Quantum Model for Hearing

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Contents

Abstract

The statistical physics vision for qualia inspires the working hypothesis that quantum number increments determine qualia independently of the context (other quantum numbers). This hypothesis; the fact that hearing is frequency and time sense; and the observation that energy is conjugate to time together inspire the idea that energy increment determines some essential sub-quale of the hearing sensation common to all sensory experiences. Hearing would thus involve the time-like counterpart of force sense and the gradient of the total energy of non-f with respect to subjective time would be the physical variable sensed.

The universal character of energy (or rather power–) quale need not lead to paradoxes. The frequency range involved with hearing is at least three orders of magnitude wider than the EEG frequency range associated with other sensory inputs. Thus the contribution of the other senses to the energy aspect of the auditory sensation might be just a very low intensity noise. Hearing could be seen as a sense specialized to the energy and time aspects of sensation. This hypothesis might well be testable, for instance, by artificially inducing cortical deafness and by finding whether some aspect of hearing is still experienced. Note that neutrino spin flip is additional aspect of hearing in the model to be discussed, and might give the essential contribution to what it feels to hear.

1. Generalization of the model for sensory receptor and new view about hearing

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework one can consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

2. Possible roles of neutrinos in hearing

One can imagine several roles for exotic neutrinos in TGD inspired theory of consciousness and it is good to provide an overall summary first.

a) Dark matter hierarchy allows to consider cognitive and emotional

representations based on cyclotron phase transitions for Cooper pairs of dark neutrinos at Z^0 magnetic flux quanta.

b) The notion of cognitive neutrino pair represents genuinely many-sheeted physics and is the key element of the original quantum model for hearing. The neutrino and antineutrino of the pair correspond to light-like causal horizons defining the throats of a CP_2 sized wormhole contact. In condensed matter the pair could have nearly vanishing total energy. Quite generally, many fermion states of the Universe, which have vanishing net fermion numbers, have interpretation as quantum superpositions of Boolean statements with the presence/absence of fermion coding for 1/0. Cognitive neutrino pairs would be a particular example of this representation and naturally related to logical aspects of cognition.

In the basic variant of the model the frequency increment of the cyclotron transition of exotic neutrino involving also spin flip codes for the pitch of the sound. The basic prediction is that several cognitive (phoneme based) and emotional (pitch based) representations of the auditory input corresponding to various levels of the dark matter hierarchy are possible. Also cognitive neutrino pairs could define this kind of representation and since a rather low level of dark matter hierarchy is in question it is possible that this particular representation does not correspond to the representation of pitch at our level of the dark matter hierarchy.

c) There are two models for memetic codons in terms of temporal sequences of cognitive neutrino pairs. In the first model the existence or non-existence of cognitive neutrino pair (more precisely, the existence of a topological sum contact connecting the neutrino and antineutrino at parallel space-time sheets) in this sequence codes for a bit. The generation of a topological sum contact between CP_2 type extremals representing neutrino and antineutrino at parallel space-time sheets would transform 0 to 1. In the second variant of the model spin direction for the cognitive neutrino codes for a bit. In this case wormhole contact must carry spin one and consist of a left handed neutrino and its antineutrino. In this case Z^0 magnetic spin-spin interaction is expected to correlate the spin directions tightly and favor parallel spins so that the system behaves like spin one object and both spins flip in the Z^0 magnetic field residing at either space-time sheet. Also Coulomb interaction between neutrino and antineutrino at light-like wormhole throats contributes to the binding energy. The long ranged Z^0 Coulombic interaction of neutrino with dark matter, say dark protons, can induce large Coulombic binding energy and further reduce the mass of cognitive neutrino pair and even change the sign of energy so that cognitive neutrino pairs could be generated spontaneously.

3. Cognitive codes and cognitive neutrino pairs

This conceptual framework leaves a lot of room for detailed models. Perhaps the most realistic view inspired by the general model of cognition and by the general vision about dark matter is that the memetic codon is represented as Z^0 magnetic body as quantum state at $\delta H_{\pm} = \delta M^4_{\pm} \times CP_2$. The super-position of zero energy pairs of memetic codons associated with δH_+ and δH_- could be interpreted as a representation of a Boolean function. Therefore the size scale of representation is measured in terms of the photon wavelength associated with the typical frequency in audible

range.

Since super-canonical Hamiltonians depend on the radial light-like coordinate of δM^4_+ via a power law and define logarithmic waves, logarithmic representation of codon is highly suggestive. This would mean that the 3-surface X^3_k representing k:th bit at $\delta H_\pm$ has size proportional to say 2^k (also more general scalings are possible). This allows to distinguish between bits, which is essential for generating selective spin flip inducing conscious bit. The most natural mechanism inducing the flip on spontaneously magnetized X^3_k is based on Z^0 ME carrying transversal Z^0 magnetic field with constant direction and having transversal sizes identical to that of X^3_k.

This representation does not favor large numbers of bits, and the requirement that cyclotron energies are in the range defined by thermal energy at room temperature and the energy 2 eV of photons which are still visible, favors 6-bit memetic code.

One can construct more complex $6n$-bit codes (more generally mn-bit codes) by allowing several levels of dark matter hierarchy labelled by the values of $\hbar_{eff}/\hbar_0 = 2^{6k}$, $k = k_0, ..., k_0 + n$. In this manner it is also possible to construct a fractal variant of the memetic code as a structured representation in which various levels of dark matter hierarchy (self hierarchy) represent m-bit bunches of information at various levels of abstraction. Given level in hierarchy experiences the level below as a mental image and the levels below that level are experienced as averages. This loss of information is an unavoidable consequence of having bird's eye of view.

1 Introduction

The quantum model of hearing has evolved through several twists and turns. For years this model seemed to be one of the stable portions of TGD inspired theory of qualia and, what was remarkable, allowed rather precise quantitative predictions. The model relied crucially on TGD based new physics: in particular, the roles of long ranged dark weak force and of neutrinos was central.

The situation changed dramatically with what might be called dark matter revolution (the recent TGD based view about the role of dark weak interactions is discussed in [F9, F9, J6] and neutrino superconductivity in [J3]). The good news was that the long ranged weak fields are assignable to exotic copies of standard model particles so that the fears about large parity breaking effects in hadronic, nuclear, and atomic scales dissolve while the large parity breaking in molecular length scales can be assigned to the exotic copies of standard model particles giving rise to long range weak and color interactions. The bad news was that the model for the cognitive aspects of hearing relied on the assumption that *ordinary* neutrinos couple to the classical long ranged Z^0 fields in condensed matter does not make sense anymore. Dark matter revolution allowed also to develop a model for the interaction between biological body and the hierarchy of magnetic bodies implying a model for how sensory organs, brain, and corresponding magnetic bodies interact. The implication was that

the possible role of exotic neutrinos is restricted to the cognitive aspects of hearing.

1.1 Development of the model of hearing

The quantum model for hearing developed long before the general theory of qualia emerged.

1. One of the impulses leading to the development of the model was the idea about realization of memetic code in terms of cognitive antineutrinos. Of course, also other realization can be considered, for instance realizations based on temporal field patterns, and it has become clear that these realizations would be very natural [M5].

2. Second crucial observation was that only Z^0 magnetic fields could allow coding of the audible frequencies to magnetic transition frequencies. Also the idea that the weakness of classical Z^0 interaction is what makes possible to isolate verbal cognition from the atomic noise was an important guiding line. Again one must be critical and notice that a direct coding of music and speech like aspects of auditory sensation in terms of em field patterns is possible and must be considered seriously [M5].

3. The concrete calculations demonstrated that, rather miraculously, the anomalous Z^0 magnetic moments of neutrinos are such that one can predict correctly the upper bound for the audible frequency range.

4. A cold shower came with the realization that the long ranged classical weak fields predicted by TGD must be due to dark matter and that dark matter could correspond to large $\hbar$ macroscopically quantum coherent phase. This meant a travel to the unknown using as a guideline only p-adic length scale hypothesis and the hypothesis that ordinary or Gaussian Mersennes define the mass scales of leptons. These hypothesis are indeed enough to deduce the p-adic mass scales of exotic leptons affecting the anomalous Z^0 magnetic moment of dark neutrino which serves as the basic parameter of the model.

I made a desperate attempt to save the model, in particular the assumption that $\Delta n = 1$ spin flip with anomalously low frequency is responsible for hearing, by replacing neutrinos with mass $\sim .1$ eV with exotic neutrinos having mass of order electron mass and with some hand-waving managed to save the quantitative arguments [16]. Second modification is that the exotic neutrinos associated with wormhole throats correspond to $k = 127$ so that their mass is of order electron mass. One can however find some justification for this assumption and connect it with the lepto-hadron mechanism explaining the anomalous production of e^+e^- pairs in heavy nucleus scattering just above Coulomb wall [F7] and with the TGD based model of atomic nuclei involving in an essential manner exotic $k = 127$ quarks [F8]. Later it become clear that although the neutrinos are dark the model does not survive thermal stability condition.

Besides this shortcoming also genuine progress occurred.

1. An important step of progress came with a generalization of the capacitor model for the sensory qualia, the general model for how magnetic body controls biological body based on the dark matter hierarchy, and a model for hair cells inspired by several mysterious aspects related to their function led to a concrete model for hearing. This model has rather close connections with experimental facts but it is not yet clear to what degree this model is consistent with the earlier pieces of theory.

2. The most decisive boost came from the increased understanding of quantum TGD itself.

   The crucial stimulus came from the understanding of the dark matter hierarchy in terms of quantized Planck constants based on the generalization of the notion of the imbedding space obtained by gluing imbedding spaces corresponding to different values of Planck constants together along $M^4_\pm$ or CP_2 factors [A9]. This makes possible a geometric description of the phase transitions changing the values of Planck constants.

   The identification of the space-time correlates of infinite primes as multiparton states allowed to identify real and p-adic bosonic partons as correlates for intentions and actions and pairs of real and p-adic fermionic partons as matter and its cognitive representation. This picture is in nice accordance with the identification of the basis of fermionic Fock states quantum variant of Boolean algebra.

   Further steps of progress came with the detailed understanding of superconformal symmetries via the formulation of quantum TGD in terms of light-like 3-surfaces identified as orbits of partons, via the master formula for S-matrix allowing to construct also S-matrix between different number fields and between different sectors of imbedding space (phase transitions changing the values of Planck constants), and the discovery of zero energy ontology in which physical states compose to positive and negative energy parts such that all net quantum numbers vanish. Zero energy ontology means that one can interpret positive and negative energy fermionic components of the state as Boolean statements and entangled state itself as a representation of a Boolean function.

3. The last step in the evolution of quantum model for hearing was inspired by the new insights listed above and the decision to give up the un-necessary assumption that $\Delta n = 1$ spin flips with anomalously low transition frequency have a special role in hearing. This allows to assume that dark neutrino is a zoomed up copy of the ordinary neutrino with mass $\sim .1$ eV and thermal stability condition can be satisfied. 6-bit genetic code (with phonemes perhaps playing the role of amino-acids) emerges very naturally from the requirement that the energy range for cyclotron transitions is between thermal energy at room temperature and 2 eV representing upper bound for energies of visible photons.

Feeding in the idea that cognitive codes are responsible for communications between different levels of dark matter hierarchy and that codons are realized most naturally as a linear sequence of ends of Z^0 magnetic flux tubes at light-cone boundary leads to rather profound insights about how genetic and memetic codes are realized in terms of Z^0 MEs. In particular, memetic code allows a fractal realization involving several levels of dark matter hierarchy (self hierarchy) so that a structured representation involving sequence of abstractions rather than a mere bit sequence is in question.

This newest part of the theory (or rather, a collection of loosely related models) involves only the general vision behind TGD inspired theory of consciousness, and it is not plagued by so many ad hoc assumptions as the earlier model for the memetic code. In any case, there is still a long way to a realistic theory but there are good hopes about being at a correct track.

1.2 Hearing as a universal frequency quale?

Paradoxically, if the general theory of qualia would have been available from the beginning, it might have been rather difficult to end up with the original proposal for the correlates for the pitch and phoneme like aspects of auditory sensation. The statistical physics vision for qualia inspires the working hypothesis that quantum number increments determine qualia independently of the context (other quantum numbers). This hypothesis, the fact, that hearing is frequency and time sense, and the observation that energy is conjugate to time, together inspires the idea that energy increments determine some essential subquale of hearing sensation common to all sensory experiences. Hearing would be the time-like counterpart of force sense and the gradient of total energy would be the physical quantity sensed.

The universal character of energy (or rather power–) quale need not lead to paradoxes. First of all, the hypothesis does not mean that the color like quale associated with the sound-no-sound dichotomy, which is analogous to white-black dichotomy, corresponds to a frequency increment. Rather, the quale in question would relate to the experienced pitch of the sound coded to a frequency increment and is therefore rather geometric quale perhaps experienced as a height in the case of vision. Hearing could be even seen as a sense strongly emphasizing the energy and time aspects of sensation.

1.3 Does the basic quale of hearing correspond to the increment of electro-weak isospin?

Dark matter hierarchy leads to a concrete model for control and communication functions associated with body parts and corresponding magnetic bodies [M3, M4, M5]. This leads also to fresh vision about hearing. One can consider a generalization of the capacitor model for the sensory qualia such that the

generalized discharges giving rise to the sensory qualia occur between the sensory organ and corresponding magnetic body.

The fundamental quale of hearing characterizable by sound-no sound dichotomy would be associated with the increment of the weak isospin and would relate to an exchange of W MEs (massless extremals) between magnetic body of cochlea and cochlea. In a completely analogous manner, visual colors would be assigned with the increments of color quantum numbers and correspond to the exchange of color MEs, which correspond to various color rotated variants of W MEs. Note that these identifications could make sense even if the size scale of the sensory capacitor is that of the sensory organ. The fundamental energy quale would be associated with all sensory qualia although hearing could be in a special position since the typical time scale assignable to the auditory sensation is longer.

The neutral MEs carrying only classical Z^0 and em fields are assigned to cognitive and emotional representations whereas W MEs carrying vanishing neutral gauge fields and color fields are assigned to the basic "long range" sensory qualia. These two kinds of MEs represent instances of two basic types of solutions of field equations for which the CP_2 projection of the space-time surface belongs a geodesic sphere of CP_2. In the first case the geodesic sphere is homologically non-trivial and in the second case trivial (see the appendix of this book).

Cochlea and its magnetic body could give rise not only to auditory qualia but also define low level cognitive and emotional representations of auditory input realized already at the magnetic body of cochlea and realized in terms of cyclotron phase transitions. The right brain signs-left brain talks metaphor leads to an identification of cognitive *resp.* emotional representations as sequences of "phonemes" *resp.* "notes". The construction of the sensory representations involves in an essential manner back projection from brain to outer hair cells. Astrocytes regarded earlier as mere metabolic energy reservoirs are in this model carriers of higher level cognitive and emotional representations: this applies to all qualia. Microtubuli are responsible for mediating auditory input to brain as acoustic/electric signals (also propagating conformational patterns could be involved) and this resolves the mystery of how frequencies above kHz frequency are heard.

1.4 Infinite primes, cognition and intentionality

Somehow it is obvious that infinite primes must have some very deep role to play in quantum TGD and TGD inspired theory of consciousness. What this role precisely is has remained an enigma although I have considered several detailed interpretations, one of them above.

In the following an interpretation allowing to unify the views about fermionic Fock states as a representation of Boolean cognition and p-adic space-time sheets as correlates of cognition is discussed. Very briefly, real and p-adic partonic 3-surfaces serve as space-time correlates for the bosonic super algebra generators, and pairs of real partonic 3-surfaces and their algebraically continued

p-adic variants as space-time correlates for the fermionic super generators. Intentions/actions are represented by p-adic/real bosonic partons and cognitions by pairs of real partons and their p-adic variants and the geometric form of Fermi statistics guarantees the stability of cognitions against intentional action. It must be emphasized that this interpretation is not identical with the one discussed above since it introduces different identification of the space-time correlates of infinite primes.

