis

Sensory canvas hypothesis means that at the perceptual level we see using ELF- rather than visible light. Of course, if primary sensory qualia are at the level of sensory receptors, this seeing has the character of imagination. Even in this case brain could use feedback to the sensory receptors assign sensory qualia with the imagination like perception. This would occur during dreaming and what is regarded as hallucinations.

One can also consider the possibility of “vision” based solely on the ELF input from brain and body having no correlate with the visible light entering into retina or even with neural activity. Even genuinely three-dimensional vision in which own body is seen as it would be seen by the external world suggests itself. The dropping of ions from the atomic space-time sheets to the magnetic flux tubes so that they end up to high n cyclotron states decaying via the emission of photons at frequencies which are harmonics of the cyclotron frequency would generate the projector MEs needed for the sensory representation of the physical body or part of it as seen by the environment.

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

There is some evidence for this kind of anomalous vision.

1. Yogis have reported altered states of consciousness in which they see their own body three-dimensionally, that is simultaneously from all directions. This might have interpretation as ELF vision involving a feedback from magnetic sensory canvas to brain to “qualiafy” the percept.
2. Becker tells in his book “Cross currents” [J13] about a young cancer patient who told that he can see the interior of his own body. The patient could also locate the remnant of the tumour correctly. If sensory receptors are necessary for visual qualia, the needed data must be received from somewhere by brain, and be projected to the visual receptors like during dreaming. The simplest option is that body parts can in some sense “see” each other. In particular, brain can “see” body parts (note that bacteria possess a primitive IR vision based on microtubules). Bio-holography provides support for the body as a hologram. For instance, an electric stimulation of ear during Kirlian imaging of a finger tip creates a Kirlian photo from which it is possible to abstract a hologram of ear (see [I13] and [K9]).
3. Also the OBE experiences, for instance those associated with NDEs, could have an analogous interpretation. The sensory input from eyes would be absent but brain would give feedback to visual receptors to “qualiafy” the the input which it might receive from other levels of self hierarchy. If even the input from neural activity is absent during NDEs so that the visual experience should be determined by the background ELF component emanating from the brain and body. The third person perspective associated with OBEs might be always present but be masked by the strong sensory input or by the absence of feedback to visual receptors. It is possible to have experiences about contact with deceased by a therapy based on rhythmic eye movements [J3, J10]. The function of eye movements might be to establish a feedback to certain brain regions serving as receivers of input from magnetic bodies of deceased or from magnetosphere.
4. I have proposed thousand and one explanations for the beautiful flow visible when I close my eyes in a calm state of mind. During my “great experience” this background flow was accompanied by extremely vivid visual hallucinations. An additional item to the long list of explanations is following. The information characterizing the flow enters from or via brain to the visual receptors and is in this manner “qualiafied”.

What has been said about magnetospheric third person aspect applies also to other senses. Interestingly, I often wake-up partially and realize that I hear my own snoring as an outsider (quite a dramatic experience!). Sometimes I have an experience which might be interpreted by saying that the hearing in the first perspective is superposed with the hearing in the third person perspective. The third person hearing has a time lag so that a kind of double breathing results.

4.2.6 Place coding of features inside brain

Place coding for various geometric parameters characterizing simple geometric “features” inside brain could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of “our” sensory canvas.

Becker tells in his book “Cross Currents” [J13] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles, ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by nonlinear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness

varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or “feature”). An analogous phenomenon occurs also for auditory inputs with slightly different frequencies fed into ears and makes it possible to “hear” sounds below the audible range. The mechanism could be the same.

If primary sensory qualia are realized only at the level of the primary sensory organs, one can make two conclusions. ELF wave wakes up a “feature” analogous to an imagined percept, and presumably realized as a particular nerve pulse pattern. ELF wave also induces a projection from the brain to the retinae “qualiafying” this feature. Blind subjects should not have these extra-sensorily induced percepts.

One can imagine two options concerning the ultimate representation of a simple geometric feature depending on whether the feature corresponds to a *collection* of points or *single* point at “our” sensory canvas.

1. The visual percept corresponds to a *collection* of activated points at “our” sensory canvas and activated geometric point corresponds to a standard mental image represented at brain level and assigned to a point of sensory canvas. The magnetic phase transition would initiate a process eventually activating particular projectors and the position of the quantum phase transition at the magnetic flux tube would determine the shape of the feature. One can criticize this option. The brain applies modular hierarchy in the information processing and simple percepts like triangles and circles which are also fundamental in the elementary geometry, are ideal for basic features assignable with a *single* point of “our” sensory canvas rather than being represented as composites of elementary features (points). The very fact that the place coding for the geometric shape of the feature is involved, suggests the same.
2. The visual percept is represented as a mental image inside brain or, more probably, at some lower level sensory canvas so that the hierarchy of the sensory canvases would directly relate to the modularity of our sensory representations and sensory canvases would be in an intense interaction by quantum entanglement much like various subprograms of a computer program. This geometric mental image is assigned with a *single* point of “our” sensory canvas by quantum entangling it with a projector ME projecting to a particular point of “our” sensory canvas. The position of the feature at the sensory canvas might be determined by the position of the volume of intersection for the beams.

Since simple objects are in question and the change of the shape corresponds to a scaling in one direction, the representation of the change of shape of the object could be in terms of a Lorentz boost of sub-CD representing the object and leaving the tip of the sub-CD invariant.

