Quantum Model for Sensory Representations

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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, fifteen year old, 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.

a) 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.

b) 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).

c) 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 corresponding 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.

d) 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 mindlike 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.

e) 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 it-

erated 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.

1 Introduction

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

1. The 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. 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; symbolic representations at space-time level are made by the classical nondeterminism of Kähler action; theory leads to a very general model of sensory experience and so called whole-body consciousness explaining basic characteristics of the mystic experiences is one of the basic predictions of the theory.

2. The understanding of the relationship between subjective and geometric time leads to the notion of psychological time involving in an an essential manner the new view about space-time, in particular the idea about mindlike space-time sheet as a geometric correlate of self. The notion of psychological time forces to view the entire many-sheeted space-time surface as a living system so that the standard notion of linear time is illusory and reflects the restricted information content of our conscious experience rather than fundamental 4-dimensional reality. The paradigm of 4-dimensional brain provides completely new understanding of the long term memory: no memory storage mechanisms are needed and one avoids the basic difficulties of neural net models. The fact that temporal duration of the lightlike self associated with ME can be arbitrarily long, is very probably of very high significance. There are two kinds of memories and emotions can be understood as resulting from the comparison of geometric memories (the expectation) with the subjective memories (what really happened).

3. 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 macroscopic space-time surfaces associated with the final state quantum histories. Quantum jumps imply dissipation at fundamental level. Dissipation serves as a Darwinian selector of self-organization patterns, which can represent both genes and memes. In particular, one can understand how habits, skills and behavioral patterns are gradually learned. 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-rhytms could quite generally correspond to dissipation-healing cycles. Motor action could be understood as geometric time reversal for the build-up of sensory representation in an appropriate time scale.

4. An essential element is macrotemporal quantum coherence accompanying the formation of bound states. The transformation of zero modes of the binding subsystems to quantum fluctuating degrees of freedom implies that a sequence of quantum jumps lasting for the

lifetime of the bound state behaves effectively as single quantum jump and there is practically no quantum decoherence. Quantum spin glass degeneracy lengthens the lifetimes of the resulting bound states. The formation of the bound states, which is the TGD analog of Orch OR, is a key process in TGD based model of living matter and quantum brain.

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

i) The formation of bound states implies subjectotemporal fractality of consciousness meaning that the basic anatomy of quantum jump is replicated in various time scales, even that of human life cycle.

ii) Bound state entanglement means fusion of mental images and gives rise to experiences of 'oneness' at all levels of the self hierarchy. 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 is present even at the molecular level. For instance, information molecules and receptors can be seen as having opposite molecular sexes with the binding of information molecule to receptor giving rise to the experience of 'oneness' and favoring co-operation instead of competition.

iii) Bound states give rise to mental images of low entanglement entropy in the real context and cognitive mental images of positive entanglement negentropy in p-adic context. Cognitive mental image with a positive entanglement negentropy gives rise to an experience of understanding.

iv) Both real and p-adic quantum computer like operations are possible for the bound states. Real-padic entanglement coefficients are necessarily algebraic numbers and a number-theoretic definition of entropy is possible: this entropy can be also negative so that it is possible assign genuine information to cognitive entanglement. This might make sense also for real bound states with an algebraic entanglement.

v) Jumping from the bottom of a valley of the quantum spin glass energy landscape to the bottom of another valley by a temporary delocalization 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.

vi) The binding energy liberated in the binding process is usable energy: this means quantum metabolism based on buy now-pay later mechanism.

The general vision about different types of conscious experiences and about qualia was discussed in [H1]. In this chapter a general model of personal sensory representations is considered: in [K3] 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 dicussed in [N1].

1.1 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 is 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 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.

   i) 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.

   ii) The empirical results [59, 48] 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 then 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 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.

   iii) 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.

   iv) 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.

   v) Self hierarchy has as its geometric correlate the hierarchy of space-time sheets. 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 subselves correspond to (at least) these topological field quanta so that we are much more than our neurons.

   vi) 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 subselves 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 Alfwen wave resonance). Various attributes associated with the object of the perceptive field are associated with these magnetic subselves 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 lightlike selves) and magnetic flux tube structures associated with brain, both having astrophysical sizes.