1.4.1 Infinite primes very briefly

Infinite primes have a decomposition to infinite and finite parts allowing an interpretation as a many-particle state of a super-symmetric arithmetic quantum field theory for which fermions and bosons are labelled by primes. There is actually an infinite hierarchy for which infinite primes of a given level define the building blocks of the infinite primes of the next level. One can map infinite primes to polynomials and these polynomials in turn could define space-time surfaces or at least light-like partonic 3-surfaces appearing as solutions of Chern-Simons action so that the classical dynamics would not pose too strong constraints.

The simplest infinite primes at the lowest level are of form $m_B X/s_F + n_B s_F$, $X = \prod_i p_i$ (product of all finite primes). The simplest interpretation is that X represents Dirac sea with all states filled and $X/s_F + s_F$ represents a state obtained by creating holes in the Dirac sea. m_B, n_B, and s_F are defined as $m_B = \prod_i p_i^{m_i}$, $n_B = \prod_i q_i^{n_i}$, and $s_F = \prod_i q_i$, m_B and n_B have no common prime factors. The integers m_B and n_B characterize the occupation numbers of bosons in modes labelled by p_i and q_i and $s_F = \prod_i q_i$ characterizes the non-vanishing occupation numbers of fermions.

The simplest infinite primes at all levels of the hierarchy have this form. The notion of infinite prime generalizes to hyper-quaternionic and even hyper-octonionic context and one can consider the possibility that the quaternionic components represent some quantum numbers at least in the sense that one can map these quantum numbers to the quaternionic primes.

The obvious question is whether configuration space degrees of freedom and configuration space spinor (Fock state) of the quantum state could somehow correspond to the bosonic and fermionic parts of the hyper-quaternionic generalization of the infinite prime. That hyper-quaternionic (or possibly hyper-octonionic) primes would define as such the quantum numbers of fermionic super generators does not make sense. It is however possible to have a map from the quantum numbers labelling super-generators to the finite primes. One must also remember that the infinite primes considered are only the simplest ones at the given level of the hierarchy and that the number of levels is infinite.

1.4.2 Precise space-time correlates of cognition and intention

The best manner to end up with the proposal about how p-adic cognitive representations relate bosonic representations of intentions and actions and to

fermionic cognitive representations is through the following arguments.

1. In TGD inspired theory of consciousness Boolean cognition is assigned with fermionic states. Cognition is also assigned with p-adic space-time sheets. Hence quantum classical correspondence suggets that the decomposition of the space-time into p-adic and real space-time sheets should relate to the decomposition of the infinite prime to bosonic and fermionic parts in turn relating to the above mention decomposition of physical states to bosonic and fermionic parts.

   If infinite prime defines an association of real and p-adic space-time sheets this association could serve as a space-time correlate for the Fock state defined by configuration space spinor for given 3-surface. Also spinor field as a map from real partonic 3-surface would have as a space-time correlate a cognitive representation mapping real partonic 3-surfaces to p-adic 3-surfaces obtained by algebraic continuation.

2. Consider first the concrete interpretation of integers m_B and n_B. The most natural guess is that the primes dividing $m_B = \prod_i p^{m_i}$ characterize the effective p-adicities possible for the real 3-surface. m_i could define the numbers of disjoint partonic 3-surfaces with effective p_i-adic topology and associated with with the same real space-time sheet. These boundary conditions would force the corresponding real 4-surface to have all these effective p-adicities implying multi-p-adic fractality so that particle and wave pictures about multi-p-adic fractality would be mutually consistent. It seems natural to assume that also the integer n_i appearing in $m_B = \prod_i q_i^{n_i}$ code for the number of real partonic 3-surfaces with effective q_i-adic topology.

3. Fermionic statistics allows only single genuinely q_i-adic 3-surface possibly forming a pair with its real counterpart from which it is obtained by algebraic continuation. Pairing would conform with the fact that n_F appears both in the finite and infinite parts of the infinite prime (something absolutely essential concerning the consistency of interpretation!).

   The interpretation could be as follows.

   i) Cognitive representations must be stable against intentional action and fermionic statistics guarantees this. At space-time level this means that fermionic generators correspond to pairs of real effectively q_i-adic 3-surface and its algebraically continued q_i-adic counterpart. The quantum jump in which q_i-adic 3-surface is transformed to a real 3-surface is impossible since one would obtain two identical real 3-surfaces lying on top of each other, something very singular and not allowed by geometric exclusion principle for surfaces. The pairs of boson and fermion surfaces would thus form cognitive representations stable against intentional action.

   ii) Physical states are created by products of super algebra generators. Bosonic generators can have both real or p-adic partonic 3-surfaces as

space-time correlates depending on whether they correspond to intention or action. More precisely, m_B and n_B code for collections of real and p-adic partonic 3-surfaces. What remains to be interpreted is why m_B and n_B cannot have common prime factors (this is possible if one allows also infinite integers obtained as products of finite integer and infinite primes).

iii) Fermionic generators to the pairs of a real partonic 3-surface and its p-adic counterpart obtained by algebraic continuation and the pictorial interpretation is as fermion hole pair. Unrestricted quantum super-position of Boolean statements requires that many-fermion state is accompanied by a corresponding many-antifermion state. This is achieved very naturally if real and corresponding p-adic fermion have opposite fermion numbers so that the kicking of negative energy fermion from Dirac sea could be interpreted as creation of real-p-adic fermion pairs from vacuum.

If p-adic space-time sheets obey same algebraic expressions as real sheets (rational functions with algebraic coefficients), the Chern-Simons Noether charges associated with real partons defined as integrals can be assigned also with the corresponding p-adic partons if they are rational or algebraic numbers. This would allow to circumvent the problems related to the p-adic integration. Therefore one can consider also the possibility that p-adic partons carry Noether charges opposite to those of corresponding real partons sheet and that pairs of real and p-adic fermions can be created from vacuum. This makes sense also for the classical charges associated with Kähler action in space-time interior if the real space-time sheet obeying multi-p p-adic effective topology has algebraic representation allowing interpretation also as p-adic surface for all primes involved.

iv) This picture makes sense if the partonic 3-surfaces containing a state created by a product of super algebra generators are unstable against decay to this kind of 3-surfaces so that one could regard partonic 3-surfaces as a space-time representations for a configuration space spinor field.

1.5 Neutrinos, hearing, and cognition

1.5.1 Possible roles of neutrinos in hearing

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1. Dark matter hierarchy allows to consider cognitive and emotional representations based on cyclotron phase transitions for Cooper pairs of dark neutrinos at Z^0 magnetic flux quanta.

2. The notion of cognitive neutrino pair represents genuinely many-sheeted physics and is the key element of the original quantum model for hearing. The neutrino and antineutrino of the pair correspond to light-like causal horizons defining the throats of a CP_2 sized wormhole contact. In condensed matter the pair could have nearly vanishing total energy.

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This conceptual framework leaves a lot of room for detailed models. Perhaps the most realistic view inspired by the general model of cognition [H8] and by the general vision about dark matter is that the memetic codon is represented as Z^0 magnetic body as quantum state at $\delta H_{\pm} = \delta M^4_{\pm} \times CP_2$. The super-position of zero energy pairs of memetic codons associated with δH_+ and δH_- could be interpreted as a representation of a Boolean function. Therefore the size scale of representation is measured in terms of the photon wavelength associated with the typical frequency in audible range.

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In the sequel a quantitative model of hearing relying on these ideas is discussed. The first section is devoted to the general model of sensory receptor and its application in the case of hearing. This part of the theory is the least speculative part of the speculative theory. The remaining sections are devoted to neutrino super-conductivity and to the possible role of dark neutrinos in the understanding emotional and cognitive aspects of hearing. It must be emphasized that the model is very general and one could also consider the replacement of neutrinos with electrons. It is only the small mass of dark neutrinos which could make the generation of cognitive neutrino pairs and cognition a spontaneous process and thus given them a unique role. The chapter involves several archeological layers and I cannot guarantee the complete absence of mammoth bones.

2 Generalization of the model for sensory receptor and new view about hearing

Dark matter hierarchy defines a well-come challenge for earlier speculative models of sensory qualia and sensory organ, and leads to a considerably more detailed view about how sensory qualia, emotion, and cognition are related. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be seriously considered. The question arises whether sensory organs define not

only sensory, but also corresponding cognitive and emotional representations. Nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations, and this encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further concrete ideas: in particular, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in case of vision and hearing.

2.1 General ideas

Consider first general ideas about sensory qualia and capacitor model of the sensory receptor stimulated by the application of dark matter hierarchy.

2.1.1 Modification of the capacitor model of sensory qualia

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

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

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

2.1.2 Selection of percepts in state function reduction

State function reduction reducing charge entanglement could give rise to the selection of percepts involved for instance with binocular rivalry involving of magnetic body in the scale of brain. This selection means that only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception.

2.1.3 Also the magnetic bodies of sensory organs carry cognitive and emotional representations

Fractality forces the conclusion that also the magnetic bodies associated with the sensory organs carry cognitive and emotional representations. The level of cognition and emotion would be only lower than the cortical level and correspond to $k_{em} = 3$ most naturally. For instance, physical pain and psychological pain would correspond to emotions at different levels of the dark matter hierarchy.

An interesting possibility is that emotions and cognitions correspond to neutral gauge fields (em and Z^0 gauge fields and neutral color gauge fields) whereas sensory qualia or at least part of them would correspond W gauge fields and color charged gluon fields. Quite generally, cognition and emotions would have neutral Lie-algebra (or Kac-Moody algebra) generators as correlates whereas charged generators would correspond to sensory qualia.

2.1.4 The new view about the role of sensory receptors and glial cells

The starting point is the 4-dimensional view about gradual build-up of 4-dimensional percept as an evoked potential representing genetic, memetic or more general codon or single "note" depending on whether one considers cognitive or emotional representation.

Quite generally, sensory receptor neurons do not fire and the primary sensory input is represented as an evoked potential. That this must be the case is easy to understand if sensory receptor neurons generate cognitive and emotional representations at their magnetic bodies based on modulations of $k_{em} = 3$ frequencies by EEG frequencies. The reason is that nerve pulse would spoil the temporal coherence of the cognitive and emotional representations by cyclotron transition patterns by taking Josephson frequency through zero to a large negative value and back to the original value. This would be like playing entire piano scale from right to left and back inducing cyclotron phase transition sweeping through a large portion of the magnetic body.

This applies also in the case of higher level emotional and cognitive representations and the only reasonable conclusion seems to be that glial cells which do not fire correspond to these representations. I have already earlier suggests this but on different grounds. Glial cells would not be mere metabolic storages but receive the metabolic energy directly because they are primary users of it utilizing it to build generalized EEG and ordinary EEG. T

he leakage of Ca^{2+} ions through sensory receptor cell membrane induced by a plasma oscillation pattern gives rise to temporal patterns of evoked membrane potential. Plasma frequency would correspond to the frequency of recurrence for these patterns. The temporal characteristics of plasma wave patterns should correlate with various codes, in particular memetic code. The same picture would apply at the level of glial cells. Neurons would us much less metabolic energy since supra currents through the cell membrane would not use much of the metabolic energy, and ionic channels and pumps would actually play the

role of sensory receptors at neuronal level [J3].

2.1.5 Hearing *resp.* vision $\leftrightarrow$ electro-weak *resp.* color interactions

Hearing-vision dichotomy and weak interaction-color interaction dichotomy could correspond to each other. The sensation of hearing could correspond to the change of weak isospin resulting in W exchange. Sound-silence dichotomy ($\Delta I_3^w = \pm 1$) would be completely analogous to white-black dichotomy assignable to color isospin ($\Delta I_3^w = \pm 1$). Similar pairing should occur at the level of cognitions and emotions accompanying auditory and visual percepts and correspond to neutral weak gauge bosons and neutral color bosons.

2.1.6 The assignment of scaled up EEG with sensory organs

The assignment of $k_{em} = 3$ variant of EEG to sensory organs suggests itself. In the case of ordinary sensory qualia the scaled up 5 Hz Josephson frequency of ordinary EEG would be 10^4 Hz. If magnetic field strength associated with DNA is scaled up to .1 Tesla for these representations, alpha band is mapped to 2×10^4 Hz. Delta band for right/left brain DNA cyclotron transitions at .5 Hz/1 Hz is mapped to 1 kHz/2 kHz. Hence the identification of the 1 kHz synchronization frequency of neural firing as the scaled up cyclotron frequency of DNA must be considered.

The frequency range $20-2\times 10^4$ Hz of frequencies audible by humans overlaps with the spectrum $0 - 10^4$ Hz of sferics known to correlate with consciousness. This coincidence has a natural interpretation in this picture since the $k_{em} = 3$ Josephson junctions (scaled up cell membrane thickness) would correspond to size scale of 80 m and scaled up cell size to the scale 160 km assignable to lito-ionosphere complex in the general model of EEG [M3]. Therefore hearing and also other sensory qualia cold be accompanied by low level cognitive and emotional representations resulting as EEG modulations of the frequencies above kHz: sensory organs would feel and cognize to some extent.

2.2 TGD based model for hearing

It is very difficult to understand how neural processing could cope with the fast temporal gradients of the auditory input. The basic difficulty is that the time scale of nerve pulses is below millisecond whereas the highest audible sounds correspond to frequencies of about 200 kHz for some sea mammals [22]. Also bats hear very high frequencies. The frequencies below kHz are known to be coded to spike interval distributions [28] but for higher frequencies this is not possible. The mystery is how brain receives the information about higher frequencies.

If sensory representations are realized at the level of sensory organs the problem becomes much easier. Without feedback from cortex one would however end up with difficulties: for instance, the phenomenon of missing fundamental could not be understood. Microtubular communications of sound to and from brain would allow to transform sound waves to signals propagating along axonal

microtubuli. Feedback along microtubuli makes possible an active construction of percept so that phenomena like missing fundamental can be explained as being caused by spike interval distribution of nerve pulse patterns associated with feedback. The outcome is a more concrete view about hearing at the level of ear. This aspect have not been discussed in the earlier model which has concentrated on an attempt to understand the cognitive aspects of hearing.

2.2.1 The anatomy of cochlea

The ear of mammals involves outer and inner hair cells [22, 23]. Outer hair cells have no axons to brain but there are efferents from cortex to them. The usual interpretation is that outer hair cells act as pre-amplifiers. They make possible feedback from cortex allowing to build sensory percepts already at the level of ear. This makes reasonable the idea that acoustic representations are indeed constructed at the level of sensory organs.

The cochlea for which piano keyboard is a good but not complete metaphor represents the phoneme as a spatio-temporal pattern. The input at a given frequency presses various keys with maximum activation at a key characterized by this frequency. The magnetic body of the entire cochlea experiences the sounds as spatial patterns of cyclotron transitions. Lower level emotional and cognitive components could emerge already here and correspond to rhythm and pitch. Meaning emerges at higher level as phonemes integrate to words and speech and associations are formed.

2.2.2 The coupling of hair cells with neurons

The coupling of hair cells with neurons mediating neuronal signals to brain is poorly understood [22, 23].

1. The transmission of neurotransmitters to postsynaptic neuron from the hair cell should be uncannily fast. The existence of unidentified very fast neurotransmitter is postulated.

2. Hair cell contains near presynaptic cleft mysterious structure with ring like shape known as presynaptic dense body. The function of this structure is not known but is believed to be crucial for the transmission of the neural transmitter.

3. There is chronical Ca^{2+} leakage to hair cell. This is also believed to be crucial for the transmission of mystery transmitter.

2.2.3 TGD based model for hearing

TGD based model hearing is inspired by the attempt to understand the meaning of the strange findings just listed.

1. It is known whether and it is difficult to understand how the audible frequencies above kHz can be coded by nerve pulse patterns. The representations based on $k_{em} = 3$ scaled up EEG suggests a solution to the problem. The fundamental sensory representations and also low level emotional and cognitive representations are realized at the level of cochlea so that there would be no absolute need to code for high frequencies by nerve pulse patterns. The representation at the level of sensory organs means that the loss of accuracy of representation due to communications with brain can be avoided. The speech and song type representations based on phonemes and sequences of notes with pitch would be realized at the level of cochlea. The feedback from cortex to the outer hair cells is essential and explains phenomena like hearing the missing fundamental.