4.2.7 The relation of mental imagery to sensory experiences

Mental imagery is something which is difficult to understand in the framework of the standard neuro science. There are empirical results suggesting that mental images correspond to patterns of activity inside cortex, which are three-dimensional and continuous so that neural activation provides a concrete recognizable image about object [J14]. Rather remarkably, also imaginative thought resembles very much visual imagery as is clear from the fact that language is full of visual metaphors [J14]. It is also known that imagery uses same regions of the cortex as real sensory experience and the problem is to understand why there is almost sensory experience involved with imagery.

In the framework of the standard neuroscience the obvious question is why the pattern of the imagery activity is not accompanied by a direct sensory experience. Also the boundary between direct sensory experience and imagination is sometimes problematic. For instance, in the state between sleep and awake sensory images often enter into mind. During dreams one can have sensory images and eidetic memory is essentially sensory memory. I have a personal experience about an extended state of consciousness, or rather whole-body consciousness (this experience actually made me consciousness theoretician!). During this state I could see my thoughts as vivid visual images and had also peculiar odour and taste experiences also reported to occur during mystic experiences.

The original belief was that imagination could involve p-adic-to-real phase transitions transforming p-adic imagery to nerve pulse patterns or membrane oscillations. The genuinely p-adic aspect of imagination would be analogous to a free choice of initial values in a computer simulation, which are then transformed to their real counterparts initiating neural activity.

It has turned out that this view is probably wrong. In the adelic vision about world both real and p-adic sectors for all p-adic number fields are present simultaneously. Imagination involves both cognitive and sensory aspect.

Why imagination does not involve sensory qualia could be explained in several manners.

1. Primary sensory qualia are realized at the level of sensory receptors and brain constructs only higher level symbolic representations of the sensory input and quantum entanglement binds these representations together. For imagination sensory receptor level is absent. This would also explain rapid eye movements during dreams as being related to the construction of visual qualia. Dreaming is indeed a cognitive activity which is learned gradually (at young age dreamer sees only static images). One could understand why motor activities are not accompanied by sensory experiences associated with motor pathways. The obvious reason for why sensory imagination should not create lively images is that this would lead to a dangerous mixing of the real and virtual. If this interpretation is correct, the study of whether feedback from brain to sensory organs occurs during sensory hallucination, provides a manner to test whether sensory hallucination is a telepathic experience resulting from the sharing of mental images or whether it might be constructed in brain by feedback to sensory receptors.
2. Imagination could rely on membrane oscillations just as higher level cognition. The finding that imagination does involve patterns of activity at visual cortex similar to those associated with ordinary visual perceptions does not support this idea.
3. If higher level sensory representations are realized at the magnetic canvas, the difference between imagination and real sensory experience could result from the absence of the projection to the sensory canvas. Also the absence of negentropic entanglement could be the reason. This state of affairs could have a detectable EEG correlate: for instance, in 40 Hz resonance band. The projector MEs responsible for the cognitive representation could be activated but be p-adic and project only cognitive images. One can however wonder why magnetic body is at all conscious about imagined mental images if it does not share these mental images.

If this explanation is correct, it would be also possible to have sensory experiences at brain level only. For instance, unconscious seeing would be possible. This kind of blind vision is indeed known to be possible and will be discussed later.

Motor output and the ultimate output giving rise to our sensory experience might be very closely related: motor action could be like printing or some control activity and sensory and cognitive representations like pictures at the monitor screen. This picture looks attractive but might neglect some deep differences suggested already by the anatomy of the central nervous system. There are reasons to expect that the construction of sensory percepts and motor activity could be geometric time reversals of each other at some levels of the self hierarchy (MEs in certain time scales). This view would mean that motor action starts from a rough sketch for the outcome of the motor action and quantum jump by quantum jump ends up to the complete performance by a process which might be regarded as a gradual carving of a four-dimensional sculpture relying on both ordinary and time reversed dissipation serving as a Darwinian selectors so that the very many sketches would lead to the same outcome. Both these views might make sense: which view is correct depends on what time scale one is considering.

4.2.8 Are the space-time sheets and sub-CDs representing objects of the perceptive field generated automatically?

One of the poorly understood aspects of sensory perception is how objects of the perceptive field are generated at the level of cognitive representations. The problem is especially difficult in the computational approach to consciousness. Natural idea is that the objects of cognitive representation directly reflect the objects of the physical world and that direct physical interaction creates these objects automatically. Various visual illusions demonstrate that also apparent objects are generated by sensory experience which suggests that it is nerve pulse patterns at the level of cortex which give rise to the objects of the perceptive field. In neural net approach to brain consciousness it is however far from trivial what these objects could be.

In TGD approach objects of the perceptive field correspond to mental images and thus sub-selves. sub-selves in turn naturally correspond to mind-like space-time sheets. Therefore the problem reduces to that of understanding how sensory input gives rise to mind-like space-time sheets: in particular, how the sensory input or nerve pulse activity induced by it determines the boundaries of the mind-like space-time sheets.

One of the basic laws about sensory experiencing is that only changes are experienced. Quantum model for the contents of consciousness of self implies this law at quantum level: only the averages of the increments of quantum numbers and zero modes are experienced consciously. By “Ontogeny recapitulates phylogeny” principles this law should have realization also at the level of dynamics of the space-time surface.

A possible space-time level counterpart of this law is that the primary at the level of primary sensory organ or secondary sensory stimulus at the level of cortex generates Kähler electric field proportional to the gradient of the stimulus. This creates however a problem. Kähler electric flux must be conserved in the approximation that vacuum Maxwell’s equations are satisfied (they are not exactly satisfied since vacuum can carry currents of Kähler charge). Suppose that stimulus has a strong gradient: where does the Kähler electric flux go? The answer is simple: mind-like space-time sheet is generated and the flux goes to the mind-like space-time sheet through wormhole contacts! Since sensory stimulus varies rapidly at the boundaries of the objects of the external world, this means that the objects of the perceptive field are automatically represented by mind-like space-time sheets and give rise to selves, mental images in the cognitive representation! Several cognitive representations with different decomposition into objects are possible.