1.2 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, fifteen 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 Z^0 MEs to em MEs, in which state they create coherent states of photons and possibly of "configuration space photons", 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. 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.

3. 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.

4. 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 mindlike 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.

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. 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 passive Z^0 MEs are involved at this stage. The answer presumably involves the generation of quantum entanglement: the recalled experience is shared by the experiencer now and in the geometric past. The recalled mental image is shared: there is no need to communicate the information defining the mental image classically since timelike entanglement is possible by the non-determinism of Kähler action.

   The mechanism involves several purely TGD based features: the lightlike character of the boundaries of MEs making possible lightlike selves; space-time sheets with a negative time orientation allowing classical signals to propagate backwards in time; the magnetic flux tube structures associated with brain having sizes of order light years making possible MEs to represent light reflected from the mirror formed by a magnetic flux tube at which MEs terminates.

7. The model of intentionality is mirror image of the model of long term memories obtained by real→ p-adic and geometric past→ geometric future replacements.

2 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 a 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 [26]. 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 verterbrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

2.1 Homeostasis as many-sheeted ionic flow equilibrium?

The experimental work of Ling, Sachs and Qin [23, 24] and other pioneers [25, 27] 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 [46]: among other things the circuitry could explain how acupuncture works.

2.2 Quantum model for pattern recognition

Time translation invariant pattern recognition circuit can be realized by using two coupled super conductors. 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, synchronooous 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 supracurrents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

2.3 General mechanism making possible biological clocks and alarm clocks, comparison circuits and novelty detectors

Weakly coupled super conductors and auantum 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 [17]

$$\begin{aligned} J &= J_0 sin(\Delta\Phi) = J_0 sin(\Omega t) \ , \\ \Omega &= ZeV \ , \end{aligned} \tag{1}$$

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 [17]

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

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 rhytmic 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

$$J = \sum_n J_0(n) sin(\Omega t + \Delta\Phi(n)) \ . \tag{3}$$

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 carriers a supra current. As the time passes the reference current dissipates by phase slippages[16, 17]. 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 nonstability 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 unstability 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 nonvanishing 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.

3 Life as symbiosis of MEs, of superconducting magnetic flux tubes, electric flux quanta, and ordinary matter?

The identification of mindlike space-time sheets as 'massless extremals' (MEs) leads to 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 [48] (these effects are discussed in detail in [J1, J2, J3]

3.1 Massless extremals

3.1.1 What MEs are?

Massless extremals (MEs) are an extremely general solution set of field equations associated with Kähler action [B1] and representing various gauge fields and gravitational fields[J4]. 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: lightlike coordinate $t - z$ and arbitary 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 lightlike vacuum current. The time dependence of the vacuum current is arbitrary, this is only possible by its lightlikeness. 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 also classical Z^0 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. Lightlike 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. TGD allows the possibility that the two sheets have opposite time orientations and therefore also opposite classical energies. More generally, the exchange of two or more MEs between material space-time sheets can be such that no net momentum exchange occurs so that the absolute minimum of Kähler action only in a finite region of space-time and gives rise to new degenerate absolute minimum of Kähler action since ME has vanishing action. This kind of structures are obvious candidates for cognitive structures since classical nondeterminism is localized in a finite space-time volume. 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.

MEs serve as receiving and sending quantum antennae [J4]. Lightlike 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 lightlike 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 [I4, I5].

3.1.2 MEs as Josephson junctions and current junctions

MEs can induce Josephson junctions and more general current carrying bridges between biostructures. 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 join along boundaries bonds 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.

ME electric field can contain also constant component.

1. This is possible if there is a vacuum charge density or ordinary elementary particles in a massless phase ("Higgs=0") at the boundaries of ME generating the field.

2. 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. Whether the wormhole contacts can propagate with the velocity of light is however not obvious. An attractive hypothesis is that the members of the ME pair have opposite time orientations so that total energy of ME pair can vanish and can be created from vacuum without any energy cost.

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.

3.1.3 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 [47, 48, 49] can be understood. Josephson current paradigm allows to understand this effect if RF or MW 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

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

For $E \sim .1$ V/m and $\omega \sim GHz$ which are typical values used in experiments [48], 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

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

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.