2. The extreme rapidity of the transfer of the postulated unidentified nerve transmitter from the hair cells to the nerve axons is a mystery. The transmitter is not needed at all if microtubuli mediate the information about evoked potentials at hair cell membrane to brain as microtubular conformal patterns and/or acoustic/electric waves. Acoustic and electric waves would be both present since microtubuli are electrets.

   The transfer of auditory information from hair cells to postsynaptic neuron could occur via acoustic transmission meaning that the time lag spent in this step would be of order $\sim .1$ ns only. The reported extreme sensitivity of of the axonal signal to the evoked potential (the resolution is about $\Delta V \sim .1$ mV) [22] conforms with the view that evoked potential provides a representation of the sensory input.

   The representation and communication of acoustic signals at microtubular level could induce the coding of frequencies sufficiently below 1 kHz to spike interval distributions [28]. The obvious critical question is how badly nerve pulse disturbs microtubular communications. One might argue that these perturbations do not affect conformational waves. As proposed earlier, the microtubular conformational wave patterns could be responsible for long term memories for instance. Acoustic waves could fulfill the same function.

3. The chronic leakage of Ca^{++} believed to relate to the transfer of the postulated fast transmitter. The TGD inspired interpretation would be that Ca^{++} wave is induced by the temporal plasma wave pattern and represents auditory percept cognitively/emotionally. The presynaptic dense body would be involved with the transformation of the temporal pattern represented by the time pattern of Ca^{2+} leakage to a signal propagating along the microtubule. Coupling to the microtubular conformational waves/acoustic signals could be also mechanical and the dense body could generate acoustic oscillations representing the temporal pattern of Ca^{2+} waves.

4. Mammals have two kinds of hair cells [23, 22]: inner hair cells are possessed also by lower life forms and outer hair cells only by mammals. Outer hair

cells are thought to act as pre-amplifiers but TGD suggests that the deeper function of outer hair cells is to mediate auditory feedback from cortex. There are indeed efferents from cortex to outer hair cells making possible cortical feedback which sometime can create sounds audible even from outside (otoacoustic sounds).

The feedback makes possible the realization of the experienced auditory percepts at the level of cochlea. This would explain various phenomena interpreted usually as a support for the hypothesis that sensory qualia are produced by neuronal activity. Consider only the emergence of pitch not present in the primary sensory input such as the missing fundamental when only its harmonics appear in the auditory input [28]. This feedback would of course occur also at the level of other sensory organs and rapid eye movements during REM sleep could be interpreted as being induced by the feedback from visual cortex.

The emergence of the outer hair cells increases the span of audible frequencies. For sea mammals 200 kHz which corresponds to 100 Hz for ordinary EEG. This would be just what would be needed for the representation of memetic codons or EEG patterns as amplitude modulations. This would mean emergence of a new symbolic level distinguishing mammals from lower levels in the evolutionary hierarchy. For frequencies below few kHz, say 3 kHz only pitch representation makes sense. Single formant vowels for which formant frequency is sufficiently below 1 kHz would have representation also as nerve pulse patterns.

Hair cells communicate with cortex using sequences of "phonemes" or "notes" defining amplitude modulations of frequencies above few kHz. At this limit modulation preserves the pitch so that durational and pitch representations are mutually consistent. This explains the unexpected finding that same brain regions, prevalently in right hemisphere, are responsible for the analysis of pitch and durational patterns [24]. Only frequency representation would be realized at the lower frequencies so that the presence of cognitive and emotional amplitude modulations at the level of cochlear would distinguish mammals from lower life forms.

2.2.4 Why microtubuli are needed?

The time pattern represented by Ca^{2+} leakage to the inner hair cell could be transferred to the postsynaptic axon and transformed to a signal propagating along the axonal microtubuli. An interesting hypothesis is that left brain utilizes phoneme sequences and right brain note sequences. Also the signals from auditory cortex to the outer hair cells would propagate along axonal microtubuli.

The signals would propagate with a velocity which could be faster than the conduction velocity of nerve pulse and constant to a very high degree unlike the conduction velocity of nerve pulse. The measurement of a time lag of order millisecond for signals arriving to the right and left ear using co-incidence detectors in the brain stem (medulla oblongata) allows to determine the direction of the sound source. The typical time interval between nerve pulses varies and

is somewhat more than millisecond, and is not at all clear whether nerve pulse conduction can preserve the time differences accurately enough to allow their meaningful comparison. If the signals from cochlea to brain stem propagate along microtubuli the situation could improve.

2.2.5 Memetic code, and genetic code as a representation of phonemes?

The average duration of phonemes is about 140 ms, which is by a factor $\sqrt{2}$ longer than the duration .1 seconds of the memetic codon. Durations vary in the range 60-300 ms. Note that the 250-300 Hz rhythm associated with speech organs defines the pitch of speech but phonemes can be recognized even in the absence of the fundamental. The basic pitch of about 250 Hz implies that the number of memetic codons associated single single period is at most 2.

Phonemes can be classified by the vocal tract mechanism generating them and phonemes can be also recognized by their spectral decomposition.

1. Formants [20, 21] correspond to vowels, approximants (say (r,l) and (j,w)) , and nasals (m and n). Only few resonant frequencies are needed to characterize the formant. Lowest formant is below 1 kHz but higher formants above kHz and frequencies up to 3 kHz are possible. It is easy to understsand that for vowels the frequency distribution does not depend on time for approximants and nasals it does.

2. Fricatives (hiss, buzz). Fricatives lack the formant structure. Both correspond to a repeated time amplitude peak and frequency distribution involves wide range of frequencies with same intensity.

3. Plosives (such as p,b and t,d) correspond to a single peak in the time domain and constant frequency distribution.

All sensory input might be transformed by a feedback circuit to sequences or notes/memetic codons represented as a modulation of the membrane voltage providing a universal cognitive/emotional representations. Also ordinary phonemes and notes would be represented in this manner. Sensory organs correspond naturally to $k_{em} = 3$ level of dark matter hierarchy since .1 seconds represents the basic unit of sensory time. Therefore memetic codons modulating scaled up EEG at $k_{em} = 3$ level would be a good guess for how the sensory input is represented cognitively.

Also other p-adic codes are possible. Phonemes, the number of which is 41 in American english, could correspond to a sub-code reducing to a genetic code with 64 codons. It is important to notice that the temporal distance between memetic codons does not matter. Other memetic codons could code for recognizable sound patterns not representing phonemes and could have meaning at some other levels of self hierarchy.

One can argue that the representations as "notes" and "phonemes" should carry roughly the same amount of information. For frequency representation as sequence of "notes" 10 octaves represents upper limit for the modulation

frequencies. For high modulating frequencies the representation tends however to fail since slow modulation is not anymore in question. This would mean that the number of distinguishable "notes" is below $10 \times N$, where N is the maximum number of distinguishable frequencies inside octave. $N = 12$, the number of half notes in octave, would give 120 different "notes", which is not far from 127 and corresponds to M_7 allowing $2^7 - 1$ different codons making almost 7 bits with bit duration of 67 ms. Since the first codon in pulse-no pulse representation must be always pulse to tell that the codeword starts, this leaves 6 bits and genetic code. Codons can have varying but long enough pauses between them and the average duration .14 s of phonemes allows this. The association of genetic or memetic codons to characteristic spectrograms of phonemes as a function of time and frequency would result by cortical feedback.

3 Dark neutrino super conductivity

The new view about dark neutrino super conductivity differs completely in details from the earlier one. The reason is the new interpretation for classical long ranged weak gauge fields as space-time correlates for a hierarchy of exotic weak bosons with scaled down mass scale. The model of dark neutrino superconductivity will be constructed using various empirical guidelines about neutrinos to set quantitative constraints. The model itself is a direct generalization of the model for quantum critical electronic super conductor based on wormholy Cooper pairs generalized to the case of ORMEs so that electrons have large $\hbar$ and nuclei are doubly dark.

Also non-superconducting neutrinos might be important. The negativity of the neutrino energy in the Z^0 Coulombic fields created by nuclei possessing anomalous weak charge makes possible creation of neutrino-antineutrino pairs from vacuum by the splitting of $\nu\overline{\nu}$ type wormhole contacts with neutrino and antineutrino at causal horizons. Hence the $\nu\overline{\nu}$ wormhole contacts, in particular those of $k = 151$ neutrinos assignable to cell membranes, could be important. Cognitive neutrino pairs indeed play a key role in TGD based model for cognition. The decay of cognitive neutrino pairs to ordinary neutrino-antineutrino pairs followed by a possible transition to dark neutrino phase provides a possible mode of quantum control by creating and controlling the density of superconducting dark neutrino Bose-Einstein condensates.

The special feature of the cognitive neutrino pairs is that they have nearly vanishing total energy and other quantum numbers. This makes them ideal candidates for realizing Boolean thoughts as sequences of cognitive neutrino pairs with the spin of cognitive antineutrino coding for the two values of the Boolean statement. Quantum model hearing relies on cognitive neutrino pairs and has been one of the quantitative victories of TGD inspired theory of consciousness and it is interesting to see whether it survives in the new vision.

3.1 The analogy between superconductors of type I and quantum critical superconductors

The original proposal was that bio-systems correspond to superconductors of type I near criticality. What makes super conductors of type I so interesting is that they allow the penetration of metastable magnetic field configurations destroying super-conductivity. Field configurations are cylindrically symmetric in the length scale λ and their cross section has very complicated topology consisting of locally stripe like regions of width of order $\lambda << \xi$ [18]. In general, the cross section consists of several disjoint regions and each region is characterized by two integers in TGD(see the appendix of this book). The magnetic flux obeys a generalized quantization condition of form $\oint(p - 2eA)dl = n2\pi$, where v denotes the velocity field of Cooper pairs and magnetic flux can be smaller than its quantized value.

For superconductors of type I metastability makes the magnetic field structure near critical value of the magnetic field an ideal control tool since the topology of the cross section can be varied easily. This means that both memory dating and simple arithmetic operations are possible since the fusion of two disjoint regions corresponds to the addition of the integers n_1. This suggests that both the topology of the magnetized region and integers n_1 and/or n_2 code the content of the observation at various p-adic levels. In the absence of sensory input the magnetic field reduces to ground state configuration (no super-conducting regions) with related integers perhaps coding long term memories.

Quantum critical superconductors are naturally superconductors of type II but in this case the supra current carrying regions are associated with the boundaries of dynamical stripe like structures so that the situation remains more or less unchanged. The super-conducting regions are associated with the boundaries between regions possessing different value of $\hbar$ and stripes correspond to a larger value of $\hbar$. Wormholy Cooper pairs are at the boundary region of two phases.

The lipid layers of the cell membrane ($k = 149$) and the entire cell membrane itself ($k = 151$) as well as the endoplasma membranes filling the cell interior indeed resemble locally super-conducting regions of quantum critical super conductor since the thickness of the membrane is very small as compared to its typical radius of curvature. The join along boundaries bonds between cells (identified as the so called gap junctions [29]) could give rise to macroscopic super conductor. In nerve cells axons are long cylindrically symmetric configurations of this type.

In accordance with the magnetic metastability, the endoplasma membranes of the cell are known to be dynamical structures, which change their size and connectedness continually. An additional support for the role of the superconductivity in the cellular information processing comes from the empirical observation that strong magnetic fields have harmful consequences for the information processing of the cell. Above critical magnetic field vortices of radius ξ inside which large $\hbar$ phase is transformed to ordinary one would be formed.

Cell size gives a good estimate for the value of the coherence length ξ of dark neutrino super-conductor identified as weak length scale.

3.2 Empirical guidelines

The empirical guidelines are following.

1. p-Adic mass calculations utilizing the information about neutrino mass squared differences support the view that neutrino Compton length scale is about $L(169)$ and neutrinos have mass of $\sim .2$ eV [F3]. There is evidence for other mass scales too, in particular $L(173)$. p-Adic mass calculations [F4] led to the conclusion that also hadronic quarks can correspond to several p-adic primes, even in the case of low mass hadrons. The TGD based model for nuclear physics assumes that color bonds having $k = 127$ quarks at their ends with MeV mass scale connect nucleons to nuclear strings. These findings encourage to ask whether also Gaussian Mersennes $k = 151, 157, 163, 167$ would define mass scales of neutrinos. The corresponding dark mass scales for $\hbar \to \hbar/v_0 \simeq 2^{11}\hbar$ correspond to $k_{eff} = 173, 179, 185, 189$ and span the length scale range 20 μm-.5 cm.

   The earlier model of neutrino superconductivity and cognitive neutrino pairs was based on $k = 151$ ordinary neutrinos having long ranged weak interactions. The new view about long range weak interaction requires much more massive neutrinos having dark Compton length around $L(151)$. Since both electron and nuclear exotic quarks [F8] correspond to Mersenne prime M_{127}, the natural guess is that also neutrinos can exist in $k = 127$ state with electron neutrinos having scaled up .55 MeV rather near to electron mass. A possible explanation for the special role of M_{127} that it is largest Mersenne prime corresponding to a non-super-astrophysical length scale. One can also consider interpretation in terms of almost unbroken electro-weak symmetry for fermions. The corresponding dark length scale would be $L(k_{eff} = 149)$ and would correspond to the thickness of the lipid layer of cell membrane.

2. The model for the anomalies of water [F9] led to the conclusion that one fourth of hydrogen atoms of water are in dark matter phase with large value of $\hbar$ and that hydrogen atoms form linear super nuclei. This hypothesis allows to estimate the Coulombic Z^0 interaction energy of dark neutrinos with water molecules. The large density of anomalous Z^0 charge for doubly dark matter with $L_w \simeq n^3 \times .2$ μm does not however require neutrino screening since color force can compensate the weak force as discussed in [F9]. The argument below shows that even in $k = 127$ neutrinos effective screening would require relativistic dark neutrinos since the density of dark neutrinos should be roughly one half of the density of water molecules for complete screening and too large by about three orders of magnitude.

3. The model for tritium beta decay anomaly gives the estimate $1/\mu m^3$ for the density of dark neutrinos in condensed matter. The density could of course be also higher in living matter. The requirement that dark neutrinos are non-relativistic implies strong bound on their density via Fermi momentum. One obtains

$$E_F \ll m_\nu \ , \tag{1}$$

which by using the expression for E_F gives for effective dimensions $D = 1, 2, 3$ the bounds for $n_{\nu,D}$

$$\begin{aligned} n_{\nu,1} &\ll \frac{1}{\sqrt{2}\pi}\frac{m_\nu}{\hbar} \ , \\ n_{\nu,2} &\ll \frac{1}{2\pi}\frac{m_\nu^2}{\hbar^2} \ , \\ n_{\nu,3} &\ll \frac{1}{6\pi^2}\frac{m_\nu^3}{\hbar^3} \ . \end{aligned} \tag{2}$$

In large $\hbar$ phase the dark neutrino density is scaled down by a large factor. In 1-D case the 3-D density is obtained by dividing by the transversal area S of the linear structure involved. The transversal size scale must at least be of the order of dark neutrino Compton lengths so that only numerical constants distinguish between the 3-D density in various effective dimensions.

Even for $k = 127$ the conditions guaranteing non-relativistic Fermi energy are non-trivial and read as

$$\begin{aligned} n_{\nu,1} &\ll \sqrt{2}x\frac{1}{L(151)} \ , \\ n_{\nu,2} &\ll 2\pi x^2\frac{1}{L^2(151)} \ , \\ n_{\nu,3} &\ll \frac{8\pi}{6}x^3\frac{1}{L^3(151)} \ , \\ x &\simeq 11.3 \ . \end{aligned} \tag{3}$$

The order of magnitude is few neutrinos per nm length scale which means that dark neutrino Cooper pairs with minimum size $L(151)$ have overlap which makes Bose-Einstein condensation possible. The upper bound for the density of Cooper pairs is considerably lower than the density of dark hydrogen nuclei if 1/4:th of hydrogen nuclei are in doubly dark phase: the ratio of 3-D densities is smaller than $(5.7, 8, 60) \times 10^{-4}$ for $D = 1, 2, 3$

if 1/4:th of hydrogen atoms are in dark phase and if all dark hydrogen atoms make a phase transition into a doubly dark phase in a given region. Therefore dark neutrinos cannot screen anomalous weak charge. Neutrino screening is not needed since long range color forces can compensate the repulsive weak force.