Also an alternative formulation of the title is as a question whether the sub-CDs serving as imbedding space correlates for the mental images are generated automatically. One could argue that quantum jump sequence generates these sub-CDs and that directed attention could induce them. Negentropy Maximization Principle suitably generalized to state that the difference for the negentropies of the final and initial state is as large as possible for a given CD might favor the generation of negentropic sub-CDs. Also the argument for the arrow of psychological time suggests that NMP should have this kind of generalization.

4.2.9 Spectroscopy of consciousness

In its original form the spectroscopy of consciousness stated that one could assign to various qualia -say colors, tastes, or odors- frequencies so that the frequency patterns would provide a spectroscopic signature of the microscopic structure of conscious experience just like frequency patterns allow to deduce highly detailed information about the structure of a distant star. Spectroscopy of consciousness could be for the brain science what atomic spectroscopy has been for physics and chemistry.

In its original form this idea turned out to be un-realistic. Sensory qualia as such do not seem to correspond to frequencies. Rather, frequencies would code for the geometric data. For the cyclotron frequencies at least only the frequency ratios seem to have a deeper meaning. The fundamental frequencies assignable to CDs however define an exception in this respect. Spectroscopy of consciousness in a more realistic form would relate to the coding of geometric

data such as positions, size scales and state of motion for the objects of the perceptive field. Frequency scales could also distinguish between higher level sensory representations assigned to brain regions of various size scales. The basic frequencies would be fundamentals and their harmonics assignable to CDs, cyclotron frequencies, and Josephson frequencies.

1. Spectroscopy of consciousness and size scales of brain structures

The size scales for various parts of brain could mapped to frequency scales characterizing the sizes of the parts of dark magnetic body so that a kind of collection of zoomed up images of brain regions would be obtained. Images of brain regions would be mental images assignable to them to the sensory receptors entangled with them.

1. In [K18] it is found that a simple scaling law $v = \lambda f$ relating the apparent wavelength and phase velocity of EEG wave and more general em waves with its frequency allows to understand the basic anatomical structure of the central nervous system as reflecting evolution regarded as the emergence of new p-adic length scales. Scaling law allows also to predict which frequencies correspond to qualia experienced at a given level of the p-adic self hierarchy for a given conduction velocity of nerve pulses identified as an effective propagation velocity of EEG waves. Scaling law could also relate the sizes $L(magn) \sim L(EEG)$ of the radial magnetic flux tube structures (magnetic canvas or magnetic body) associated with the secondary sensory organs of size $L \sim \lambda$: $L(magn) \sim L(EEG) = c/f = (c/v)L$. Wave length of EEG could code for the size of the structure defining a kind of zoom-up of the brain region in question at the magnetic body.
2. The hierarchy of Planck constants allows to understand how photons for which the energies $E = hf$ are much below the thermal energy in standard quantum theory can be so important biologically. EEG photons would obviously have a rather large value of Planck constant. This hypothesis encourages the identification of the above defined velocity ratio as $r = c/v = \hbar/\hbar_0$. \hbar would be Planck constant for say ELF photons communicating the signal to the corresponding dark layer of the magnetic body. In brain the dark photons could be transformed to ordinary short wave length photons by a leakage to $r = 1$ page of the Big Book in an energy conserving manner. The part of the magnetic body at a particular page of the Big Book would represent an r-fold zoom up of the brain region considered. If one takes seriously the proposal that DNA double strands act as relay stations between the brain and magnetic body, these values of Planck constants could be assigned with the flux tubes assigned to DNA nucleotides. I have proposed a similar scenario but with motivations coming from an attempt to understand how the realization of the genetic code at the level of dark nucleon physics discovered for few years ago could relate to the biochemistry and DNA [L1, K7, K20], [L1].
3. The fundamental frequencies would be most naturally cyclotron frequencies of charged elementary particles and biologically important ions at the magnetic flux tubes with large \hbar . TGD based nuclear physics predicts also the possibility of exotic chemically equivalent bosonic counterparts of the ordinary fermionic ions so that Bose-Einstein condensate of also these ions at cyclotron states could define macroscopic quantum phases. The corresponding higher level qualia would correspond to phase transitions changing cyclotron quantum numbers. Cyclotron energies scale as \hbar so that energy scale would distinguish between different pages of the Big Book whereas frequency would be the same form them if the strength of the magnetic field is same for all the pages. Energy coding would be in question. These photons would be naturally generated at the magnetic flux tubes which suggests that they could be used for communications from the magnetic body to biological body.

2. Spectroscopy of consciousness, CDs, and Josephson junctions

Zero energy implies the notion of CD as imbedding space correlate of self and the moduli space of CDs should play a key role in the understanding of the geometric qualia. Hence the spectroscopy of consciousness could relate very closely to the scales of CDs.