3.1.4 MEs and exotic representations of supercanonical algebra

The exotic representations of p-adic supercanonical and Super Virasoro algebras forming excellent candidate for a hierarchy of lifeforms are associated with both p-adic and real MEs. p-Adic representations have interpretation as cognitive representations but also real counterparts of these representations could be important biologically. For supercanonical representations the scaling operator L_0 is *not* assumed to contribute to the mass squared operator unlike for quaternion conformal representations. Otherwise real massses for exotic representations would be astrophysical and real counterparts of these MEs could occur only as pairs of opposite time orientation and vanishing net energy.

In p-adic context and for $L_0 \propto p^n$, $n = 1, 2, ..$, the real counterpart of the scaling eigenvalue is extremely small, being proportional to $1/p^n$ for R_p. Obviously these states are approximately scaling invariant. Indeed, by Fermat's theorem, the integrated p-adic scalings a^{L_0}, a positive integer, act like identity operator modulo $O(1/p)$ corrections. By the inherent fractality of Super Virasoro and supercanonical algebras, one can indeed construct representations of subalgebras spanned by supercanonical and Super Virasoro algebra for which conformal weights are proportional to p^n.

Mersenne primes $M_n = 2^n - 1$ are especially interesting since for them the action of the integrated scaling 2^{L_0} on the states having $L_0 \propto n$ reduces to that of a unit operator apart from $O(1/M_n)$ corrections. In real context the scaling 2^{L_0} acts in an excellent approximation as a fractal scaling by a power of p which has physical interpretation in terms of the approximate invariance of fractal under scalings by powers of p. This makes Mersenne primes especially interesting. In fact, also Gaussian Mersennes are biologically highly interesting [J7]. For Mersenne primes only integrated p-adic scalings leave states almost invariant. In both cases one can speak about approximate conformal invariance since the states generated by L_n do not have zero norm unlike for the usual representations of the conformal algebra so that L_n act more like oscillator operators and generate new states.

These states are generated by a subalgebra of Super Canoical Algebra in case of MEs since the conformal weight of the vacuum state vanishes (for ordinary elementary particles conformal weight of the vacuum is negative integer). Thus very special representations of p-adic Super Virasoro algebra are in question.

The degeneracy of states (number of states with same mass very small squared) is proportional to the exponent of L_0 and is enormous for the physically interesting values of p-adic prime p. This means that these states provide huge negentropy resources. Thus exotic Super Virasoro representations be interpreted as quantum level articulation for the statement that TGD Universe is quantum critical quantum spin glass. Exotic Super Virasoro representations clearly provide an excellent candidate for an infinite hierarchy of life forms.

The lifeforms defined by $L_0 \propto p^n$ representations are labelled by three integers (k,m,n): physically interesting primes correspond to $p \simeq 2^{k^m}$, whereas k prime and m are integers, and the power n appearing in $L_0 \propto p^n$. Besides this there are lifeforms associated with Mersenne primes. Perhaps it is these lifeforms which make mindlike space-time sheets living creatures and these lifeforms emerge already in elementary particle length scales and become increasingly complex when the p-adic length scale increases. Life could perhaps be regarded as a symbiosis of these lifeforms.

These lifeforms ('mind') would interact with each other and ordinary matter via the classical gauge fields associated with MEs. A natural hypothesis is that the quantum phase transitions of the macroscopic quantum phases for the particles of the exotic Super Virasoro representations formed in classical fields of MEs (mindlike space-time sheets) give rise to some (but not all) qualia.

3.1.5 MEs and quantum holography

Sokolov and collaborators [18] 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 lightlike 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. Lightlike current would be like a dynamical (four-dimensional) diffraction grating. Lightlike 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 configuration space 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 [18] generalizes to the case of MEs provided one can device a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix is in which each pixel gives rise to a photocurrent [18], 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 lightcone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

   The concrete realization of holographic teleportation proposed in [18] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is perfoming 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 hologrammic 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 lightlike vacuum current at a 3-dimensional timelike section of ME as a function 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 taylor-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 commmunicated to the geometric past followed by answe. 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 supercanonical representations at the lightlike boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K3] 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 supercanonical 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 configuration space photons are possible and characterized by configuration space 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 configuration space photons would be responsible for visual colors and polarization sense and the corresponding holograms might be the crux of quantum control in living matter.