For $k \geq 151$ situation the conditions guaranteing non-relativistic Fermi momentum cannot be satisfied for dark neutrino density $\sim 1/\mu m^3$. Hence the conclusion seems to be that $k \geq 151$ dark neutrinos are most naturally relativistic.

4. Z^0 force is automatically vacuum screened above length scale L_w, which is about $3-6$ Angstroms for dark nuclear matter with $n = 3$ and $1.8-3.6$ μm for doubly dark case. In the latter case the screening condition does not pose condition on neutrino density. For $k \geq 151$ the condition implies that dark neutrinos are relativistic.

   Z^0 magnetic penetration length λ_Z is obviously not longer than L_w. If there is active screening by supra currents one has $\lambda_Z < L_w$. This gives using $\lambda^2 = m_\nu/4\pi g_Z^2 n_c$

$$\begin{aligned} n_{\nu,1} &> m_\nu L_w \times \frac{S}{4\pi g_Z^2 L_w^2}\frac{1}{L_w} \quad , \\ n_{\nu,2} &> m_\nu L_w \times \frac{d}{4\pi g_Z^2 L_w}\frac{1}{L_w^2} \quad , \\ n_{\nu,3} &> m_\nu L_w \times \frac{1}{4\pi g_Z^2 L_w^3} \end{aligned} \tag{4}$$

   Here S resp. d is the transversal area resp. thickness of effectively 1-D resp. 2-D super conductor. Notice that this conditions does not involve $\hbar$ at all and it seems that the large value of $\hbar$ automatically implies that L_w gives the magnetic penetration length. For $k = 151$ the 3-dimensional densities are in all cases of order few neutrinos per $L^3(151)$ so that the together with the conditions guaranteing non-relativistic Fermi energy these conditions force dark neutrino density to a rather narrow range. For $d = L(151)$ and $S = L(151)^2$ the lower bound for 3-D density is same in all cases and given by $n_{\nu,3} > .3/L(151)^3$ for $m(\nu_e) = .55$ MeV. The lower bound is by three orders of magnitude below the upper bound from the requirement that situation is non-relativistic. The upper bound for the 3-D density give the rough lower bound $\lambda > 10^{-3/2} L_w \simeq 6L(151) > \xi_T \simeq L(151)$, where ξ_T is estimate for the transversal coherence length so that in the transversal direction type II superconductor would be in question. In longitudinal direction the coherence length $\xi_L = L_w > \lambda$ identified as a length of Cooper pair flux tube structure would mean type I super conductivity. The interpretation could be as follows. If axonal membrane is this kind of mixed superconductor, overcritical Z^0 magnetic field parallel to axon, would penetrate in flux quanta parallel to axon. For type

I case transversal Z^0 magnetic field near criticality would penetrate into the axonal membrane as stripe like patterns with stripes of width λ.

The Compton length of neutrino gives lower bound for the thickness of the magnetic flux tube of the dark neutrino Cooper pairs.

1. $L(149)$ and $L(151)$ would correspond to lower bounds for thickness and length of the flux tubes for dark $k = 127$ neutrinos.In effectively 1-D case $k = 127$ with $S = L^2(149)$ neutrinos give for the neutrino density a lower bound which is of order one neutrino per $1/\mu m$. This would suggest that the lipid layers of cell membrane correspond to the pair of magnetic flux tubes defining the wormholy neutrino Cooper pairs.

2. One can also consider the possibility that the height of Cooper pairs is scaled up to $L(k_{eff} = 151{+}22) = L(173) = 20$ μm would give the length of the flux tube and axons between cell membranes are good candidates here. The vacuum screening of weak interaction above L_w however strongly suggests $\xi < L_w$.

3.3 Dark neutrino superconductor as a quantum critical superconductor

The scarcity of the empirical guide lines forces the use of the model of quantum critical electronic superconductivity as the basic format. For $k = 127$ neutrinos the generalization of the wormholy model for electron Cooper pairs is not completely straightforward task since the finite range $L_w \simeq n^3 \times .2$ μm of exotic weak interactions causes delicacies.

3.3.1 The case of $k = 127$ neutrinos

The following arguments fix the generalization of the model for dark neutrino Cooper pairs in the case of $k = 127$ neutrinos.

1. Since the relevant length and mass scales of neutrinos and electrons are essentially identical, the dark neutrino Cooper pairs are expected to have similar sizes and are both associated with the boundaries between doubly dark and ordinary nuclear matter. In the case of cell cell interior and exterior would naturally correspond to these phases of matter. Of course, only partial darkness is possible: the model explaining the anomalies of water [F9] suggests that 1/4:th of hydrogen ions is in doubly dark phase in the cell interior and in dark phase in cell exterior.

2. The model of ORMEs as superconductors assumes that dark electrons have large $\hbar$ with $k_{eff} = 149$ and nuclei are in doubly dark phase with $k = 127$ dark quarks coupling to doubly dark $k = 113$ weak bosons possessing range of order $L_w \simeq n^3 \times .2$ μm. The wormholy Cooper pairs of dark electrons and neutrinos can be assumed to have same transversal size $L(149)$ as ordinary Cooper pairs.

3. The expression for the energy of Cooper pair has the general form $E = a/L^2 - b/L$ corresponding to kinetic energy and Coulombic interaction energy. The scaling up of $\hbar$ in the stability condition of for Cooper pairs discussed in [J1] amplifies the contribution of the kinetic energy by a factor 2^{22}. This means that this factor also scales up the length of the Cooper pair to about 4 cm.

The situation is not quite this simple however. The most obvious implications of the finite range of the exotic weak force are $\lambda \simeq L_w$ and $\xi \leq L_w$, which is rather near to $L(167) = 2.5$ μm for $n = 3$. It simply does not make sense to talk about coherence and correlations above the weak length scale L_w. Therefore the energy of the Cooper pair is minimized subject to the constraint $L \leq L_w$ for the length of the Cooper pair which gives $L = L_w$. Situation remains the same even in the case of triply dark nuclear matter giving $L_w = n^3 \times .4$ mm.

Cell membranes and the dynamical endoplasma membranes within cell have interpretation as stripe like regions to which super-conducting dark electrons and neutrinos can be associated naturally. Macroscopic quantum coherence is often assigned to the ordered water in cell interior and the question is whether ordered water could correspond to doubly dark phase. One can also wonder whether the phase transitions between sol and gel phases associated with nerve pulse activity could correspond to transitions between dark and doubly dark phases. Since the transversal length scale of chromosomes and micro-tubules is also characterized by $L(151)$, it is natural to expect that dark electrons and neutrinos play key role in the dynamics of these structures.

3.3.2 Is neutrino superconductivity possible for $k \geq 151$?

For $k \geq 151$ the doubly dark coherence lengths are much longer than L_w for doubly dark matter. One would however expect that the coherence length for Cooper pairs should be longer than the Compton length. Situation changes if dark nuclei correspond to triply dark nuclei with $L_w \simeq 3.6$ mm for $n = 3$ triply dark nuclei. The requirement that coherence length is longer than Compton length is satisfied up to $k = 157$ and for $k = 163, 167$ L_w defines naturally the height of Cooper pair space-time sheet.

By the naive scaling the radius of the flux tube associated with neutrino Cooper pair would be $L(k + 22)$, $k = 151, 157, 163, 167$. The naive scaling of $L(151)$ giving the height of the flux tube would give for the height of neutrino Cooper pair $L(k + 44)$ which is longer than L_w for triply dark matter. As in the previous case L_w would be the upper bound for the height and would correspond to a maximal binding energy. These length scales would determine the transversal and longitudinal coherence lengths ξ_T and ξ_L of neutrino superconductor.

As already found, it is not possible to have non-relativistic Cooper pairs for reasonable values of dark neutrino density. Also stability condition assuming non-relativistic dark neutrinos leads to contradiction. Hence the energy of neutrino is difference of relativistic energy $E = 2\pi/L$ and Z^0 Coulombic interaction

energy behaving in the same manner with respect to scalings. This implies that minimum energy is achieved for $L = L_w$. The scale of zero point kinetic energy would be $E = 2\pi/L_w \simeq E = 3.4$ K.

Unless ordinary and dark space-time sheets are thermally isolated, the BE condensate is thermally unstable for $k > 151$. For $k = 151$ dark neutrinos the critical temperature determined by $E_0 \sim 2\pi/L(151) \simeq 800$ K and gives critical temperature of order room temperature. Thermal isolation in reasonable time scales might be however possible since only de-coherence phase transition mediates interactions between ordinary matter and dark neutrinos.

The large values of these scales would mean that dark neutrino superconductivity would relate to the control of smaller structures of size of order neutrino Compton length $\sim L(k)$ by structures of size $L(k + 22)$. The decoherence transition in which dark neutrino Cooper pairs decay to ordinary neutrinos would certainly be an essential aspect of this transition. The creation of ordinary neutrinos by the splitting of $\nu\overline{\nu}$ wormhole contacts (cognitive neutrino pairs) would be another facet of the quantum control.

3.4 Structure of brain and neutrino super conductivity

The structure of the brain affords evidence for the p-adic hierarchy of superconductor structures associated with coherence lengths ξ and suggests that sensory stimulus represents itself regions of larger $\hbar$ at various levels of the condensate containing cells activated by the sensory stimulus. Regions carrying magnetic fields could correspond to both the weak magnetic fields guaranteing effective one-dimensionality of the super conductor or magnetic fields associated with the defects of the super conductor.

Perhaps the entire organism could be regarded as a hierarchy of quantum critical super-conductors with super-conducting regions identifiable as boundaries between regions having different values of $\hbar$: the large the structure the larger the value of $\hbar$. The radius of curvature of cell membrane is so large that locally the magnetic field has constant direction.

In the absence of sensory input the condensate levels carry some preferred magnetic field configuration. The simplest possibility is the presence of constant magnetic or Z^0 magnetic field. The magnetic field of the flux tube containing the Bose-Einstein condensate of wormholy Cooper pairs does not destroy the superconductivity based on spin 1 Cooper pairs. Topological field quanta are quite generally characterized by frequency type parameters ω_1, ω_2 and integers n_1, n_2 assignable to the increments of phases of CP_2 complex CP_2 coordinates around homologically nontrivial loops and analogous to angular momentum values [D7]. In particular, the integers n_1 could be carrier of biologically relevant information.

A fascinating possibility is that the Gaussian and ordinary Mersennes associated with $k = 113, 127, 151, 163, 167$ define the fundamental p-adic length scales and the large $\hbar$ satellites of these length scales could give rise fractal copies of the structures in these length scales scaled up by powers of $n/v_0 \simeq n \times 2^{11}$. In particular, the Mersennes $k = 127, 151, 157, 163, 167$ span 40 half octaves whereas the Mersennes $89, 107, 113, 127$ span 39 half octaves. Therefore one can

wonder whether the biologically most relevant length scale range could contain a scaled down copy of elementary particle physics such that $k = 167, 163, 157$ correspond to three charged lepton generations.

Be as it may, the two lowest levels in the dark hierarchy cover the length scales associated with living organisms. Second fascinating possibility is that the twin primes $k, k+2$ might be of special biological relevance as the appearance of various twin structures in bio-matter would suggest. In the following the empirical evidence supporting these hypothesis is discussed.

3.4.1 Structures in the cell length scale, miracle length scales, and twin primes

The miracle length scales defined by Gaussian Mersennes should make themselves manifest in cell length scales.

1. The two-layered structure of the cell membrane and of endoplasma membranes would naturally correspond to $k = 149$ and $k = 151$ p-adic levels. Membranes could be identified as regions between large $\hbar$ phase in the interior of cell and ordinary phase in the exterior of cell carrying wormholy Cooper pairs of electronic and neutrino type quantum critical superconductors and containing also cognitive neutrino pairs.

2. The interior of the cell contains structures, which might be identified with condensate levels $k = 163$ and $k = 167$, and might correspond to some higher levels in the information processing hierarchy of the cell. Cell nucleus with size in the range $5 - 10$ μm can accommodate all the miracle length scales. Biophotons [31] have energies in visible range and ultraviolet and visible wavelengths thus almost cover miracle length scales. For large $\hbar$ variants the wavelengths would be scaled up by powers of n/v_0 and these photons might be involved with quantum control of short length scales by longer length scales. The formation of Bose-Einstein type condensate of bio-photons could relate to the formation of gap junctions between cells.

3. The next level corresponds to a pair of length scales $L(167) = 2.5$ μm (lower bound for the cell size) and $L(169 = 13^2) = 5$ μm allowed if one generalizes length scale hypothesis so that it allows k to be power of prime. The size of cell nucleus varies in the range 5-10 μ and one can wonder whether this length scale pair and corresponding Cooper pairs could relate to the twin structures formed by chromosomes and to the doubling of DNA during cell division.

4. Epithelial sheets consist of double cell layers and appear very frequently in multicellular bio-systems (skin, glands, sensory organs, etc.). It would be natural to interpret them as region in large $\hbar$ phases can be present. Eye provides an example of this kind of structure [29]: eye can be regarded as a composite structure consisting of single cell layer (rods and cones) and two-layered structure consisting of layers of bipolar cells and ganglion

cells Great variety of super-conductors are possible at this length scale. These structures might involve doubly dark neutrino and electron super conductivity with transversal length scales $L(149+22) = L(171) = 10$ μm and $L(151 + 22) = L(173) = 20$ μm.

3.4.2 Scaled up variants of cell membrane?

The information processing of the brain could involve dynamical membrane like structures inside the brain as dynamical units with electron and neutrino superconductivity playing key role in the functioning of the structure. This would mean that the couplings between cells of the brain understood as neural net should have tendency to form dynamical two-dimensional surface like structures.

These higher level membranes could have functions analogous to those of ordinary cell membranes. Action potential between the cell layers and nerve pulse might be well defined concepts. These membranes could form cell like structures filled with dynamic "endoplasma" membranes. For instance, the twin primes $k = 179, 181$ could define generalized cell membrane like structure of thickness $L(181) \simeq 320$ μm.

Generalizing the ideas of TGD one might speculate that these membranes could act as Josephson junctions and communication between the structures should take place via counterparts of ordinary nerve pulses: also the existence of the counterpart of EEG is suggestive. Various parameters characterizing exotic nerve pulse and EEG should be related by simple scaling to those characterizing ordinary nerve pulse and EEG.

3.4.3 Cortical structures and first level satellites of miracle length scales

The obvious place for the identification of large scale super conducting structures of is cortex. The relatively small thickness of the cortex (about 1 mm) implies that curvature effects do not mask the local cylindrical symmetry. Cortex is indeed known to possess columnar organization. For instance, in visual cortex there are two columnar structures with very complicated cross section perhaps identifiable as stipe like structures associated with quantum critical super-conductivity at higher level of dark matter hierarchy. These structures have also binary structure characteristic for the wormholy Cooper pairs.

1. Field axis orientation columns

The first columnar structure [29] in the visual cortex corresponds to the so called field axis orientation columns consisting of locally stripe like regions of cells (see Fig. 3.4.4), which preferentially react to the orientation of a bar of light in the visual field. The width of the stripes with fixed orientation is about $20 - 50$ μm [29].

The first large $\hbar$ satellite of $L(151)$ is indeed $L(173) = 20$ μm. A possible interpretation is that continued stimulus with fixed orientation creates at $k = 173$ level a cylindrical magnetic field configuration, which leaves only the

regions reacting to this particular orientation in super conducting state. Doubly dark electronic and neutrino super conductors for which the length scales corresponding to $k = 171$ and 173 would appear naturally in the large $\hbar$ scaling of the cell membrane. It should be noticed that $k = 171$ corresponds to the upper bound 10 μm for the size of nucleus varying in the range 5-10 μm.