1. For a fixed value of \hbar rather few size scales for CDs would be involved (nuclei, quarks, electron plus their possibly existing p-adically scaled up variants). The fundamental frequencies assignable to CDs would correspond to the time scales of CDs and would scale like $1/\hbar$ whereas energy would not be affected in the scaling of \hbar .
2. The problem is that for energies above thermal energy at physiological temperatures the size scale of CD should correspond to those assignable to very heavy particles. If only photon energies above thermal energy are relevant for biology the frequencies 10 Hz and 1 kHz assigned to electron and quarks would be excluded. If the leakage of classical em oscillations of given frequency leaking between different pages of the Big Book automatically generates photons with scaled up energies, the problem disappears. Each of the r sheets of the many-sheeted covering would carry single quantum with the original frequency. The frequency would be r -fold harmonic of the frequency of the fundamental for the scaled up CD.
3. Also Josephson frequencies associated with the cell membrane identified as Josephson junction (also flux tubes connecting the membrane to DNA strand could serve as Josephson junctions) are involved. Josephson energies do not depend on \hbar since the frequencies behave like $1/\hbar$ so that a hierarchy of representations at the pages of the Big Book in different time scales would be obtained as kind of spatio-temporal zoom-ups. In this case the communications would be naturally from the biological body to the magnetic body and sensory data could be communicated in this manner.
4. The photon energy $E \sim .05$ eV assignable to the cell membrane potential energy is at the border of the thermal threshold and corresponds to a wave length $\lambda = 2.4 \times 10^{-5}$ meters. For M_{89} corresponding to intermediate gauge bosons one has $L(89, 2) = L(178) \simeq 1.2 \times 10^{-4}$ m - the size scale of a large neuron and only 5 time longer than λ so that $r = 5$ would allow to overcome the thermal threshold. Could even intermediate gauge boson length scale be relevant for biology? The lifetime of intermediate gauge boson is much shorter than this time scale but one can ask whether photons could correspond to M_{89} .

3. Spectroscopy of consciousness and the moduli space of CDs

Consider next the concrete realization of the spectroscopy of consciousness in terms of the moduli space of CD.

1. The moduli space of CDs which is Cartesian product of part associated with M^4 degrees of freedom and CP_2 degrees of freedom. In M^4 degrees of freedom one has the position of say lower tip parameterized by M^4 and the coordinates for the relative position of tips defining sub-set of the future directed light-cone M_+^4 . The position in M^4 for the lower tip of sub-CD could code for the position of the object of the perceptive field.
2. The quantization of the proper time distance between the tips in octaves reduces the situation to a union of hyperboloids and a further discretization to a lattice of hyperboloid is suggestive by number theoretical considerations. The interaction of a photon with this kind of hyperboloid representing sub-CD is resonant if the frequency corresponds to the temporal difference between the tips as measured in the rest system of CD so that frequency coding of the Lorentz boost performed for sub-CD results.
3. One particular application would be the coding of the velocity (including its direction) of an object of perceptive field to the boost applied to sub-CD leaving its lower tip invariant. The positions of sub-CDs would not be updated continually and the sensation about continuous motion would result from the separate representation of the velocity. This interpretation is supported by a syndrome in which patient does not perceive motion and the positions for the objects of the perceptive field are updated with so long time intervals that the ordinary street traffic is too dangerous for the patient. The size scales of sub-CDs would give rise to a natural length scale hierarchy characterizing the sizes of the details of the representation. $M^2 \subset M^4$ fixed partially by the tips of CD defines preferred quantization axes for energy and spin and this choice would be be

relevant for purely quantal aspects of the sensory representation. The Lorentz boosts of discrete spectroscopies would code for the motion of the objects of the perceptive field.

4. In CP_2 degrees of freedom moduli would correspond to $CP_2 \times CP_2$ such that for both factors a preferred point and a homologically trivial geodesic sphere S^2 has been selected. These choices give rise to flag manifold $SU(3)/U(1) \times U(1)$ labeling the choices of the quantization axes. In the recent case color rotations for the tips would represent the geometric data at the basic level. Also now discretization for the CP_2 points assignable with the second tip would be natural. $M^8 - H$ duality is fundamental element of quantum TGD and means that CP_2 points code for hyper-quaternionic planes of hyper-octonionic M^8 containing a preferred M^2 . This would suggest that CP_2 could also code for geometric data as is suggested by the findings of Barbara Shipman concerning the role of the flag-manifold $SU(3)/U(1) \times U(1)$ in the model of honeybee dance [A1]. The hyper-quaternionic plane assignable to the point of space-time surface at given point identified as a plane spanned by the Kähler-Dirac gamma matrices would correspond to a point of CP_2 .

Spectroscopy of consciousness is considered in detail in [K18] - the spirit is of course extremely adventurous since so little is known and potential reader can take this as a mere exercise perhaps helping to identify the rules of the game. Especially fascinating is the possible connection of the theory of the magnetic qualia with atomic and nuclear spectroscopy: the structure of the periodic table could reflect itself directly itself in the spectroscopy of consciousness via cyclotron frequencies inversely proportional to the masses of ions. Various full electronic shells (He, Ne, Ar, Kr, Xe) correspond to a hierarchy of geometric qualia relating directly with the band structure of EEG. The periods also could also relate to the five-layered structure of sensory cortex (primary, secondary, etc... areas).

4.3 Is The Pain In The Toe In The Toe, In Brain, Or Somewhere Else?

The basic question concerns about the seat of the primary sensory experience. There are three options.

1. Standard neuroscience says that our sensory experience can be localized to cortex.
2. The apparently very naive view is that sensory experience receives a contribution also from the primary sensory organs. Certainly primary sensory organs could be experiencers in TGD framework (and probably are) but this experience need not contribute to our sensory consciousness unless there is a negentropic entanglement between brain and sensory organs. Let us assume further that magnetic body plays no role.
3. The notion of magnetic suggests that sensory representations conscious-to-us correspond to a sequence of entanglements connecting the magnetic body and the primary sensory organ and perhaps including even to the object of the external world. This picture differs in even more radical manner about the view of standard neuroscience. As far as the analysis of the sensory data is considered, this view need not differ in an essential manner from the standard view: magnetic sensory canvas could be analogous to a passive monitor screen. Magnetic body could also participate actively to the construction of the percept by sending virtual sensory feed-back through brain to the sensory organs.