3.2 MEs and mind

MEs provide a concrete realization of geometric memory. The model for qualia discussed in [K3] and also in [M3, M4, M5, 32] allows to sharpen this model to provide predictions about EEG correlates of memory.

3.2.1 MEs as mindlike space-time sheets

The properties of virtual MEs, in particular finite time duration, vanishing action, and the modification of absolute minimum of Kähler action in finite space-time region, make virtual MEs ideal candidates for mindlike space-time sheets. An atractive hypothesis is that important mindlike space-time sheets consist of MEs. It was already found that Josephson junctions could correspond to ME pairs consisting of positive and negative energy space-time sheets. The vanishing of the total energy of ME pair makes it an ideal cognitive structure since the creation of these pairs from vacuum changes space-time surface in finite space-time volume only and does not cost energy.

The hypothesis implies that MEs are an electromagnetic lifeform interacting with ordinary bio-matter. As a matter fact, MEs with sizes smaller than the size of organism would make also biomatter living. In particular, classical EM fields interacting with bio-matter should decompose into MEs representing mindlike space-time sheets which are geometric correlates of mental images.

3.2.2 ELF selves as MEs building quantum holograms?

ELF em fields could correspond to MEs or ME pairs having size of order Earth and give rise to levels of collective consciousness responsible for the cultural aspects of our consciousness. M The basic function of MEs would perhaps be the formation of quantum holograms of colored configuration space photons acting as control commands. At DNA level this could be achieved by static ME pairs associated with the nucleotides and tranforming genes to quantum holograms. In case of neuronal axons (Z^0) ELF MEs should propagate with the effective phase velocity of nerve

pulse along axon and generate nerve pulse. The propagaton of nerve pulse inducing dropping of ions to magnetic flux tubes, and the consequent generation of EEG MEs would in turn generate code nerve pulse sequence to a quantum hologram and sensory representation. The meaning of the concepts like 'active' and 'passive' hologram and reference wave have been already discussed.

The experiments of Mark Germine [41] 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.

3.2.3 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 hologrammic 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 lightlikeness 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 experience 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.

3.2.4 Life as a symbiosis of MEs, superconducting magnetic flux tube structures, electric flux quanta, and of biomatter

The general TGD based vision about life is as a symbiosis involving MEs, superconducting magnetic flux tube structures, and electric flux quanta forming fractal hierarchies and controlling the ordinary biomatter residing at the atomic space-time sheets.

Electric and magnetic flux quanta are actually dual to each other. Indeed, the attempt to understand the non-Hertzian scalar waves of Tesla led to the realization that by the electric-magnetic duality of quantum TGD magnetic flux tube structures have as their duals topological field quanta of electric field carrying essentially constant energy density [I4, I5]. Biosystems are full liquid crystal electrets and electric flux quanta are ideal for their modelling.

Also non-Hertzian scalar waves representing a space-time sheet moving with light velocity and carrying an essentially constant electric field in the direction of propagation are predicted. The non-Hertzian waves could be emitted in the generation of nerve pulses in directions transversal to the parallel axons and negative energy non-Hertzian waves could provide a mechanism of bound state formation between identical nerve pulse patterns representing symbolically thoughts as 'association sequences', that is temporal sequences of spacelike 3-surfaces with timelike separations (made possible by classical non-determinism of the Kähler action).

The basic interaction mechanisms of MEs with superconducting flux tubes are magnetic induction generating supracurrents, 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 lightlike boundaries representations of super conformal– and supercanonical algebras with gigantic almost-degeneracies of states due to the almost-commutativity of Poincare algebra and supercanonical algebra. Supercanonical states define genuine quantum gravitational state functionals in the space of three-surfaces, the 'world of worlds', and correspond to a higher abstraction level than ordinary quantum states defined in the 'world' (space-time). This 'world of worlds' aspect of quantum gravitational states explains why quantum gravity is crucial for consciousness.

4 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 prejucides about human consciousness.

4.1 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.

4.1.1 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. Imagination would involve as a seed p-adic cognitive representation, which is transformed by a p-adic-to-real phase transition to a real form, which in turn serves as initiating cell membrane oscillation pattern leading to an almost sensory experience or almost motor action (also nerve pulse patterns might be involved).