Ocular dominance columns

Ocular dominance regions consist of cells reacting appreciably to the stimulus from the second eye only, and form columnar structures [29] with complicated cross section and become visible via a continued stimulation of one eye only (see Fig. 3.4.4). The typical width of the stripe in the region is about $200 - 500$ μm.

The weak length scale of triply dark nuclear matter corresponds to $k_{eff} = n^3 \times 400$ μm so that $n = 1$ would make sense. The large $\hbar$ satellite of $L(157)$ is 160 μm.

The levels $k = 179$ and $k = 181$ forming a pair with $L(179) \simeq 160$ μm might be the relevant p-adic levels now. The ocular dominance columns associated with right and left eye alternate and the regions formed by right-left pairs of ocular dominance columns is a natural candidate for the double layered structure at level 179 involving Bose-Einstein condensate of wormholy Cooper pairs.

3. Hyper columns

The visual cortex contains also larger structures, "hyper columns" [29], which form basic units for the processing of visual information (and sensory information in general). These structures have roughly the size of order 1 mm, the thickness of the cortex. The large $\hbar$ satellite of $L(163)$ is 1.28 mm. $L(167)$ would give to large $\hbar$ satellite $L(167 + 22) = L(189) = .5$ cm. Also structures with this size scale could also appear in brain.

3.4.4 Structures in the length scale of body and second level satellites of miracle length scales

In contrast to the prevailing view in neuroscience, in TGD framework entire body is seat of consciousness and brain only builds symbolic representations about sensory data. Also the idea about body as a passive receiver of commands from brain is given up and brain and body can be said to react to the desires of the magnetic body serving as a space-time correlate for the intentional me. Hence it makes sense to consider the possibility that also structures with scales larger than typical brain structures could be of importance for understanding conscious experience and functioning of living system.

The higher large $\hbar$ satellites of $k = 151, 157, 163, 167$ are $k = 195, 201, 207, 211$ and correspond to length scales 4 cm, 32 cm, 2.5 m, 10 m. k=163 and 167 could correspond to quantum critical super-conductivity in large sized organisms. These length scales could be also important for the structural organization of bio-systems. The fourth level in the hierarchy of dark nuclear matters would correspond to $L_w = n^4 \times .8$ m and might have relevance for information processing in the length scale of human body.

Double layered structures (both k and $k+2$ primes) might appear in these length length scales.

1. For $k = 191, 193$ one has $L(191) \simeq 1$ cm.

2. $k = 197, 199$ is the largest doublet, which might be realized in bio-systems one has $L(197) \simeq 8$ cm. One cannot exclude the possibility that right and left brain hemispheres correspond to the condensation level $k = 197$ and whole brain to the condensation level $k = 199$.

3. For the next pair ($k = 227, 229$) (note the large gap in development) one has $L(227) \simeq 2500$ m, which is probably not realized in bio-systems at the level of organisms. One can of course ask whether biological organisms could form super organisms involving these higher levels.

4 Dark neutrinos and quantum model for hearing and cognition

The quantum model for hearing and cognition (for the original version see [16]) has been one of the trouble maker ideas from the very beginning. The original idea was based on wrong interpretation of the long range electro-weak gauge fields predicted by TGD as being associated with ordinary atomic nuclei.

The realization that long ranged electro-weak could be assigned to the particles of dark matter hierarchy in length scales below the scaled up Compton length of charged ew bosons, resolved the interpretational problem and predicted entire dark hierarchy of electro-weak physics with same mass spectrum. Of course, also electro-weak bosons with masses characterized by some other p-adic primes than M_{89} can be considered.

The intriguing and encouraging outcome of the original model of memetic code [16] was that the $\Delta n = 1$ spin flip transitions for which frequency is vanishing at the limit of vanishing Z^0 magnetic moment of neutrino corresponds to frequency in audible range if Z^0 magnetic field is of same order of magnitude as Earth's magnetic field. The problem is that thermal stability condition is not satisfied for ordinary value of Planck constant and since the frequency of $\Delta n = 1$ spin flip transition is proportional to Δg_Z and thus to α_Z thermal stability condition fails even when one allows large vales of Planck constant. The reason is that the frequency of $\Delta n = 1$ spin flip transition is proportional to α_Z and therefore reduced in the scaling of $\hbar$ by a factor n_a/n_b meaning that the energy of transition is invariant in the scaling of $\hbar$. To obtain a correct scaling one should assume that Z^0 magnetic field is scaled up by a factor n_a/n_b and this would require a gigantic value of Z^0 magnetic field.

In this kind of situation it is difficult to make the decision whether to throw all of it to the dust bin or to just continue to play with all imaginable alternatives. The question is whether dark neutrinos could still play the proposed role in cognition and hearing.

I decided to continue without giving up $\Delta n = 1$ spin-flip and made a desperate attempt to save the model by replacing neutrinos with mass $\sim .1$ eV with exotic neutrinos having mass of order electron mass and with some hand-waving managed to save the quantitative arguments [16]. It cannot exclude dark exotic neutrinos with electron mass since M_{127} is completely exceptional as the largest Mersenne prime not giving rise to super-astronomical length scale and there is evidence for dark exotic quarks with mass of order electron mass and they play key role in TGD based model of atomic nucleus providing also explanation for tetra-neutron [F8]. The model does not however satisfy the thermal stability criterion since the value of Planck constant is $\hbar_{eff} = 2^{11}\hbar_0$.

As far as hearing is considered, the most obvious option is that cyclotron transitions of Cooper pairs of neutrinos or of spin one wormhole contacts carrying quantum numbers of left handed neutrino and antineutrino at the light-like throats of the contact are responsible for the emotional and cognitive aspects of hearing identified as qualia of Z^0 magnetic body. This assumption fixes the

magnitude of Z^0 magnetic field once neutrino mass is known and it is possible assume mass of order .1 eV and thus minimize the number of ad hoc assumptions. The coding could based on varying value of Z^0 magnetic field strength or coding by harmonics of the cyclotron frequency. The wormhole contact option is especially interesting because it could be interpreted in terms of information transfer between two space-time sheets or even between different levels of dark matter hierarchy.

4.1 General Ideas

4.1.1 Some whys and hows related to cognitive codes

Consider first the basic questions and ideas behind the model of the memetic/genetic code and cognitive codes in general.

1. It is perhaps a good idea to ask what the purpose of the memetic/genetic code could be. A transmission of information which becomes conscious at the receiving end suggests itself. Higher levels of dark matter hierarchy are the most natural receivers of this information. So perhaps an information transmission from lower to higher levels in dark matter hierarchy is in question so that two different branches of imbedding space rather than only 2 different space-time sheets would be involved. The information would be most naturally about space-time behavior of magnetic or Z^0 magnetic field in the case that bits are represented by spins.

2. At more mundane level, memetic/genetic code would correspond to the cognitive aspect of hearing and language. The coding of sounds by temporally ordered bit sequences would be in question and give them meaning. It must be admitted that the original idea about 126-bit memetic code could quite well be un-realistic as far as understanding of language is considered. There are good reasons to believe that 6-bit genetic code might be enough to understand phoneme structure of language.

3. Fermion number (1/0) or spin direction could represent bit. Spin seems the more natural option. Spin one Cooper pairs of neutrinos, if possible, could code for the direction bit. Cognitive neutrino pairs represented as spin one wormhole contacts, define an attractive option since in this case there would be a double representation of code words having interpretation in terms of a binary communication between two space-time sheets. The bit sequence would transmit information about the external Z^0 magnetic field determining the sequence of bits by spontaneous magnetization mechanism. Single bit could correspond to large number of cognitive neutrino pairs. Spontaneous magnetization is achieved for large values of Planck constant since energy minimization fixes the direction of spin to be parallel to Z^0 magnetic field.

4. Both options seem to require some kind of temporally ordered lattice which contains the cognitive neutrino pairs. The problem is how to realize this

temporal lattice. The original model of memetic code was based on linear temporal sequence with each bit represented by a time interval of equal length. The basic law of sensory physiology however says that sensation depends logarithmically on the physiological intensity of stimulus. This would suggest that the linearity is achieved for the logarithm of the Minkowski time coordinate. The logarithmic realization memetic code with 127 bits requires a range of time scales varying with a scale factor 2^{127} whereas genetic code with 6 bits is quite a realistic looking option.

4.1.2 Fermions, bosons, cognition and intention

Before saying anything about cognitive neutrino pairs, the more recent ideas about role of fermions in cognition must be discussed. Fermionic Fock state basis defines in a natural manner a quantum version of Boolean algebra and thus fermions could relate to Boolean cognition. This quantal Boolean algebra should have space-time time correlate by quantum-classical correspondence and p-adic space-time sheets should somehow enter into the game.

The general model for cognition suggests strongly that real fermionic parton and its p-adic counterpart correspond to a pair of space-time sheets obeying same algebraic equations and define particle and its cognitive representation. This picture follows naturally from the identification of space-time correlates of infinite primes and integers in terms of many-parton stats and in this picture the pair is completely analogous to a hole particle pair resulting when negative energy fermion is kicked from Dirac sea. Real and p-adic bosonic partons would in turn correspond to actions and intentions so that boson-fermion dichotomy would have profound role in the theory of consciousness.

One could define the classical conserved charges of p-adic parton to be same as those for the real parton in the case that they are algebraic numbers belonging to the algebraic extension of p-adics considered. It is not clear whether one can talk about sums of real and p-adic energies classical conserved quantities in this case. Even if this is the case, it seems that real fermion and its p-adic counterpart cannot form zero energy states so that energy conservation would hold true for then separately and real stats would have vanishing net quantum numbers. In p-adic sector the conservation laws are not absolute for field equations and p-adic states might have vanishing net quantum numbers.

4.1.3 Zero energy ontology as a further guideline

The quantum model for the cognitive aspects of hearing was based on the coding of information to bit sequences formed by cognitive neutrino pairs whose proper identification is a story in itself. An essential element was quantum non-determinism represented at space-time level as a failure of complete determinism of Kähler action. Cognitive neutrino pairs would have nearly zero energy which would allow them to pop up from vacuum spontaneously, exist for some time, and disappear. These temporal sequences could be regarded as bit sequences with spin or mere existence of non-existence of neutrino coding for bit. The

proposed mechanism was based on the negative Coulombic interaction energy with condensed matter cancelling the rest mass of neutrino.

Zero energy ontology, which forms the basis of quantum TGD its recent form, allows to interpret the vanishing of energy much more generally. In zero energy ontology physical states have vanishing net quantum numbers and positive *resp.* negative energy components of the states reside at the boundaries of lightcones M^4_+ *resp.* M^4_- such that various cones M^4_+ (M^4_-) are nested past within each other. At the level of quantum TGD the tips of these lightcones correspond to arguments of n-point functions. Also more than one past directed light cones are possible. In the case of cognitive representations there is temptation to interpret positive and negative many neutrino states as Boolean statements. By allowing these states to entangle one would obtain quantal representation of Boolean function. If this picture is correct then the time interval between positive and negative energy components of the zero energy states should correspond to the time scale of human thought so that zero energy ontology would be experienced directly.

4.1.4 Why neutrinos are so special?

If fermions quite generally are responsible for cognition as it seems to be the case, one must ask, why neutrinos are so special. An essential element in the model of cognitive neutrino pair was the small mass of neutrino so that these pairs have very small or even vanishing or negative energy. The negative energy could be due to the Z^0 Coulombic field created by condensed matter. This allows to play with the idea that cognitive representations emerge spontaneously. This assumption could still be kept although the notion of zero energy ontology implies that at fundamental level all physical states have vanishing total quantum numbers.

4.1.5 Thermal stability as a new constraint and fractal hierarchies of dark matter

The work with dark matter related ideas inspires the conservative condition that the energies associated with the cyclotron frequencies of biologically important ions (neutrinos) are above thermal energy in magnetic (Z^0 magnetic) fields considered. If one takes seriously the argument suggesting that favored values of n_a and n_b correspond to n-polygons constructible using only compass and ruler, powers of two can define fractal hierarchies for Planck constants defined as $n_a/n_b = 2^{mk}$, $k = 0, 1, 2, ...$

For the hierarchy of EEGs the Planck constant hierarchy $n_a/n_b = 2^{11k}$ ($m = 11$) seems to be preferred. For cyclotron frequencies in dark magnetic field of $B_d = .2$ Gauss cyclotron energy is above thermal threshold for $k \geq 4$. Also other hierarchies are possible. For instance, the basic facts about music experience suggest $n_a/n_b = 2^k$ ($m = 1$) hierarchy. Genetic code in turn suggests $n_a/n_b = 2^{k6}$ ($m = 6$) hierarchy considered already earlier on basis of some numerical co-incidences. 6-bit genetic could and be enough to explain phonemes

as a representation of genetic codons analogous to amino-acids.

If the cyclotron transitions of cognitive neutrinos in Z^0 magnetic field correspond to ELF frequencies, the hierarchy 2^{k6} of genetic codes is definitely preferred, with $k = 6$ the largest value of k. The Compton length of cognitive neutrino would thus be of order 3×10^5 m and W boson Compton length of order of $L_w(k = 6) = 2^{36} L_w \simeq 1.6$ μm below which ew gauge fields would behave like massless fields.

One could also consider the possibility that ELF frequencies for classical electro-weak gauge fields correspond to an energy of order of W boson mass so that these fields can induce electro-weak transitions. This would be guaranteed for $n_a/n_b = 2^{7\times 11}$ defining the longest electromagnetic cyclotron time scale which for $B = .2$ Gauss is below the typical duration of life cycle. In this case the Compton length of W boson would be of order Earth size (this size scale would correspond to the size of Z^0 magnetic body).

4.2 Neutrinos and hearing

The sensation of hearing would correspond to Z^0 cyclotron transitions. Higher cyclotron harmonics could representing higher harmonics of the fundamental or define the audible frequencies in the case that the value of Z^0 magnetic field is not variable. There are several constraints on the model of hearing which forces to modify the original model.

4.2.1 What particles form the macroscopic quantum phase?

Concerning the building blocks of the cyclotron condensate there are two options to consider.

1. Cooper pairs for dark variants of ordinary neutrinos could form the cyclotron condensate.

2. $\nu_L \overline{\nu}_L$ wormhole contacts possessing spin are good candidates for realizing cognitive codes and conceptual economy favors these.

4.2.2 What is the interaction between sound waves and Z^0 magnetic field?

Z^0 magnetic transition frequencies code for audible frequencies and this fixes order of magnitude for Z^0 magnetic field to fT range if one assumes neutrino mass to be of order .1 eV. Magnetic fields of this strength are known to correlated with brain functioning.

The interaction between sound waves and Z^0 magnetic flux quanta is expected to involve some kind of resonance. What comes in mind first is that the wavelength of sound wave equals to the radius of the Z^0 magnetic flux tube determined by quantization of Z^0 magnetic flux. This gives a reasonable estimate for the thickness of flux tube. $B_Z = 10^{-11} B_d$, $B_d = .2$ Gauss corresponds to $f_c = 20$ Hz cyclotron frequency defining the lower bound of audible frequencies.

The wavelength of sound is in this case 15 m for $v_s = 300$ m/s. That hearing would not be completely inside-head phenomenon could relate to our ability to directly experience sounds as belonging to the world external to our head and would conform with the general vision.

Nerve pulse patterns only generate a symbolic representation of what is experienced as sensory qualia. Nerve pulse patterns should give rise to a representation in terms of genetic code words using cognitive neutrino pairs but also this seems to involve Z^0 magnetic body in an essential manner. For kHz frequency one would have $\lambda \sim .3$ meters, roughly the size scale of head appearing also as resonance frequency in synchronous neuronal firing. The thickness of the magnetic flux tube would code for the fundamental frequency and could quite well vary. Fractal hierarchy in powers of 2 suggests itself.

4.2.3 Thermal stability

Thermal stability in strong sense that also dark matter is assumed to be at room temperature provides a tight constraint to the model. If the lowest audible frequency, about 20 Hz, corresponds to thermal energy $\sim .03$ eV at room temperature, one could understand why lower frequencies are not heard. Of course, explanation might also rely on the fact that it is we who do not experience these frequencies consciously but that it is the next level of dark matter hierarchy which is able to hear these frequencies. If a higher level of dark matter hierarchy is the experiencing conscious entity, it might be possible to understand why the non-audible sounds created by say organ music induce deep spiritual experiences also at our level.