The view 2) is not automatically excluded in TGD framework as it is in standard neuroscience.

1. The experiments of Libet about passive aspects of consciousness [J9] could be seen as supporting the hypothesis that the data is sent to the magnetic body, which causes the time lapse meaning that the sensory data is 3-5 seconds old [K21].
2. The location of primary qualia to the level of sensory receptors would also allow to understand why sensory pathways are specialized to definite qualia despite the fact that there seems to be no obvious structural or functional differences at neuronal level. As already found, one could also understand the difference between imagination and sensory experience and why feedback to visual receptors (REM) is present during dreaming.

3. The identification of long term memories as multitime experiences containing contributions from the distant geometric past forces to consider the possibility that sensory organs are primary sensory experiencers whereas the standard dogma of the neuro science is that all sensory experiences occur at brain level at geometric now. The idea that also primary sensory organs are seats of the primary sensory experiences, could explain Libet's experiments, explains the observation that persons who have become blind gradually, lose their ability to have dreams and also the rapid eye movements and feedback from brain to auditory organs during REM sleep. It must be emphasized that these phenomena can be understood also in options 1) and 3).

One can represent several objections against the identification of the primary sensory organs as seats of our primary sensory experience (Option 2)¹.

1. The first class of objections is that our sensory perception involves a lot of computation (consider stereo vision as an example) and this computation cannot be performed at the level of the sensory organ. These objections look at first rather convincing but relate only to the cognitive aspects of sensory perception, not the to the primary sensory qualia. The computation can be carried out and involve also magnetic body and the back-projection to the primary sensory organs could allow to construct the percept as an artwork at the level of primary sensory organ.
2. The second class of objections is related to the explanatory power of the idea of standard neuroscience that entire sensory pathways containing also neurons of cortex are seats of the sensory experience (For option 1) they are involved with the construction of the sensory experience). This idea allows to regard brain as kind of musical instrument such that each neuron produces its characteristic sensory experience so that our experiences are combinations of the primitive neuronal experiences. For conscious information processing this is a crucial advantage: for instance, incoming nerve pulse patterns in associative regions of brain are consciously differentiated from each other as different modalities so that same nerve pulse pattern can have different meaning as sensory modalities. This objection suggests that the idea of restricting sensory experiences at the level of primary sensory organs is wrong. On the other hand, neuronal pathways and brain could be specialized to build cognitive representations and primary sensory qualia could be at the level of sensory receptors. The feedback from brain to the sensory receptor level could also make possible to manipulate the sensory input.
3. The view about brain as a collection of standard features which are activated by the sensory input and projected to the magnetic canvas and thus associated with the objects of perceptive field is in conflict with the idea that our experience receives a direct contribution from the primary sensory organs. Situation of course changes if one allows entanglement of brain with sensory organs.
4. The phenomena like dreams, hallucinations, synesthesia, phantom limb, and the experiences generated by stimulating neurons of sensory pathways and projected pain are obvious counter arguments against the idea that sensory organs are primary sensory experiencers (or form parts of them). The identification of the long term memories as multitime experiences allows in principle to overcome these objections, and a more detailed discussion of this point is in order.

In the following the explanations of various strange phenomena of sensory consciousness are studied and the explanations provided by the options 1), 2) and 3) are compared. It must be emphasized that the possibility that even sensory organs (and even neurons) have senses is not excluded by these arguments: what is however clear that *our* sensory landscape is constructed in cortex.

¹The topic of discussion might look rather academic from the point of view of neuro science but it is not that in TGD framework: it took years to decide whether this idea could make sense or not.

4.3.1 Back projections and cross projections

During REM sleep rapid eye movements occur and are thought to accompany dreaming. It is not however clear to me whether the correlation between rapid eye movements and visual dreaming is one-to-one. The ringing of the ears is a real physical process occurring in ear and these oto-acoustic emissions, as they are called, can be sometimes heard by even outsider [K16]. Rapid eye movements during dreams and oto-acoustic emissions can be regarded as back-projections from brain to primary sensory organs.

1. These phenomena can be understood without any difficulties in the options 1) and 3). For instance, rapid eye movements could be understood as feedback generated by a visual dream.
2. For the option 2) rapid eye movements could be seen as necessary prerequisite of dreaming and to “qualiafy” imagined mental images.

Synesthesia involves cross-modal associations of form $A \rightarrow B$ (say visual to auditory).

1. In option 2) both dreams, hallucinations, and synesthesia rely on the feedback from brain to sensory organs to “qualiafy” the mental images. The prediction is that there should be a feedback, not only between sensory areas, but between sensory organs or the cross-associated qualia. This prediction is certainly testable. For instance, auditory-visual synesthesia should be lost if eyes are damaged.
2. The simplest view allowed by options 1) and 3) is that this kind of sensory leakage occurs at the level of neuronal connections.

4.3.2 Projected pain and phantom leg

Projected pain and phantom leg provide a further test for the proposed options.