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 Z^0 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 that Z^0 ME is color rotated by coherent state of configuration space photons to electromagnetic ME which in turn generates coherent state of photons and configuration space 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 Z^0 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.

4.1.2 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 Z^0 MEs. The classical Z^0 fields entering to brain and body would represent very high level commands, and might be transformed to endogenous sounds by Z^0-piezoelectric effect identifiable as internal speech (internal speech could also correspond to p-adic Z^0 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 Z^0 MEs as bridges between two space-time sheets characterized by different p-adic primes, and inducing a flow of Z^0 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 Z^0 ME to the conduction velocity of nerve pulse or of some other excitation involves the shift of entire Z^0 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 spacelike and timelike soliton sequences predicted by the model for Josephson junctions.

4.1.3 Boolean mind and memetic code

TGD leads to a model of Boolean mind in terms of temporal sequences formed by cognitive neutrino pairs with a vanishing total energy [L1]. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, leads to a prediction of order .1 seconds for the duration of the 'wake-up' period of subself corresponding to the codeword of the memetic code. This codeword consists of 126 bits represented by cognitive antineutrinos such that the two possible Z^0 magnetization directions correspond to two values of Boolean statement. This implies tha 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 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.
i) Membrane oscillation/nerve pulse patterns correspond to temporal sequences of Z^0 magnetization directions for cognitive antineutrinos coding for yes/no Boolean statements.
ii) The spin polarization of antineutrinos is changed from the standard direction fixed by the spontaneous Z^0 neutrino magnetization in the direction of axon by Z^0 ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses very probably 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 Z^0 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. This expectation seems to be more or less correct. The full memetic code is very probably realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech [L1, M2, M4, M5, 32].

4.2 Brain, EEG, and quantum holograms

MEs are at the highest level of control hierarchy formed by MEs, superconducting magnetic flux tube structures, and the matter at atomic space-time sheets, and are thus involved with the fundamental control operations. EEG MEs can have also the role as an entangler 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.

There are two options for how sensory EEG MEs are realized.

1. EEG MEs would 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. For this option Z^0 MEs parallel to axons would induce nerve pulse activity. Z^0 MEs would result as p-adic MEs representing intentions, and would then be transformed to real MEs representing actions: magnetic body would intend.

2. EEG MEs could be realized as pre-existing sensorily passive Z^0 MEs analogous to recodes. They would be color rotated to em MEs when the sensory representation is activated. The model of nerve pulse and EEG suggests that Z^0 state corresponds to motor action and color rotated em ME corresponds to the subsequent sensory input. There are two problems which make this option less favored.

   i) The first problem is how brain manages to perform the needed color rotation. The record is in a (sensorily) passive state when ME corresponds to Z^0 ME and in an active state when the Bose-Einstein condensation of the configuration space photons on ME generated by another ME induces a color rotation of ME so that it becomes active em ME. The

fundamental control operation would be the activation of Z^0 MEs to em MEs which in turn would generate coherent state of photons and configuration space photons acting as a control command, interact classically with the magnetic flux tubes inducing magnetic quantum phase transitions waking up magnetic subselves, and inducing supra currents affecting currents at the atomic space-time sheets via ionic flow equilibrium. The phase congugate of the hologram would correspond to time a reversed command.

ii) The second problem relates to the interpretation of EEG MEs resulting as a correlate for cyclotron radiation when ions drop to the magnetic flux tubes.

As discussed in [M2], 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 lightlike vacuum currents. TGD based model of EEG and nerve pulse [M2] 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.

The notion of neural window, which was the original form of 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 super conductor. The photons radiated by the mindlike 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 hologrammic 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 axons 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 mindlike 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 configuration space 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.

4.3 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 subself. If the sign of entropy feed to mental images correlates with the entropy gradient of the system represented by subself, 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: subselves 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.

4.4 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 mindlike 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 gemeralized 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.

4.5 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 [M2], 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 messanger 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 join along boundaries bond. 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.

4.6 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, Hodkin-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 subselves 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.

4.7 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 he 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 reverbatory. 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.

5 Sensory representations

In this section concrete model for the sensory representations is developed on basis of the general vision already outlined.

5.1 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.

5.1.1 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

subselves represented by magnetic or Z^0 magnetic flux tubes. Particular EEG frequency wakes-up particular subself in a specific position and orientation and gives rise to a 'feeling of existence' in some part of the virtual world of brain (or possibly outside brain!). Sensation of motion of object of perceptive field results automatically when subself moves inside self. 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.

5.1.2 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.

1. Are 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 subselves 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 gigants 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 [I3] 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 (subselves) 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!

2. Are the sensory representations 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.

5.1.3 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 subselves 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 Alfven 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 subselves 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 Alfwen 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 there 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 would be realized in a strong sense.

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. Thalamus is believed to generate 40 Hz rhytm and is thus a good candidate for the central sensory entangler and projector. Hippocampus 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. Perhaps even at the length scale of genes. The remaining question is how motor activities are realized in this picture. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my personal attempts to understand consciousness, might help here. Computer screen corresponds to the magnetic canvas. The one who sits there presumbly corresponds to our magnetic body (as far as conscious-to-us intentions are considered). The central unit corresponds to the brain. Sensory projector MEs are generated automatically by nerve pulse activity and code the picture on the monitor. Z^0 MEs as active quantum holograms acting as control commands generating nerve pulse patterns would provide a realization of keyboard. Thus it would seem that those aspects of the computer which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the brain consciousness and computer programmers seem to mimic what happens inside (and outside) their own brain.

5.1.4 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.

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" [45] 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 [58] and [K2].

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 [28, 44]. 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.

5.1.5 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" [45] 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.

5.1.6 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 [54]. Rather remarkably, also imaginative thought resembles very much visual imagery as is clear from the fact that language is full of visual metaphors [54]. 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.

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

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 sensory representations are realized at the magnetic canvas, the difference between imagination and real sensory experience could result from the absence of the sensory representation, that is projection to the sensory canvas. This state of affairs could have a detectable EEG correlate: presumably 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.

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.

5.1.7 Are mindlike sheets 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 subselves. subselves in turn naturally correspond to mindlike space-time sheets. Therefore the problem reduces to that of understanding how sensory input gives rise to mindlike space-time sheets: in particular, how the sensory input or nerve pulse activity induced by it determines the boundaries of the mindlike space-time sheets.

On 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: mindlike space-time sheet is generated and the flux goes to the mindlike 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 mindlike space-time sheets and give rise to selves, mental images in the cognitive representation! Several cognitive representations with different decomposition into objects are possible.

5.1.8 Spectroscopy of consciousness

In [M5] 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 (but actually representing drift velocity of ELF MEs). 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 $L \sim \lambda$: $L(magn) \sim L(EEG) = c/f = (c/v)L$.

The identification of the quantum correlates of sensory qualia, the realization of the sensory representations using magnetic canvas and frequency coding, and scaling law imply what might be called spectroscopy of consciousness. Spectroscopy of consciousness is described in detail in [M5] and is shown to be consistent with the data about EEG correlates of sensory experience, emotion, cognition and memory (available to me. The model leads to myriads of precise predictions for EEG correlates of primitive building blocks of conscious experience so that the model, although not claimed to be final at the level of detail, is testable.

Especially beautiful is the connection of the theory of the magnetic qualia with atomic and nuclear spectroscopy: the structure of the periodic table reflects directly itself in the spectroscopy of consciousness. 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 seem to correspond to the five-layered structure of sensory cortex (primary, secondary, etc... areas).

If one assumes that p-adic length scales define preferred lengths for MEs, then apart from scaling the spectrum of supercanonical transition frequencies is constant of Nature and this leads to extremely powerful predictions and theory is immediately testable. One can indeed identify the basic resonance frequencies associated with EEG as lowest frequencies of this kind. Furthermore, the lower bounds of EEG bands correspond to fundamental frequencies of Super Virasoro transitions. Also now the representations associated with various p-adic length scales seem to correlate

with the hierarchy formed by the areas of the sensory cortex.

Spectroscopy of consciousness promises to be for brain science what atomic spectroscopy has been for physics and chemistry. It is somewhat astonishing that this possibility has not been noticed before. After all, spectral lines provide extremely effective, reliable and universal manner to code information and brain is the most refined information processing system we know.

5.2 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) The apparently very naive view is that sensory experience gets 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 entanglement between brain and sensory organs.

2) Standard neuroscience says that our sensory experience can be localized to cortex.

3) The view about ultimate (conscious-to-us) sensory representations as being realized on the magnetic canvases formed by a hierarchy of magnetic flux tubes structures 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 does not differ in an essential manner from the standard view: magnetic sensory canvas is analogous to a passive monitor screen.

The view 1) is not automatically excluded in TGD framework as it is in standard neuroscience.

1. The experiments of Libet about passive aspects of consciousness [42] could be seen as supporting the hypothesis that subcortical parts of the sensory pathways contribute to our sensory experience [H5].

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 2) and 3).

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

[1]The 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.

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 2) 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.

5.2.1 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 otoacoustic emissions, as they are called, can be sometimes heard by even outsider [32]. Rapid eye movements during dreams and otoacoustic emissions can be regarded as backprojections from brain to primary sensory organs. These phenomena can be understood without any difficulties in the options 2) and 3). For instance, rapid eye movements could be understood as feedback generated by a visual dream. For the option 1) rapid eye movements could be seen as necessary prerequisite of dreaming and to "qualiafy" imagined mental images.

Synesthesia involves cross-modal associations of form $A \to B$ (say visual to auditory). The simplest view allowed by options 2) and 3) is that this kind of sensory leakage occurs at the level of neuronal connections. In option 1) 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.

5.2.2 Projected pain and phantom leg

For option 1) the explanation of phantom pain as 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 cause of pain is in the geometric now. The assumption that 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 sensory and cognitive sensory canvases.

For the standard explanation (option 2) 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 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 the Option 1).

For option 3) the explanation of the phantom leg phenomenon would be very simple. The loss of physical limb does not mean the loss of its magnetic counterpart (located perhaps at another side of the globe!). Thus phantom pain might be caused by either sensory input from other parts of leg projected to the magnetic sensory canvas, and much less probably, from external electromagnetic stimulation at magnetic resonant frequency. The reason why the latter option is much less probable is that the radial bundles of MEs and magnetic flux tubes associated with a particular secondary sensory organ are expected to have a large number of wormhole contacts and/or join along boundaries contacts and form single coherent structure. Otherwise it is difficult to understand how the input from MEs of a particular brain could compete with the input from other sources. Phantom pain could result if the nerve pulse patterns from the stump of the limb are such that they are interpreted as pain signals in cortex. One can also consider the view is that phantom pain is geometrically remembered pain from the period when leg still exists and thus would have a real cause.

The phenomenon of projected pain could be also understood in option 3) in the same manner as for option 2). It is also possible that the magnetic map of body coded by MEs is partially out-of-date so that some parts of this map correspond to the structure of body during early developmental periods. This would mean that the MEs representing by their orientation and activation frequency the positions of parts of body would not be updated after early developmental stages properly. This hypothesis is testable and if somatosensory map is not out-of-date, projected pain could be seen as a support for the notion of magnetic sensory canvas.

5.2.3 Color constancy and sensory organs as primary experiencers

The phenonenon color constancy [36], 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 wavelenghts 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.

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.

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 mindlike space-time sheets residing in the retina.

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 gardients 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 mindlike space-time sheet at which part of the flux goes.

Thus retina would automatically create representation for the objects of the visual field as mindlike space-time sheets, which in turn could give rise to subselves 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 mindlike space-time sheets, which give rise to subselves representing the decomposition of the perceptive field to objects.

5.2.4 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.

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.

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[37].

In option 3) blind sight has several explanations. There is entire p-adic hierarchy of increasingly refined visions involving retinal vision, amygdalar vision, and various visions corresponding to sensory areas of cortex. There is also the possibility that blind sight results from the lost ability to project the cortical sensory image to the magnetic canvas. In this case blind sight could be purely cognitive seeing. 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.

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. The standard explanation (option 2) is that patient is not conscious about being blind: the fact that patent seems to gradually accept the situation that he does not see, supports this explanation.

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 hallucinations or visual memories. It would not be surprising that this useless vision would be gradually lost. Note however that lower level visual systems might work.

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").

5.2.5 Woman without body

In his book 'The man who mistook his wife for a hat' [56] 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 1) since neural pathways are prerequisites of

quantum entanglement between brain and sensory receptors (also these might have been destroyed). Options 2) 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.

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