1. In non-relativistic case magnetic transition frequencies do not depend on the value of Planck constant and energies scale as n_a/n_b. If given frequency range corresponds a fixed energy range one must have $B_Z \propto n_a/n_b$. For $n_a/n_b = 2^{km}$, $k = 1, 2, ...$ fundamental frequency range would correspond to m octaves. $m = 6$ corresponding to genetic code and $m = 11$ corresponding to hierarchy of EEG:s are the basic candidates.

2. Small neutrino mass and large value of Planck constant however imply that the magnetic interaction energy contributes significantly to the rest mass. This implies that cyclotron frequency behaves as $(n_a/n_b)^{-1/2}B_Z^{1/2}$ and cyclotron energy as $(n_a/n_b)^{1/2}B_Z^{1/2}$. The implication is that B_Z must scale as $(n_a/n_b)^{-1/2}$ to guarantee that the energy range to which frequency range is mapped remains invariant under the change of Planck constant. As a consequence, frequency range is scaled down by n_a/n_b as in non-relativistic situation. $n_a/n_b = 2^{k6}$ give a hierarchy of ranges consisting of 6 octaves each.

   $k = 4$ would result for 2^{k11} hierarchy for ELF frequency range and assuming non-relativistic magnetic interaction energies: the frequency of cyclotron photon with thermal energy would be around $f_c = .5$ Hz for $k = 4$ level. The audible frequency range however starts from 20 Hz. This

can be understood for $n_a/n_b = 2^{k6}$ if $k = 6$ corresponds to audible frequencies in the 6-octave range 20-1280 Hz assuming reasonable values for neutrino mass and the strength of Z^0 magnetic field. The invariance of energy range under changes of k requires that frequency range is scaled down by 2^6 under $k \to k + 1$. In music 8 tone system would mean that 6-octaves contain 18 bits of information.

4.2.4 Upper bound for the energies of dark cyclotron photons

If the energies of dark cyclotron photons are too high, their transformation to ordinary photons might induce disastrous biological effects. In absence of anything better, a reasonable guess is that energies cannot be above energies of visible photons. This would give upper bound of $E \leq 2$ eV. The range $[.03, 2]$ eV spans approximately 6 octaves which supports $m = 6$ hierarchy inspired by genetic code. For $m = 11$ hierarchy the upper bound would be 64 eV which not look promising. The range 20-1280 Hz would correspond to 64-fold scaling. Note that 1260 Hz corresponds to the duration of the bit of the linear model of memetic code assuming that total duration of 126-bit codon corresponds to 10 Hz frequency. $f \sim 1$ kHz is also critical frequency for hearing and appears as resonance frequency in synchronous neuronal firing.

4.2.5 The dependence of Z^0 magnetic interaction energy and corresponding frequency on $\hbar$

For large values of n_a/n_b since the change of rest mass must be taken into account in the calculation of the cyclotron energy and frequency. The reason is that the magnetic interaction energy modifies the rest mass of neutrino. If the cognitive neutrino is at rest the magnetic interaction energy E_n in cyclotron state can be simply added to the rest mass: $m_\nu \to m_\nu + E_n$. The formula for magnetic interaction energy is modified to

$$\begin{aligned} E_n &= n \times (n_a/n_b) \times \omega_c \times \frac{m_\nu}{m_\nu + E_n} \ , \\ \omega_c &= \frac{\hbar_0 Q_Z(\nu) J g_Z B_Z}{m_\nu} \ . \end{aligned} \tag{5}$$

From this one obtains

$$\begin{aligned} E_n &= \frac{m_\nu}{2}\left(-1 \pm \sqrt{1 + 4n(n_a/n_b)(\omega_c/m_\nu)}\right) \ , \\ f_n &= \frac{n_b}{n_a} m_\nu \left(-1 \pm \sqrt{1 + 4n(n_a/n_b)(\omega_c/m_\nu)}\right) \ . \end{aligned} \tag{6}$$

E_n contains spin interaction energy, harmonic oscillator zero point kinetic energy and cyclotron contribution. Zero point energy and spin interaction energy cancel each other for the lower energy states.

At non-relativistic limit one obtains

$$\begin{aligned} E_n &= n \times (n_a/n_b) \times \omega_c \ , \\ \omega_c &= \frac{Q_Z g_Z J B_Z}{m_\nu} \ . \end{aligned} \tag{7}$$

The resulting asymptotic formulas for E_n and f_n at the limit of large n_a/n_b are given by

$$\begin{aligned} E_n &= \sqrt{n} \times \sqrt{n_a/n_b} \times \sqrt{Q_Z(\nu) g_Z J B_Z} \ , \\ f_n &= \frac{1}{2\pi} \sqrt{n} \times (n_b/n_a)^{1/2} \times \sqrt{Q_Z(\nu) J g_Z B_Z} \ . \end{aligned} \tag{8}$$

Note that there is no dependence on neutrino mass so that the coding at this limit is in some sense universal. Somewhat unexpectedly, frequencies scale as $(n_b/n_a)^{1/2}$ and energies as $(n_a/n_b)^{1/2}$. Energy range remains invariant if $g_Z B_Z$ scales as n_b/n_a as is clear from the defining condition for E_n.

The correspondence between thermal energy and lower limit for audible frequencies fixes the value of n_a/n_b to $n_a/n_b = 2^{6\times 6}$ so that genetic code results. For $Q_Z(\nu) g_Z B_Z/e \simeq .4$ fT the energy range is in a reasonable approximation $[.07, 4.5]$ eV for the frequency range $[20, 1280]$ Hz. Magnetic fields of order fT are known to correlate with brain functioning so that the result makes sense. Note that .07 eV and .05 eV are the Josephson energies associated with the neuronal resting potential and activation potential. The frequencies above 1280 Hz correspond to $k < 6$. For $k = 5$ $g_Z B_Z$ is scaled up by a factor 2^6. For humans $k = 6, 5$ cover frequencies up to 80 kHz containing the 10-octave audible range $[20, 20 \times 10^3]$ Hz. $k = 6, 5, 6$ covers the frequencies up to 5 MHz. Usually the sounds produced by bats are in the range 20-200 kHz. Operating regime is around 30 kHz but horseshoe bats can detect echo fluctuations at 83 kHz caused by the wing flutter of an insect. This frequency is just at the lower bound of the $k = 4$ representation.

4.2.6 Some intriguing observations

The following observations might not represent mere accidents.

1. The biologically especially relevant range of p-adic length scale spanned by $L(173) = 20$ μm defining the size of large neuron and by $L(149) = 5$ nm defining thickness of lipid layer of cell membrane corresponds to 2×6 octaves (the range of audible frequencies is 10 octaves).

2. For $n_a = 2^{4\times 11}$ the p-adic length scale $L_{M_{89}}$ characterizing weak bosons is scaled up to $L(89+88 = 177) \simeq 80$ μm and is differs by a factor $1/\sqrt{2}$ from the secondary p-adic length scale $L(2, 89) = L(178) = \sqrt{2} L(177)$. This supports the view that something deep is involved with $k = 4$ level which also corresponds to the ordinary EEG. For $n_a/n_b = 2^{7\times 6}$ the dark length

scale is $L(89+78) = L(167) = 2.5$ μm and corresponds to a Gaussian Mersenne.

3. Also the scales $L(k)$, $k = 151, 157, 163$ correspond to Gaussian Mersennes. These length scales which I have assigned with the coiling hierarchy of chromosomes. Intriguingly, if magnetic field scales as $1/L(k)^2$, these primes define three levels in $n_a/n_b = 2^{k6}$ hierarchy assignable to the genetic code.

4.3 Cognitive codes based on cognitive neutrino pairs

The previous discussion provide a good background for the attempt to formulate of the model for cognitive (memetic/genetic) codes.

4.3.1 Cognitive neutrino pairs as wormhole contacts

It is good to list the basic assumptions of the model.

1. It is assumed that real-padic fermion pairs provide fundamental cognitive representations. The aspects of the model related to the presence of p-adic space-time sheet are neglected in the sequel. The fermions in question can appear also as fermion-antifermion pairs assignable to the light-like throats of wormhole contact.

2. Zero energy ontology is assumed and the sequences of cognitive fermions at future and past directed light-cones are interpreted as inputs and outputs of Boolean functions with Boolean functions represented in terms of entangled states. Note that zero energy ontology allows superposition of arbitrary fermion numbers for positive energy states since net fermion numbers vanish.

3. The representation as states at lightcone boundary brings naturally in logarithmic waves and it is assumed that the temporal durations of bits would come as powers of 2 or more generally prime p. Logarithmic accuracy poses strong limits on the number of bits of the codon.

4. Dark matter hierarchies $n_a/n_b = 2^{mk}$, $k = 0, 1, 2..$ are considered. The cases $m = 11$ (hierarchy of EEGs) and $m = 6$ (genetic code) are of special interest. Memetic codons with 126 bits could in principle be represented using $m = 6$ hierarchy if one allows 21 layers in this hierarchy $k = 21$. This would however correspond to a huge scaling factor $2^{126} \sim 10^{38}$ requiring all p-adic length scales between CP_2 size the secondary p-adical length scale $L(2, 127)$. This looks unrealistically large.

Wormhole contacts have boson like characteristics and can be scalars, vectors, and perhaps even antisymmetric tensors with 2 physical components by generalization of gauge invariance so that antisymmetric tensor replaces gauge potential. Entire variety of new kinds of vector particles is predicted and should

play a role in condensed matter physics. What is interesting is that these wormhole contacts can also connect space-time sheets belonging to different sectors of the imbedding space characterized by different values of $M^4_{\pm}$ Planck constants.

1. Cognitive neutrino pair is interpreted as spin one $\nu\overline{\nu}$ wormhole contact. Between-two-worlds character motivates partially this assumption and bit sequence could code by spontaneous Z^0 magnetization the spatio-temporal behavior of Z^0 magnetic field at either space-time sheet to a bit sequence and transmit the information to the other space-time sheet.

2. A strong correlation between spin directions of neutrino and antineutrino is highly desirable. For scalar second neutrino would be right handed and it is difficult to imagine correlation between spin directions since there is no interaction. Furthermore, for scalar standard rules of angular momentum addition preclude definite spin direction for ν_L. This leaves only spin one into consideration. In this case strong correlation between spins mediated by electro-weak gauge fields defined by CP_2 spinor connection is possible. Therefore the spin flip of either neutrino induces spin flip of both ν_L and $\overline{\nu}_L$. The field affecting the wormhole contact would be effectively the difference of Z^0 gauge fields at the two space-time sheets. Assuming complete correlation between spin directions, the spin appearing in the cyclotron frequency is $J = 1$.

3. The rest mass of vector wormhole contact could be very low. The attractive Z^0 Coulombic and Z^0 magnetic interactions between neutrino and antineutrino could generate strong binding energy and make the state very light. The need for small rest mass could explain why neutrino wormhole contacts. Also the large negative Z^0 Coulombic interaction energy make with dark condensed matter could be reduce the rest mass and make possible spontaneous generation of pairs from vacuum. One can ask whether it is possible to regard wormhole contact as a massless particle below dark weak scale.

4.3.2 Ideas about representation of memetic/genetic codons

It is best to approach the model of memetic code by listing some tentative ideas.

1. Space-like bit sequence at one space-time sheet could correspond to a time-like bit sequence at another space-time sheet. In TGD Universe this is possible by warping and anomalous time dilation even in the absence of classical gravitation (in terms of warped isometric imbeddings of M^4 to imbedding space). Strong warping of dark space-time sheet could make time like sequence space-like.

   The weird properties of graphene [33] include high conductivity, massless conduction electrons, and reduction of light velocity to $c/300$. The model explaining these findings is relies on dark electron concept, general p-adic mass mass formulas, and warping [J1].

Space-like sequence could be transformed to a time-like sequence or vice versa if cognitive neutrinos are realized as wormhole contacts connecting space-time sheets along a curve which is space-like at the first sheet and space-like at the other sheet. This kind of transformations would be very much analogous to reading or writing, and might represent fundamental aspects of cognition.

2. One could also consider assigning light-like bit sequences with light-like partonic 3-surfaces whose dynamics is basically random since light-likeness is the basic dynamical constraint. Thus information storage on geometry could be considered with p-adic length scale defining a natural unit of length. The properties of the generalized eigenstates of the modified Dirac operator support the hope about linear representation of the memetic code. The braiding for the number theoretical braid defined by algebraic points in the intersection of real and p-adic partonic 2-surfaces is the natural representation of information in this case and could related directly to topological quantum computation type activities [E9].

3. One could try to assign a temporal lattice structure with the preferred light-like direction of $\delta M^4_+ \times CP_2$ defining the quantization axis of spin at the level of generalized imbedding space geometry. The transitions affecting Planck constant would occur via partonic 2-surfaces having at most projection in 2-D time-like plane defined by this direction. Supercanonical Hamiltonians have power dependence on the radial light-like coordinate r: logarithmic waves are in question. This favors (possibly fractally nested) logarithmic coding using octaves of the some fixed value of the light-like coordinate r.

   More generally, logarithmic coding of physiological intensities to conscious experiences could be understood quite generally if fundamental sensory representations are assigned with light cone boundaries and supercanonical partial waves have a fundamental role in the representation of physical states. Memetic/genetic codon could correspond to a quantum state containing partons with light like separations with respect to $M^4_\pm$ metric along the preferred light-like ray but having space-like separations with respect to the induced metric.

4. Phase transitions changing Planck constant are possible for the bits of memetic codon and the bits of the codon can belong to different branches of the imbedding space. The neutrino and antineutrino at the contacts of spin one wormhole contact could belong to different branches of imbedding space with different values of $\hbar(M^4_\pm) = n_a\hbar_0$. In this manner a higher level of dark matter hierarchy could receive information from the lower level.

4.3.3 Is it possible to realize memetic code?

Z^0 magnetic body should experience memetic/genetic codons somehow. Perhaps only changes of memetic/genetic code words induced by temporal and spa-

tial dependence of Z^0 magnetic field are experienced consciously. This would not be a problem if there is background Z^0 field reducing the codon to a fixed reference state representing spontaneous magnetization with all spins in same direction. This is achieved if Z^0 magnetic tubes represent bits. In the time/length scale of single bit B_Z would be constant and would force cognitive neutrino pair to have same spin direction as B_Z. Population of cognitive neutrino pairs would allow to achieve statistical determinism.

1. Logarithmic realization of genetic code

Logarithmic waves suggest a fractal structure with temporal durations of bits coming as powers of 2^k along the preferred light-like radial direction. For the hierarchy of genetic codes 6-bits would form the basic structure. The higher the level of dark matter hierarchy characterized by $n_a/n_b = 2^{k6}$, the longer the duration of bit so that more and more abstracted representations would result from Z^0 magnetic field. The increasing duration of the bit would also uniquely characterize its position in the bit sequence.

For a six bit genetic codon with duration of $T(127) = .1$ seconds, the bits would have durations $T(127)/2^k$, $k = 1, 2, .., 6$ with slowest duration equal to 15.6 ms, safely above the ms duration of nerve pulse. The lowest bit would correspond to 20 Hz frequency.

The realization of the bit sequence along a light-like geodesic at light-cone boundary could be based on ZEG. The field pattern of Z^0 ME (topological light ray) is constant in the radial light-like direction so that it can carry a Z^0 magnetic field pulse with a constant direction of transversal B_Z. The Z^0 ME possibly inducing a spin flip of k:th bit, call it ME_k, should affect only the 3-surface $X^3_k \subset \delta M^4_+ \times CP_2$ representing k:th bit. If the transversal sizes of ME_k and X^3_k are same and scale like (say) 2^k, a selective resonant interaction could become possible.