1. For the standard explanation (option 1)) one must assume that the experience of pain is localized to the somato-sensory map in brain. The explanation of the projected pain is based on the observation that projected pain is felt in the body part which was very near to the body part contain the actual cause during early developmental stages. If somatosensory maps are not updated properly, projected pain becomes possible. This applies also to option 2).
2. For option 2) the explanation of phantom pain as a remembered pain and thus as a real pain in the geometric past when the limb still existed, is the simplest one. Projected pain cannot be however interpreted as a remembered pain since the physical cause of pain is in the geometric now. The assumption that the sensory pain (as distinguished from psychic pain) is a cortical sensation whereas only pure sensory experiences would be located in the primary sensory organs looks rather strange taking into account the universality of emotions as entropic qualia. What goes wrong with this argument is that the experience of pain is confused with the experience about where the pain is. The wrong location could result when the mental image about pain is projected in a wrong manner to the body map. A leakage between sensory pathways could cause the wrong localization.
3. Also for option 3) the simplest explanation of the phantom leg phenomenon is that the pain is geometrically remembered pain from the period when the leg still exists and thus would have a real cause. Also other possibilities can be imagined. The loss of the physical limb need not mean the loss of its magnetic counterpart so that phantom pain might be caused by either by a sensory input from other parts of leg projected to the part of the magnetic sensory canvas representing the lost leg. This could explain also the projected pain. The magnetic map of body coded by MEs could be partially out-of-date so that some parts of this map correspond to the structure of biological body during the early developmental periods. The pain in left arm during heart attack could be understood in this manner.

4.3.3 Color constancy and sensory organs as primary experiencers

The phenomenon of color constancy [J1], which forms one of the most important aspects of vision, is a further objection against the identification of sensory organs as primary sensory experiences. At least if one believes that colors are primary sensory qualia. If the object of the visual field is illuminated with a monochromatic light of constant intensity, its color does not change. This is quite contrary to what one might expect on basis of what is expected to happen in the color sensitive cones in retina detecting wavelengths concentrated around blue, red and green. A particular case of the color constancy phenomenon arises when entire visual field is illuminated with a monochromatic light of a constant intensity: what is experienced is complete darkness. The ability to see the real colors of the objects of the external world, which is made possible by the color constancy phenomenon, is of course extremely valuable for survival purposes.

1. For option 1) color constancy is a challenge. Color constancy suggests that retina cannot be the primary sensory experiencers of color qualia since in this case our subjectively experienced world would be changing its colors continually. This conclusion might be too hasty. In fact, one could defend the hypothesis about sensory organs as primary sensory experiencers and use color constancy as a guide line in the attempts to guess how sensory representations for the objects of the external world are generated as sub-CDs residing at the retina.
2. In option 2) and 3) it can be assumed that the subtraction of the background involves computational processing at the level of brain. If the objects of the perceptive field are generated at the level of brain by nerve pulse patterns, this is probably the case. The subtraction of the background is possible to realize by excitatory and inhibitory projections and mathematically one can regard the sensory image of a colored object of a perceptive field as an integral function for the gradient of the intensity of the sensory input. For a monochromatic constant input the derivative vanishes as also integral function. The task therefore is to realize this integral function in terms of a neural circuit using excitatory and inhibitory inputs and outputs.

The explanation of the color constancy could reduce to the hypothesis that sensory qualia correspond to increments of quantum numbers rather than quantum numbers themselves.

1. If the color perception generated by the illumination at a particular wavelength depends only on the spatial gradient of the illumination, color constancy follows as a consequence. Since the eye is performing saccadic motion, this translates to a temporal gradient of illumination. The temporal change of the illumination at a particular wavelength should thus induce a particular color quale. But this is consistent with the assumption that color qualia correspond to the increments of color quantum numbers in the quantum jump. This model explains also why the saccadic motion is necessary to generate color qualia, and qualia at all. Quite sensory percepts result only when physical change is involved. Saccadic motion maps the gradients of illumination to increments of color quantum numbers.
2. One might also understand why a rotating Benham top containing only black and white regions can produce color sensations. Since both the saccadic motion and the motion of disk are involved, one can imagine that for a rotating disk the proportions of various primary qualia are affected such that a net color is perceived. For instance, the intensity of the perceived color could depend on the velocity with which the eye crosses the intensity gradient and this dependence could depend on wavelength.

All geometric aspects of sensory experiences should reduce to representations generated by zero modes, in particular zero modes characterizing classical Kähler field, which can reduce to pure electromagnetic (vision?) or Z^0 field (auditory experience?). Color constancy could be understood if the incoming light intensities associated with the wavelengths around three basic colors generate Kähler electric fields proportional to the gradient of the intensity. If the gradient is strong, as it is on the boundary of the retinal or neural image of the object, the

conservation of the Kähler electric flux forces the generation of mind-like space-time sheet at which part of the flux goes.

Thus retina would automatically create representation for the objects of the visual field as mind-like space-time sheets, which in turn could give rise to sub-selves representing objects of the visual field as mental images! These objects need not however correspond to our conscious experiences. In fact, the boundaries of all objects of perceptive field should be generated by strong gradients and same principle would apply also to the higher level representations of sensory information. A gradient of Kähler (electric) field proportional to the gradient of primary/secondary sensory stimulus is generated in primary/secondary sensory organ and automatically generates mind-like space-time sheets, which give rise to sub-selves representing the decomposition of the perceptive field to objects.

4.3.4 Blind sight and Anton's syndrome

In blind sight cortically blind patient claims to be blind but is actually able to locate objects in the visual field when asked to do that. By training the patient can even develop some kind of primitive conscious experience of motion, shape and color.

1. For option 1) blind sight looks first problematic since the basic assumption is that primary visual qualia are generated at the level of retina. If the entanglement with retina is lost the visual qualia at retina are not assigned with the magnetic sensory canvas and the person is not conscious that his eyes see. The primitive conscious experiences of motion, shape and color would arise at the sub-cortical level make it possible to locate objects in the visual field. Blind sight would be also vision without cortical cognition (such as feature recognition). Training would generate gradually entanglement between sub-cortical areas and the cortical areas responsible for projections to the sensory magnetic canvas.
2. In option 2) the explanation for the blind sight would be the existence of two separate visual systems. Possible candidates for these systems as regions of cortex have been even identified [J2].
3. In option 3) blind sight has several explanations. The simplest explanation is that the negentropic entanglement between magnetic body and brain is absent so that brain would see consciously but not the magnetic body representing us. Blind sight could thus be interpreted as a support for the notion of magnetic body. A test for the magnetic canvas hypothesis might be based on the elimination of the MEs responsible for the sensory projection to the magnetic canvas somehow. This option is of course not the only possible one. There is entire p-adic hierarchy of increasingly refined visions involving retinal vision, amygdalar vision, and various visions corresponding to sensory areas of cortex.

The patient suffering from Anton's syndrome is cortically blind but claims that he sees but behaves as if he were blind and confabulates all kinds of explanations for his behavior.

1. The advocate of option 1) could argue that patient sees at the subcortical level and hence has pure experience of vision without any cortical cognitive processing of what he is seeing. Person is cognitively blind. There would be no recognition of objects in the visual field, to say nothing about associations and memories related to these objects. Therefore sensory (or subcortical) seeing would not help the patient much and he would behave effectively as a blind person. One could even consider the possibility that patient gradually loses the ability to see because this ability is not useful anymore. A possible test (probably already carried out) for the hypothesis is to check whether patient can show the direction of an intensive light source (even this might require "cognitive seeing").
2. The standard explanation (option 2) is that patient is not conscious about being blind: the fact that patient seems to gradually accept the situation that he does not see, supports this explanation. It would be possible to have the experience of seeing without actually seeing.

3. Option 3) would allow the possibility that the parts of the cortex responsible for projecting sensory data to the sensory magnetic canvas remain intact and that the visual images are visual memories. It would not be surprising that this useless vision would be gradually lost. Note however that lower level visual systems might work.

4.3.5 Woman without body

In his book “The man who mistook his wife for a hat” [J12] Oliver Sacks tells about a tragic situation in which his patient lost totally her body image. Body image is provided by proprioception together with vision and sense of balance. The sensory neurite suffered by the patient destroyed patient’s proprioceptive sensory pathways. Patient did not however lose tactile senses. The proprioceptive homunculi in patient’s parietal lobes suffered no injury. Patient learned to cope with everyday activities by using vision and sense of balance and all kinds of clever feedback and feedforward mechanisms to compensate the lost proprioception. For instance, patient regained her ability to speak, to keep her bodily posture and walk. She however lost her balance immediately if she closed her eyes. Patient did not however get back her phenomenal body image in this manner.

The loss of body image is not a problem for option 2) since neural pathways are prerequisites of quantum entanglement between brain and sensory receptors (also these might have been destroyed). Options 1) and 3) can explain the loss of body image without difficulties. These options could even allow to regain the body image artificially, for instance by artificial neuronal stimuli providing a representation for the positions of various body parts. In both cases artificial electric stimulation of cortex should generate tactile sensations of some kind.

REFERENCES

Mathematics

- [A1] 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.
- [A2] Zuber J-B Iztykson C. *Quantum Field Theory*, volume 549. Mc Graw-Hill, New York, 1980.

Theoretical Physics

- [B1] Sokolov IV et al. Quantum holographic teleportation of light fields. Available at: <http://arxiv.org/abs/quant-ph/0007026v1>, 2001.

Condensed Matter Physics

- [D1] Liquid crystals on line. Available at: <http://www.lcionline.net/>.
- [D2] Anderson PW. *Rev Mod Phys* ., 38, 1966.
- [D3] Tilley K Tilley DR. *Super Fluidity and Super Conductivity*. Adam Hilger Ltd, 1986.

Physics of Earth

- [F1] Hecht J. The Giant Crystal at the Heart of the Earth. *New Scientist*, page 17, January 1994.

Biology

- [I1] Brief introduction into WaveGenetics. Its scope and opportunities. Available at: <http://www.wavegenetics.jino-net.ru>.
- [I2] Woodbury DJ. Pure lipid vesicles can induce channel-like conductances in planar bilayers., July 1989.
- [I3] Gariaev P et al. *The DNA-wave biocomputer*, volume 10. CHAOS, 2001.
- [I4] Gariaev PP et al. The spectroscopy of bio-photons in non-local genetic regulation. *J Non-Locality and Remote Mental Interactions*. Available at: <http://www.emergentmind.org/gariaevI3.htm>, (3), 2002.
- [I5] Lev AA et al. Rapid switching of ion current in narrow pores: implications for biological ion channels. *Proc R Soc London. Series B: Biological Sciences*, pages 187–192, June 1993.
- [I6] Tovmash AV Gariaev PP, Tertishni GG. Experimental investigation in vitro of holographic mapping and holographic transposition of DNA in conjunction with the information pool encircling DNA. *New Medical Technologies*, 9:42–53, 2007.
- [I7] Ling GN. *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity*. Blaisdell Pub. Co., New York, 1962.
- [I8] Fröhlich H. The extraordinary dielectric properties of biological materials and the action of enzymes. *Nature*, 72(1968):641–649, 1975.
- [I9] Saunders PT Ho M-W. *Liquid Crystalline Mesophase in living organisms*. World Scientific, Singapore, 1994.
- [I10] Volkenstein MV. *Biophysics*. Mir Publishers, Moscow, 1983.
- [I11] Ho MW. *The Rainbow and the Worm*. World Scientific, Singapore, 1993.
- [I12] Qin F Sachs F. Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal. *Biophys J*, pages 1101–1107, September 1993.
- [I13] Tshitshinadze G Shaduri M. On the problem of application of Bioenergography in medicine. *Georgian Eng News*, 2, 1999.

Neuroscience and Consciousness

- [J1] Breaking the Code of Color. Available at: <http://www.hhmi.org/senses/b/b120.htm>.
- [J2] The zombie within. *New Scientist*, 159(2150), September 1998.
- [J3] Botkin AL. The Induction of After-Death Communications Utilizing Eye-Movement Desensitization and Reprocessing: A New Discovery. *J Near-Death Studies*, (3):181, 2000.
- [J4] Selden G Becker RO. *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York, 1990.
- [J5] Blackman CF Blanchard JP. A model of magnetic field effects on biological system with conforming data from a cell culture preparation. *On the Nature of Electromagnetic Field Interactions with Biological Systems*, 1994.
- [J6] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.
- [J7] Yarrow D. Spin the tale of the dragon. Available at: <http://www.ratical.org/reatv11e/RofD2.html>, 1990.
- [J8] Blackman CF et al. Multiple power density windows and their possible origin. *Bioelectromagn*, 10(2):115–128, 1989.
- [J9] Libet B et al. Subjective referral of the timing for a conscious sensory experience. *Brain*, 102, 1979.

- [J10] Shapiro F. *Eye moment desensitization and reprocessing: Principles, processes and procedures*. Guilford, New York, 1995.
- [J11] Germaine M. Experimental verification of Stapp's theory'. Available at: <http://listserv.arizona.edu/lsv/www/quantum-mind.html>, 2000.
- [J12] Sacks O. *The man who mistook his wife for a hat*. Touchstone books, 1998.
- [J13] Becker RO. *Cross Currents*. Penguin Putnam Inc., New York, 1990.
- [J14] Pinker S. *How the Mind Works*. W. W. Norton & Company, Inc., New York, 1997.

Books related to TGD

- [K1] 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.
- [K2] 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.
- [K3] Pitkänen M. Biological Realization of Self Hierarchy. In *Bio-Systems as Self-Organizing Quantum Systems*. Onlinebook. Available at: http://tgdtheory.fi/public_html/bioselforg/bioselforg.html#bioselfc, 2006.
- [K4] Pitkänen M. DNA as Topological Quantum Computer. In *Genes and Memes*. Onlinebook. Available at: http://tgdtheory.fi/public_html/genememe/genememe.html#dnatqc, 2006.
- [K5] 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.
- [K6] Pitkänen M. Genes and Memes. In *Genes and Memes*. Onlinebook. Available at: http://tgdtheory.fi/public_html/genememe/genememe.html#genemec, 2006.
- [K7] 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.
- [K8] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdgeom/tgdgeom.html#kahler, 2006.
- [K9] Pitkänen M. Macro-Temporal Quantum Coherence and Spin Glass Degeneracy. In *Bio-Systems as Conscious Holograms*. Onlinebook. Available at: http://tgdtheory.fi/public_html/hologram/hologram.html#macro, 2006.
- [K10] Pitkänen M. Magnetospheric Sensory Representations. In *Magnetospheric Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/magnconsc/magnconsc.html#srepres, 2006.
- [K11] Pitkänen M. Matter, Mind, Quantum. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#conscic, 2006.
- [K12] 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.
- [K13] Pitkänen M. Quantum Antenna Hypothesis. In *Quantum Hardware of Living Matter*. Onlinebook. Available at: http://tgdtheory.fi/public_html/bioware/bioware.html#tubuc, 2006.
- [K14] Pitkänen M. Quantum Control and Coordination in Bio-systems: Part I. In *Bio-Systems as Self-Organizing Quantum Systems*. Onlinebook. Available at: http://tgdtheory.fi/public_html/bioselforg/bioselforg.html#qcococI, 2006.

- [K15] Pitkänen M. Quantum Control and Coordination in Bio-Systems: Part II. In *Bio-Systems as Self-Organizing Quantum Systems*. Onlinebook. Available at: http://tgdtheory.fi/public_html/bioselforg/bioselforg.html#qcococII, 2006.
- [K16] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#hearing, 2006.
- [K17] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#pulse, 2006.
- [K18] Pitkänen M. Quantum Model of EEG. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#eegII, 2006.
- [K19] Pitkänen M. Self and Binding. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#selfbindc, 2006.
- [K20] Pitkänen M. The Notion of Wave-Genome and DNA as Topological Quantum Computer. In *Genes and Memes*. Onlinebook. Available at: http://tgdtheory.fi/public_html/genememe/genememe.html#gari, 2006.
- [K21] Pitkänen M. Time and Consciousness. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#timesc, 2006.
- [K22] Pitkänen M. Twistors, N=4 Super-Conformal Symmetry, and Quantum TGD. In *Towards M-Matrix*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdquantum/tgdquantum.html#twistor, 2006.

Articles about TGD

- [L1] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: <http://tgdtheory.fi/articles/nuclstring.pdf>, 2007.
- [L2] Pitkänen M. CMAP representations about TGD. Available at: <http://www.tgdtheory.fi/cmaphtml.html>, 2014.
- [L3] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: <http://www.tgdtheory.fi/tgdglossary.pdf>, 2014.
- [L4] Pitkänen M. Quantum model of qualia. Available at: <http://www.tgdtheory.fi/webCMAPs/Quantummodelofqualia.html>. 2014.
- [L5] Pitkänen M. TGD inspired theory of consciousness. Available at: <http://www.tgdtheory.fi/webCMAPs/TGDinspiredtheoryofconsciousness.html>. 2014.
- [L6] Pitkänen M. The notion of self. Available at: <http://www.tgdtheory.fi/webCMAPs/Theotionofself.html>. 2014.