2. Fractal realization of memetic codons

Linear coding along light-cone boundary would allow 126-bit memetic codons. The time span of existence for the bit translates to the light-like radial extension of partonic 2-surface which would be about 1/1.260 milliseconds which somewhat shorter time span than the basic ms time scale of neuronal activity. For light-like coordinate this would correspond to a distance of about 3×10^5 meters between two bits represented as $\nu\overline{\nu}$ wormhole contacts. The problem is that the radial dependence of super-canonical Hamiltonians is essentially given by power law so that logarithmic coding is favored over linear coding.

One can however imagine also a logarithmic realization of memetic codon using dark matter hierarchy. One obtains a hierarchy of codes corresponding to the levels of dark matter of $n_a/n_b = 2^{6k}$. In this realization the duration of the bit at the level $k + 1$ of dark matter hierarchy is duration of the 6-bit codon at the previous level. This encourages to consider a fractal structure in the sense that each bit 6-bit structure at the next level corresponds to 6-bit in an improved resolution. Two-level hierarchy would give $6^2 = 36$ bits and three-level hierarchy $6^3 = 216$ bits so that the realization of menetic code or

something very near to it would not be a problem in this kind of framework. For instance, 3-level hierarchy using 5 bits giving 125 bits and by adding one additional bit (start/end bit) one would obtain 126 bits.

The fractal memetic codon involving several branches of the imbedding space would define a structured representation of information rather than mere sequence of bits. The most obvious interpretation would be that 6 bit representation at highest dark matter level gives a rough over all view and lower dark matter levels add details to the representation.

5 More general view about cognition

The model of Penrose and Hameroff [30] postulates the reduction of our conscious experiences and cognition to micro-tubular level whereas TGD postulates in some sense just the opposite of this: our magnetic bodies could have astrophysical size.

These views are actually not mutually exclusive. The mental images at magnetic bodies could directly entangle with sub$\cdots$subselves with sizes smaller than cell length scales. Geometrically this would mean the formation of join along boundaries bonds between ELF space-time sheets and subcellular space-time sheets, say micro-tubular, protein and DNA space-time sheets. Also the not conscious-to-us information processing occurring at these levels could be crucial for our consciousness and somewhat analogous to the machine language of computer programs. The length scales of micro-tubules suggest that they could be also seats of cognitive antineutrinos. Penrose and Hameroff also speculate with the possibility that micro-tubules could act as quantum computers. It is interesting to find how these speculations relate to TGD based views about bio-system and consciousness. This is especially so because in TGD framework entire universe can be formally regarded as a quantum computer in some very general sense. The following considerations indeed suggest that DNA, micro-tubules and axonal membrane form an integrated cognitive (or to be precise, symbolic structure; cognitive and symbolic representations correspond to p-adic and real numbers in TGD terminology) structure.

5.1 Micro-tubules and information transfer from cell membrane to nucleus

TGD suggests a generalization of the basic views about genetic code: in particular Boolean mind could also emerge at DNA level. This raises the question about the relationship of DNA self-consciousness (predicted by TGD) to our consciousness. The basic new ingredient is the notion of the manysheeted DNA. The notion of many-sheeted DNA means that the space-time sheet of DNA has wormhole contacts and join along boundaries contacts with the space-time sheets of the entire hierarchy of space-time sheets. The concept of many-sheeted DNA allows new views about how genetic code is expressed in morphogenesis and one cannot exclude the possibility that genetic program could give rise to

Boolean mind already at DNA level (see the chapter "Many-sheeted DNA"). An attractive hypothesis is that genes represent long term beliefs which become conscious when gene is active and transcribed to mRNA. Biofeedback realized by connecting 'our' space-time sheets to gene space-time sheets by join along boundaries bonds, might make gene level cognition conscious to us. A variant of this hypothesis is that intronic portion of DNA represents memes consisting of segments of 21 DNA triplets representing memetic codons and translated to field patterns of MEs forming basic control commands and basic elements of language at much more general level than the spoken language, which would represent only a tip of an iceberg

That DNA might be directly involved with neural processing is suggested by several findings. It is known that biofeedback to DNA level is possible and it is also claimed that music affects directly DNA. In the chapter "Genes and Memes" a model for the interaction of the cell membrane dynamics with the intronic portion of DNA representing memes as sequences of memetic codons consisting of 21 DNA triplets is discussed. This interaction would translate memes to field patterns associated with MEs. It would be much faster than the translation of genes to proteins and an essential part of what happens in postsynaptic neuron.

Memes transcribed to Z^0 MEs could generate nerve pulse patterns and membrane oscillations. Conversely, nerve pulse patterns could modulate the light-like vacuum currents of the massless extremals possibly associated with the radial micro-tubules having direct contacts with the neuronal cell membrane (but not with ordinary cell membranes!) and connecting it with the nuclear region of neuron and in this manner nerve pulse patterns would be communicated to DNA level. The effect of some anesthetics (say noble gases), usually interpreted as a support for the identification of our consciousness as a micro-tubular consciousness, could be due to the failure of this communication induced by the effects of the anesthetics at the micro-tubular level. Unconscious state not able to self-organize at micro-tubular level could have dramatic effects to our consciousness also in TGD framework.

5.2 DNA, micro-tubules, and cell membrane as cognitive structures?

Cognitive antineutrinos are crucial for TGD based model of cognition. They are associated with the defects of Z^0 super conductor and involve strong Z^0 magnetic fields. There are three types of neutrinos having nearly degenerate masses and this suggests the possibility of three basic types of cognition. DNA, micro-tubular and cell membrane could be seats for all or some of these three types of cognition. Z^0 magnetic system with linear structure like micro-tubule can be in three different phases corresponding to ferromagnetic phase, spin glass phase and the phase in which directions of the cognitive neutrino spins are random. In the proposed model of DNA (ee the chapter 'Many-sheeted DNA') exons and introns correspond to ferromagnetic phase and are thus ideal for the storage of long term memories (they could code both the matter– and mind like

hardware of living matter). The model of EEG and nervepulse suggests that axonal cell membranes correspond to random phase ideal for communication purposes. Micro-tubule interiors or surfaces or both could in turn correspond to spin glass phase ideal for short term working memory storage: this function would explain the maximation of the lengths of the sensory axons. Of course, if micro-tubules are near criticality, they can also be in ferromagnetic and random phases depending on situation. Indeed, micro-tubules could have both memory storage and information transfer functions and serve as a bridge between DNA and cell membrane cognition.

Micro-tubules have outer and inner radii equal to $1.25 \times L(151)$ and $.75 \times L(151)$ so that the thickness of the micro-tubular surface is $L(149) = L(151)/2$. The area of the micro-tubular surface is quantized to the area $\pi L(151)^2$ of a cylinder with radius $L(151)$. This geometric quantization rule might not be a mere accident. One can consider the possibility that either the micro-tubular surface itself, micro-tubular interior or entire micro-tubule or some of them correspond to a defect of neutrino super conductor and is carrier of cognitive antineutrinos. The higher density of matter at micro-tubular surface suggests that it is a good candidate for a seat of $k = 149$ cognitive antineutrino pairs. Of course, also micro-tubule interior could be a carrier of cognitive antineutrinos. For instance, the hypothesis that the space-time sheet associated with micro-tubular surface contains odd number of cognitive antineutrinos per tubulin dimer would mean quite huge information storage capacity made possible by antineutrino spin. In the following the idea about DNA, micro-tubules and axonal membrane as seats of cognition is discussed at quantitative level.

5.2.1 Criterion for the spontaneous generation of cognitive neutrino pairs from vacuum

The formation of cognitive antineutrino pairs could be basically due to the instability of vacuum. At $k = 169$ space-time sheet cognitive neutrinos could form bound states with nuclear Z^0 charge associated with the structure in question. The original hypothesis that cognitive antineutrinos can condense on $k = 151$ space-time sheets only, could be too restrictive and one can consider a more general criterion stating that the rest mass of cognitive antineutrino condensed on given space-time sheet and determined by the p-adic prime characterizing it, is nearly equal to the binding energy of a cognitive neutrino on $k = 169$ space-time sheet:

$$m(\nu, k < 169) = E(\nu, 169) \quad .$$

The value of the binding energy depends on the local density of the biomatter and varies in wide limits from the density of water to the density of matter in DNA strand and micro-tubular surface.

In case of DNA the naive expectation is that defects must correspond to DNA threads with thickness of few Angstroms characterized by $k = 139$. This need not be however the case since many-sheeted space-time concept allows

DNA threads to have thickness of, say, $L(149)$, (nucleosomes around which DNA thread winds correspond to $k = 149$ and have radius $L(149)$). In fact, many-sheeted space-time concept suggests a rather science fictive solution to the problem how DNA replication is possible on the surfaces of the nucleosomes: since nearby portions of DNA thread do not correspond to same space-time sheet, the opening of DNA double strand can occur without any problems. Consider now the estimate.

1. Electron neutrino rest mass is given by

$$m(\nu_e, k) = 2^{(169-k)/2} m(\nu_e, 169) \simeq 2^{(139-k)/2} \times .74 \times 10^4 \ eV \ .$$

2. The rest mass should be compensated by the negative Z^0 interaction energy of neutrino at $k = 169$ space-time sheet. The energy in question is the interaction energy of neutrino with neutrons of biomatter and both DNA thread, nucleosome consisting of histone octamers and neutrinos themselves contribute to this energy. The non-vanishing negative value of interaction energy results from the localization of the nuclear Z^0 charge as opposed to the even distribution of neutrino Z^0 charge. An order of magnitude estimate for the interaction energy of the neutrino is obtained from the parametrization

$$E(\nu, 169) = k_1 \frac{\alpha_Z Q_Z^2(\nu) N(n)}{d} \ .$$

   $N(n)$ denotes the total number of neutrons in the vicinity of neutrino and d denotes the average distance to the nearest neighbor. k_1 denotes numerical constant. $d \simeq 10^{-10}$ meters is good guess and $N(n)$ has order of magnitude equal to the number of neutrons in a typical atom of biomolecules involved. This gives

$$E(\nu, 169) = k_1 \times \alpha_Z Q_Z^2(\nu) N(n) \times .81 \times 10^4 eV \ .$$

3. Cancellation condition implies

$$k_1 \times N(n) = .91 \times \frac{1}{\alpha_Z Q_Z^2(\nu)} \simeq 210 \ \text{ for } k = 139 \ ,$$
$$k_1 \times N(n) = .91 \times \frac{1}{32 \alpha_Z Q_Z^2(\nu)} \simeq 6.6 \ \text{ for } k = 149 \ .$$

   For $k = 139$ neutrinos the number $N(n)$ of nearest neighbor neutrons should be of order 200: this value is quite too large. For $k = 149$ the condition gives rather reasonable order of magnitude estimate $k_1 N(n) \sim 7$. Similar estimate applies in case of micro-tubules and allows to assign $k = 149$ to the micro-tubule surface and $k = 151$ to micro-tubule interior.

4. The net Z^0 charge of cognitive antineutrinos is smaller than nuclear Z^0 charge since there is net neutrino density on $k = 169$ space-time sheet and

cognitive neutrinos represent additional contribution to neutrino background generated from vacuum. The requirement that net average Z^0 charge density vanishes implies $n(\overline{\nu}_c) = n(neutron) - n(\nu)$, where ν refers to a ordinary neutrino and ν_c refers to a cognitive neutrino. The resulting upper bound for the density of cognitive antineutrinos is

$$n(\overline{\nu}_c) \leq n(neutron)$$

and can be used as a constraint for the model.

5.2.2 Estimate for the density of cognitive antineutrinos needed to generate Z^0 magnetic field

Flux quantization for the strength of the Z^0 magnetic field associated with the micro-tubular surface gives idea about the neutrino density per unit length needed assuming that cognitive antineutrinos serve as the source of the Z^0 magnetic field. The conditions

$$g_Z B_Z 2q_Z(\nu) = \frac{m\times 2\pi}{S} \quad , m = 0, 1, 2, \cdots \quad ,$$

$$g_Z B_Z = \frac{1}{4\pi} g_Z \frac{\mu_Z(tot)}{V} = \frac{1}{4\pi} g_Z \frac{dN(\nu)}{dL} \frac{1}{S} \frac{g_Z Q_Z(\nu)}{2m(\nu,k)}$$

give

$$\frac{dN(\nu)}{dL} = \frac{m\times 4\pi}{\alpha_Z} m(\nu, k) \quad ,$$

$$\alpha_Z = \frac{\alpha}{sin(\theta_W)cos(\theta_W)} \quad , \quad \alpha \simeq \frac{1}{137} \quad , \quad sin^2(\theta_W) \simeq .23 \quad .$$

Micro-tubule interior corresponds to $k = 151$ whereas micro-tubular surface corresponds most probably to $k = 149$. Note that this estimate does not depend on whether the micro-tubular surface, interior or entire micro-tubule is assumed to be the carrier of cognitive antineutrinos. Estimates holds also true for DNA thread which should have $k = 149$ by the previous estimate. The estimate for the linear density of cognitive antineutrinos is about 21 cognitive antineutrinos per Angstrom for the minimal value of the Z^0 magnetic field. This value means roughly 30 cognitive antineutrinos per tubulin dimer having parallel spin. This number is considerably smaller than the total number of neutrons per tubulin dimer. One can also consider liquid crystal like structure: micro-tubule could consist of layers such that cognitive antineutrinos in each layer have two possible directions of Z^0 magnetization.

If the DNA space-time sheet containing cognitive antineutrinos has the thickness of DNA thread about 2.5 Angstroms, the criterion would give linear density of 64×21 antineutrinos per Angstrom, which is nonsensical and the only possibility would be that Z^0 magnetic field is wormhole magnetic field having Z^0 wormholes as sources [J5]. If DNA thread has radius $L(149)$ there are $k = 42$ cognitive antineutrinos per Angstrom, which looks rather reasonable.

The rather large number of cognitive antineutrinos means that DNA molecules can be regarded as Z^0 magnetized objects. This means that spin flip for cognitive antineutrinos must be a phase transition like process.

5.2.3 Spin flip frequencies for cognitive antineutrinos

Cognitive neutrino spin flip is crucial for cognition. For unmixed tau neutrino associated with the micro-tubule interior spin flip frequency does not depend on the p-adic prime characterizing antineutrino and is obtained by scaling the lower bound for the corresponding frequency in case of τ neutrino associated with the axonal membrane by the ratio of the areas of flux tubes involved.

$$f_L(structure) = \frac{S(membrane)}{S(structure)} f(membrane) \quad .$$

For muonic and electronic neutrino the corresponding frequencies are scaled down by a factor depending on mass ratios:

$$f(\nu_L) = \frac{m(L)}{m(\tau)} \times \frac{m_0(\nu_L)}{m_0(\nu_\tau)} f(\nu_\tau) \quad , \quad L = e, \mu \quad .$$

Note that the frequencies do not depend on the mass scale of neutrino and are thus scaling invariant quantities in a well defined sense. This universality could have deep consequences as far as consciousness is considered. The table gives frequencies for $(n+1, up) \leftrightarrow (n, down)$ transitions in case of DNA thread, micro-tubular surface and cell membrane.

An interesting possibility is that the three unmixed almost mass degenerate neutrino families, predicted by TGD to have masses $m(\nu_e) = .23$ eV, $m(\nu_\mu) = .4$ eV and $m(\nu_\tau) = .87$ eV, correspond to three different levels of cognition. Each of them could be associated with both DNA, micro-tubules and cell membrane.

1. The frequency and time scales associated with micro-tubules are rather interesting. $\overline{\nu}_\tau$ corresponds to $f_L \simeq 7.2$ Hz which is within uncertainties involved the frequency scale defined by the duration of the memetic codeword. For muonic neutrinos one has $T_U(\nu_\mu) = 5.1$ seconds. Rather interestingly, Comorosan effect occurs when organic molecules are radiated by a time which is multiple of 5 seconds [J5]. The fact that Comorosan effect occurs very generally suggests that 5 seconds is 'universal' time scale in biosystems. Perhaps Z^0 magnetic defects with dimensions of micro-tubular surface assocated with self-organization of liquid crystals serve as templates for the formation of micro-tubular surfaces and are involved with the bio-catalysis even in absence of micro-tubules. The requirement $T_U(\nu_\mu) = 5$ seconds reduces $T_U(\nu_e) \simeq 31.5$ to 30.88 minutes which is twice the period of about 15 minutes for the electric oscillations of DC currents flowing along the meridians of the meridian system discovered by Becker [32]. For micro-tubule interior the corresponding time scale would be 17.8 minutes.

2. In case of DNA the thickness of DNA thread is larger than $L(149)$ but smaller than $L(151)$. The first guess is that geometric average of these length scales is in question. The guess is motivated by the fact that also the p-adic time scale associated with memetic code is the geometric average of p-adic length scales associated with twin primes k and $k+2$. For this choice $T_U \simeq 15.75$ minutes for electronic neutrinos is quite near to the period of about 15 minutes for the electric oscillations of DC currents flowing along the meridians of the meridian system discovered by Becker [32]. The requirement $T_U(\nu_\mu) = 5$ seconds in case of micro-tubular surface (Comorosan effect) implies $T_U(\nu_e) = 15.44$ seconds which is the period of electrical oscillations in the meridian system. The scaling factor 2 relating micro-tubular and DNA length scales suggests strongly that there is direct interaction and communication between DNA and micro-tubules.

3. The upper bounds for various time scales in case of cell membrane are rather long and could be perhaps identified as basic time scales of neuronal consciousness.

Structure	DNA	micro-tubule surface	cell membrane
$f_L(\nu_e)/Hz$	10^{-3}	5.29×10^{-4}	5.14×10^{-7}
$T_U(\nu_e)$	15.75 min	31.5 min	22.2 d
$f_L(\nu_\mu)/Hz$	.39	.195	1.895×10^{-4}
$T_U(\nu_\mu)$	2.55 sec	5.1 sec	87.9 min
$f_L(\nu_\tau)/Hz$	14.4	7.2	7×10^{-3}
$T_U(\nu_\tau)$	.07 sec	.14 sec	2.4 min

Table 8. Lower bounds for the frequencies of $(n+1, up) \leftrightarrow (n, down)$ transitions from the quantization of Z^0 magnetic flux for DNA thread (thickness $\sqrt{2}L(149)$); micro-tubular surface of thickness 5 nm and inner radius 1.5 nm and cell membrane taken to have inner radius $R = L(169) \simeq 4.4$ μm and thickness $L(151)$. Also the corresponding time scales T_U are given.

5.3 Micro-tubules as quantum computers?

Penrose and Hameroff have also speculated with the possibility that micro-tubules could act as quantum computers such that each tubulin corresponds to one bit. One could argue that quantum computers represent too advanced technology to be realizable in living matter. Be as it may be, the consideration of this option in TGD framework is instructive since it throws also light into the relationship between quantum TGD and ordinary quantum mechanics. When subsystem has overcritical entanglement with its environment, it does not perform quantum jumps and should be analogous to a quantum system obeying Schrödinger equation. That this expectation is correct, is not at all obvious due to the radically different view about time provided by TGD.

1. As long as one can neglect the effects of other quantum jumping subsystems and treat the entire universe as nonquantum jumping system, each quantum jump involves the action of a unitary S-matrix U on the state of subsystem and its complement and one has

$$\psi \rightarrow U\psi \quad .$$

In this approximation the effect of n subsequent quantum jumps on system and its complement is given by

$$\psi \rightarrow U^n\psi \quad .$$

2. Since single quantum jump corresponds to average ingrement $\tau \simeq 10^4$ Planck times, it makes sense to express U as an exponential of a Hamiltonian effectively generating discretized unitary time development with the duration $\tau \simeq 10^4$ Planck times of chronon.

$$U_0 = exp(i\tau H) \quad .$$

From this one obtains that a period of entanglement with duration t corresponds to the time development operator

$$U = U_0^n \quad , \quad n = \frac{t}{\tau} \quad .$$

Subsystem can never behave as an ideal quantum computer and the best one can achieve is that the entanglement with external world is just above the critical entanglement to prevent the occurrence of quantum jumps.

The basic problem of biosystem as a quantum computer idea is the realization of almost dissipation free systems in the hot, wet and noisy environment provided by brain. Cognitive antineutrinos associated with, say micro-tubules, might be ideal in this respect since dissipative effects are very small. Of course, also other superconductor predicted by TGD could serve the same purpose. Quantum computer like system should be extremely flexible in order to allow the realization of a Hamiltonian associated with a given computation. Spin glasses are indeed systems of this kind since the values for the basic couplings of spin glass like system, rather than being 'fundamental constants', obey probability distribution. In TGD framework entire universe is quantum spin glass so that the prospects for the possibility of quantum computation look good. Perhaps micro-tubules in spin glass phase could provide a realization for quantum computers based on cognitive antineutrinos.

5.4 Cognition at the level of the entire body?

Under the assumptions made, memetic code could in principle be realized everywhere in the nervous system, the intronic portion of DNA could code memes as sequences of 21 DNA triplets, and neutrino based cognition could be present in some primitive form in the entire nervous system. What is required for transcription of the nerve pulse patterns to the memetic codewords is the presence of Z^0 magnetic field of order one .5 Tesla in axons. Thus the receipe for building intelligent biomatter would be simple: provide axons with Z^0 magnetic field having critical value giving rise to neutrino spin flip frequency of order 10^3 Hz. One could however consider also the possibility that the mere presence of the cognitive anti-neutrinos is enough and that language is only a more refined form of cognition. Thus in principle our organs, in particular sensory organs, and skin could be much more intelligent creatures than our brains are accustomed to think!

In the chapter "Biosystems as superconductors" it was shown that cognitive neutrino pairs can be created from vacuum only if there are free neutrino vacancies at $k = 169$ space-time sheet and that these vacancies could be created by the excitation of nuclei by phonons in turn interacting with neutrinos via the classical Z^0 force. Perhaps the needed acoustic energy could be generated by blood flow. Indeed, intensive blood flow to various parts of body accompanies situations, where those parts of our body are active. Consider only what happens, when person flushes. 'Pinocchio effect' in which blood flows into the nose of a person who is lying, is second example. The blood flow into genitals during sexual arousal could be also regarded as a signal for higher level of cognitive consciousness in parts of body, to which we usually do not assign very high intelligence quotient. What is remarkable that blood flow revealed by PET (positron emission tomography) scan would provide a direct measure for the presence of 'our' consciousness and one could build quite reliable 'our consciousness' maps. Oxygen consumption revealed by fMRI (functional magnetic resonance imaging) might in turn serve as a measure for the presence of lower levels of consciousness ('sub-conscious' from our point of view).

Cognitive neutrino pairs could be present also in the ordinary cell membranes. The presence of strong Z^0 magnetic field necessary for the mechanism generating generating cognitive neutrino pairs in cell membrane regions implies spontaneous magnetization of antineutrinos and freezes these degrees of freedom. Information storage is possible only if there is some mechanism changing the direction of the antineutrino spin. The small frequency difference between $(n+1, up)$ and $(n, down)$ states makes this kind of mechanism possible. What is needed is Z^0 magnetic pulse of correct duration in ELF range and it might be that solitons of various ionic superconductors having correct duration could induce spin flip.

One can consider also other representations of information using cognitive neutrinos at cellular space-time sheets (as opposed to cognitive antineutrinos at cell membrane space-time sheets discussed in this chapter). For instance, the spin direction of the nonrelativistic *neutrino* member of the cognitive neu-

trino pairs at $k = 169$ space-time sheet, or some larger space-time sheet, could be controlled by the weak Z^0 magnetic fields generated by blood – and cytoplasmic flows. The magnetization direction of the cognitive neutrinos would provide kind of not-conscious-to-us map of the Z^0 magnetic fields at the cellular $k = 169$ space-time sheets. Since memetic codewords would be involved, temporal aspect would be also present. This kind of map could generate intracellular self-consciousness: cell is full of endoplasma membranes so that his map would be rather faithful. This consciousness would in turn contribute to body consciousness. Perhaps it is worth mentioning that I have personally experienced an altered state of consciousness during which my visual field contained as a background an extremely complicated and beautiful flow consisting of dots: I interpreted it as a representation for either liquid flow or of magnetic field. A possible interpretation for the experience is as 'biofeedback' to cellular level making it possible to experience what it is to be a cell.

One can wonder what happens in the ordinary liquid flow, in which Z^0 magnetic fields and neutrinos are also present. Can one assign conscious intelligence with the flow of the ordinary water? Is here the fundamental explanation for why life originated in sea and why we are actually 70 per cent of sea water?

1. Quantum jumps and moments of consciousness do certainly occur in hydrodynamics flow. Dissipation in liquid flow is signature for the occurrence of quantum jumps between histories and ordinary dissipative flow is only a phenomenological description replacing the sequence of quantum jumps between non-dissipative hydrodynamical flows with single dissipative hydrodynamical flow. The mechanism of dissipation proposed in [D7] is based on the decay of vortices to smaller vortices and involves implicit assumption about the presence of quantum jumps in length scales characterized by vortex sizes.

2. One possibility is that neutrino magnetization generating defects of the neutrino super conductor (temporal sequences of cognitive neutrino pairs are not involved now) gives rise to a primitive self-conscious representation of the liquid flow. This representation would give no conscious information about the time development of the flow as memetic codewords do. Cell membranes would have evolved from these defects.

3. One could have even more. The model for sensory qualia suggest strongly that axon interior is the carrier of Earth's magnetic field whereas the model for cognition implies that cell membrane able to cognize is the carrier of the Z^0 magnetic field: one cannot however exclude the presence of a small magnetic field also in cell membrane. This implies that average magnetic fluxes per axon area, and hence also macroscopic average fields, are of same order of magnitude for magnetic and Z^0 magnetic fields necessary for the generation of cognitive neutrino pairs. This raises the possibility that Earth has also Z^0 magnetic field quantized in flux tubes with geometry of hollow cylinder and dimensions of axon so that conditions making possible some form of Boolean mind might be normal. This assumption is

consistent with the fact that Z^0 magnetic fields correspond to the defects of the neutrino super conductor. If this is indeed the case then even ordinary liquid flow could involve rudimentary cognition and cell membranes could be regarded as structures evolved around the hollow Z^0 magnetic flux tubes. Thoughts would precede brain!

This picture suggests also some guidelines for the possible future attempts to construct artificial life.

1. Strong electric fields are needed to generate cognitive resources if the proposed interpretation of quantum criticality is correct [H1]. Weak magnetic fields are needed to build up the needed effectively one-dimensional superconductors at non-atomic space-time sheets.

2. A further necessary prerequisite is varying liquid flow creating sufficiently strong Z^0 magnetic fields generating automatically stripe like defects serving as templates for cell membrane like structures serving as seats for cognition. One cannot exclude the spontaneous generation of mindlike space-time sheet pairs carrying the strong Z^0 magnetic fields associated with cell membrane: in fact, Earth's Z^0 magnetic field could already contain these structures. The complexity of liquid flow should correlate with the complexity of neutrino cognition possibly present in the system.

3. ELF em fields oscillating with magnetic transition frequencies might be of considerable help in the enterprise. Besides these ingredients simple carbon compounds serving as basic building blocks of artificial life should be present.

4. The mechanism for the creation of cognitive neutrino-antineutrino pairs relies crucially on the cancellation of the rest mass + kinetic energy of the cognitive antineutrino at $k = 151$ space-time sheet and Coulombic Z^0 interaction energy of the cognitive neutrino at $k = 169$ space-time sheet. This mechanism is possible only under very restricted range of Z^0 charge densities for matter and water containing organic compounds in right proportions is probably crucial for achieving this condition.

Putting all these together and letting the soup to quantum self-organize, the first signs of life would sooner or later emerge (provided I have not forgot some item from the list!). It would be also interesting to study the interaction of living cells interacting with sufficiently complicated water flow, possibly in presence of strong electric field.

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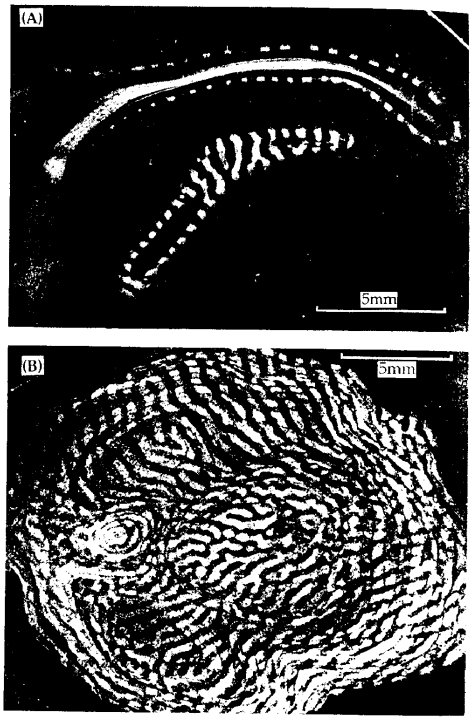
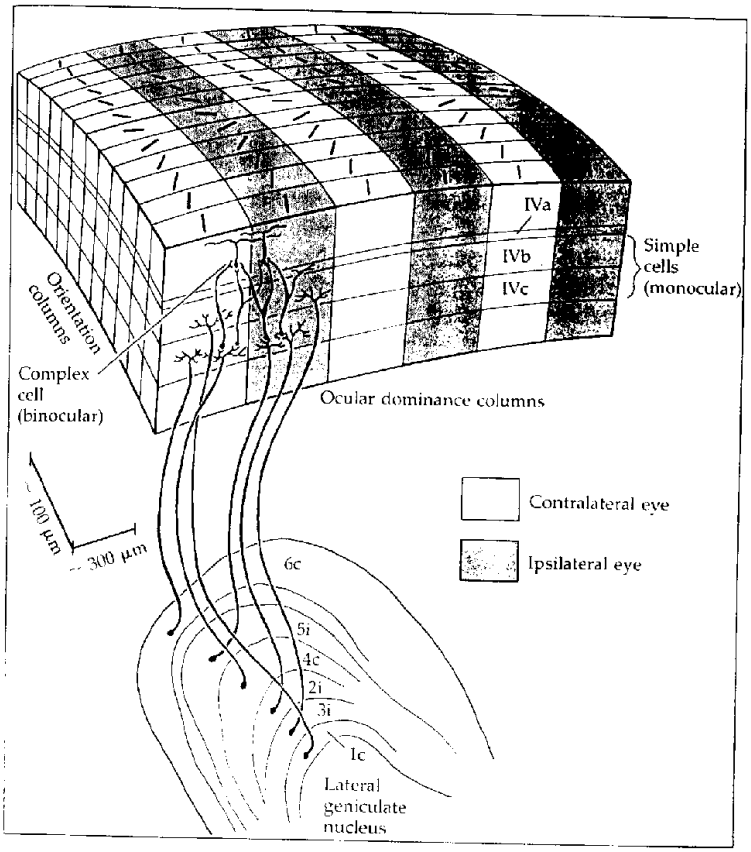


4

OCULAR DOMINANCE COLUMNS IN MONKEY CORTEX demonstrated by injection of radioactive proline into one eye. (A) and (B) are autoradiographs photographed with dark field illumination in which the silver grains appear white. (A) This horizontal section first passes through the visual cortex at right angles to the surface displaying columns cut perpendicularly, then in the center horizontally through layer IV cutting columns tangentially. (B) Reconstruction made from numerous horizontal sections of layer IVC in another monkey in which the ipsilateral eye had been injected (no single horizontal section can encompass more than a part of layer IV of the cortex because of its curvature). Dorsal is above, medial to the right. In both (A) and (B), the ocular dominance columns appear as stripes of equal width supplied by one eye or the other. (C) Reconstruction of the pattern of ocular dominance columns over the entire exposed part of layer IVc. Scale 5 mm. (A and B from LeVay, unpublished, photos by courtesy of S. LeVay; C from LeVay, Hubel, and Wiesel, 1975.)

Figure 1:



7 **RELATION BETWEEN OCULAR DOMINANCE and orientation columns. Scheme in which the ocular dominance and orientation columns run at right angles to each other. An example of a complex cell is shown in an upper layer, receiving its inputs from two simple cells that lie in adjacent ocular dominance columns but share the same orientation columns. (From Hubel and Wiesel, 1972.)**

Figure 2: