Quantum Model for the Direct Currents of Becker

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Abstract

Robert Becker proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents.

TGD inspired model for nerve pulse assumed that ionic currents through the cell membrane are probably Josephson currents. If this is the case, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since

the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually currents and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

1 Introduction

Robert Becker [J2] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents.

TGD inspired model for nerve pulse [K4] assumed that ionic currents through the cell membrane are probably Josephson currents. If this is the case, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually currents and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

Whether the model for quantum direct currents is consistent with the proposed vacuum extremal property of the cell membrane [K4] remains an open question but both options explain the special role of Ca^{++} currents and current of Na^{+} Cooper pairs in the generation of nerve pulse as in would take place in TGD Universe. In fact, it is not clear what one exactly means with the vacuum extremal property of cell membrane. Many-sheeted space-time allows to consider space-time sheets which can be both almost vacuum extremals and far from vacuum extremals. Also space-time sheets for which Planck constant is so large that both electronic and protonic Josephson currents become possible. Various pumps and channels could actually correspond to magnetic flux tubes along which various ionic supra currents or even Josephson currents can flow. The condition that both electronic and protonic supra currents are possible in same length scale leads to the hierarchy of Planck constants coming approximately as powers of $m_p/m_e \simeq 2^{11}$ proposed originally as a general truth. Radiation at Josephson frequency serves as a signature for Josephson currents.

In the following a TGD inspired quantum model for the direct currents of Becker as direct quantum currents is developed and shown to be consistent with what is known about nerve pulse generation. The model of nerve pulse based on this model is discussed in [K4].

2 Connection between laser induced healing, acupuncture, and association of DC currents with the healing of wounds

The findings of Robert Becker (the book "Electromagnetism and Life" by Becker and Marino can be found from web [J2]) meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a

pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

Growth effects include the alteration of bone growth by electromagnetic energy, the restoration of partial limb regeneration in mammals by small direct currents, the inhibition of growth of implanted tumors by currents and fields, the effect upon cephalocaudal axis development in the regenerating flatworm in a polarity-dependent fashion by applied direct currents, and the production of morphological alterations in embryonic development by manipulation of the electrochemical species present in the environment. This partial list illustrates the great variety of known bioelectromagnetic phenomena.

The reported biological effects involve basic functions of living material that are under remarkably precise control by mechanisms which have, to date, escaped description in terms of solution biochemistry. This suggests that bioelectromagnetic phenomena are fundamental attributes of living things ones that must have been present in the first living things. The traditional approach to biogenesis postulates that life began in an aqueous environment, with the development of complex molecules and their subsequent sequestration from the environment by membranous structures. The solid-state approach proposes an origin in complex crystalline structures that possess such properties as semiconductivity, photoconductivity, and piezoelectricity. All of the reported effects of electromagnetic forces seem to lend support to the latter hypothesis.

2.1 Observations relating to CNS

The following more quantitative findings, many of them due to Becker, are of special interest as one tries to understand the role of DC currents in TGD framework.

1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole like structure with neural system in positive potential and perineural tissue in negative potential. There is also an electric field along neuron in the direction of nerve pulse propagation (dendrites correspond to - and axon to +) (note that motor nerves and sensory nerves form a closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are same in a static situation.

2. A longitudinal potential along front to back in brain with frontal lobes in negative potential with respect to occipital lobes and with magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [K4]). Propagating potentials were discovered also in glial cells. The interpretation was in terms of electrical currents.

3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.

4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

2.2 Observations relating to regeneration

The second class of experiments used artificial electrical currents to enhance regeneration of body parts. These currents are nowadays used in clinical practice to induce healing or retard tumor growth. Note that tissue regeneration is a genuine regeneration of an entire part of organism rather than mere

simple cell replication. Salamander limb generation is one of the most studied examples. Spontaneous regeneration becomes rare at higher evolutionary levels and for humans it occurs spontaneously only in the fractures of long bones.

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.

2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.

3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.

4. Regeneration is possible in salamander but not in frog. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of or order -1 mV went first positive value of order +10 mV. In frog it returned smoothly to its original value without regeneration. In salamander it returned during three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value as regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current induced regeneration also in the case of frog and in even in the denervated situation. Thus the flow of electrons to the stump is necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.

5. It was also learned that a so called neural epidermic junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of nervation. The conclusion was that the DC voltage and electronic current relevant for regeneration can be assigned the interface between CNS and tissue rather than with the entire nerve and regeneration seems to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seems to make possible the flow of electrons from CNS to the stump.

6. The red blood cells of animals other than mammals are complete and possess thus nuclei. Becker and collaborators observed that also red blood cells dedifferentiated to form blastema. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as signal for gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By

the way, the role of the cell membrane fits nicely with the view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes connecting DNA and cell membrane serving as braids.

7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of large negative potential of stump as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed. In TGD based model also super-conducting charge carriers are possible and this finding does not tell anything about them.

2.3 Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [J1] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. Ebner and Schuerch studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range .5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novaris) applied for a patent "Method of enhanced fish breeding" [J1] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers report [J1] that also the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted (it is not difficult to guess the reasons why!). In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, micro-organisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive containing also older genomes even potential genomes or that topological quantum computer programs [K1] determine the morphology to certain extent and that external conditions such as electric field determine the self-organization patters characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during the ontogeny could mean a gradual shift of the activated part of the memone, perhaps assignable to tqc programs, and be controlled by the gradually evolving electric field strength.

The finding that led Ebner to his discovery was that it was possible to "wake up" ancient bacteria by an exposure to an electrostatic field. The interpretation would be in terms of loading of metabolic batteries. This would also suggest that in the case of primitive life forms like bacteria the electric field of Earth has served as metabolic energy source whereas in higher life forms endogenous electric fields have taken the role of Earth's electric field.

2.4 A TGD based model for the situation

On basis of these observations one can try to develop a unified view about the effects of laser light, acupuncture, and DC currents. It is perhaps appropriate to start with the following - somewhat leading - questions inspired by a strong background prejudice that the healing process - with control signals from CNS included - utilizes the loading of many-sheeted metabolic batteries by supra currents as a basic mechanism. In the case of control signals the energy would go to the "moving of the control knob".

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies.

2. Supra currents flowing along magnetic flux tubes would make possible dissipation free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a completely general mechanism applying in various states of regeneration process. This might be the case. In quantal situation the metabolic energy quanta have very precise values as indeed required. For ohmic currents at room temperature the thermal energies are considerably higher than those corresponding to the voltage involved so that they seem to be excluded. The temperature at magnetic flux tubes should be however lower than the physiological temperature by a factor of order 10^{-2} at least for the voltage of -1 mV. This would suggest high T_c super-conductivity is only effective at the magnetic flux tubes involved. The finding that nerve pulse involves a slight cooling of the axonal membrane proposed in the TGD based model of nerve pulse [K4] to be caused by a convective cooling due the return flow of ionic Josephson currents would conform with this picture.

3. What meridians are and what kind of currents flow along them? Could these currents be supra currents making possible dissipation-free energy transfer in the healthy situation? Does the negative potential of order -1 mV make possible flow of protonic supra currents and loading of metabolic batteries by kicking protons to smaller space-time sheets? Could electronic supra currents in opposite direct induce similar loading of metabolic batteries? Could these tow miniature metabolisms realize control signals (protons) and feedback (electrons)?

The model answering these questions relies on following picture. Consider first meridians.

1. The direct feed of metabolic energy as universal metabolic currencies realized as a transfer of charge carriers to smaller space-time sheets is assumed to underly all the phenomena involving healing aspect. Meridian system would make possible a lossless metabolic energy feed - transfer of "Chi" - besides the transfer of chemically stored energy via blood flow. The metabolic energy currencies involved are very small as compared to .5 eV and might be responsible only for "turning control knobs". The correlation of the level of consciousness with the overall strength of DC electric fields would reduce to the level of remote metabolic energy transfer.

2. The model should explain why meridians have not been observed. Dark currents along magnetic flux tubes are ideal for the energy transfer. If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to $\hbar$, classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV. For large values of $\hbar$ an oscillating Josephson current would be in question. The semiconductor like structure at the end of meridian -possibly realized in terms of pair of space-time sheets with different sizes- makes possible a net transfer of metabolic energy even in this case as pulses at each half period of oscillation. The transfer of energy with minimal dissipation would thus explain why semiconductor like property is needed and why acupuncture points have high value of conductivity. The identification of meridians as invisible magnetic flux tubes carrying dark matter would explain the failure to observe them: one further direct demonstration for the presence of dark matter in biological systems.

3. In the case of regeneration process NEJs would be accompanied by a scaled down version of meridian with magnetic flux tubes mediating the electronic Josephson current during blastema generation and protonic supra current during the regeneration proper. Space-time sheets of proton *resp.* electron correspond to k_p and $k_e = k_p + 11$. In a static situation many-sheeted Gauss law in static situation would guarantee that voltages over NJE are same.

4. One can of course worry about the smallness of electrostatic energies ZeV as compared to the thermal energy. Zero point kinetic energy could correspond also to the magnetic energy of the charged particle. For sufficiently large values of Planck constant magnetic energy scale is higher than the thermal energy and the function of voltage could be only to drive the charged particles along the flux tubes to the target: and perhaps act as a control knob with electrostatic energy compensating for the small lacking energy. Suppose for definiteness magnetic field strength of $B = .2$ Gauss explaining the effects of ELF em fields on brain and appearing in the model of EEG. Assume that charged particle is in minimum energy state with cyclotron quantum number $n = 1$ and spin direction giving negative interaction energy between spin and magnetic field so that the energy is $(g-2)\hbar eB/2m_p$. Assume that the favored values of hbar correspond to number theoretically simple ones expressible as a product of distinct Fermat primes and power of 2. In the case of proton with $g \simeq 2.7927$ the standard metabolic energy quantum $E_0 = .5$ eV would require roughly $\hbar/\hbar_0 = 17 \times 2^{34}$. For electron $g - 2 \simeq \alpha/\pi \simeq .002328$ gives $\hbar/\hbar_0 = 5 \times 17 \times 2^{30}$.

Consider next NEJs and semiconductor like behavior and charging of metabolic batteries.

1. Since NEJ seems resembles cell membrane in some respects, the wisdom gained from the model of cell membrane and DNA as tqc can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterized by a large value of Planck constant are involved with both meridians and NJEs and might even dominate. Magnetic flux tubes act as Josephson junctions generating oscillatory supra currents of ions and electrons. For large values of $\hbar$ also meridians are short in the relevant dark length scale and act as Josephson junctions carrying oscillatory Josephson currents.

2. The findings of Becker suggest that acu points correspond to sensory receptors which are normally in a negative potential. The model for the effects of laser light favors (but only slightly) the assumption that in a healthy situation it is protons arriving along magnetic flux tubes which are kicked to the smaller space-time sheets and that negative charge density at acu point attracts protons to the acu point. Electrons could of course flow in reverse direction along their own magnetic flux tubes and be kicked to the smaller space-time sheets at the positive end of the circuit. In the case of brain, protonic end would correspond to the frontal lobes and electronic end to the occipital lobes. This kind of structure could appear as fractally scaled variants. For instance, glial cells and neurons could form this kind of pair with neurons in negative potential and glial cells in positive potential as suggested by the fact that neuronal damage generates positive local potential.

3. Classically the charge carriers would gain energy $E = ZeV$ as they travel along the magnetic flux tube to NJE. If this energy is higher than the metabolic energy quantum involved, it allows the transfer of charge carrier to a smaller space-time sheet so that metabolic resources are regenerated. Several metabolic quanta could be involved and the value of $V(t)$ would determine, which quantum is activated. The reduction of the V below critical value would lead to a starvation of the cell or at least to the failure of control signals to "turn the control knob". This should relate to various symptoms like pain at acupuncture points. In a situation requiring acupuncture the voltage along flux tubes would be so small that the transfer of protons to the smaller space-time sheets becomes impossible. As a consequence, the positive charge carriers would accumulate to the acu point and cause a further reduction of the voltage. Acupuncture needle would create a "wound" stimulating large positive potential and the situation would be very much like in regeneration process and de-differentiation induced by acupuncture could be understood.

Many questions remain to be answered.

1. What causes the de-differentiation of the cells? The mere charging of metabolic energy batteries perhaps? If so then the amount of metabolic energy- "chi"- possessed by cell would serve as a measure for the biological age of cell and meridian system feeding "chi" identified as dark metabolic energy would serve as a rejuvenating agent also with respect to gene expression. Or does the electric field define an external energy feed to a self-organizing system and create an electromagnetic environment similar to that prevailing during morphogenesis inducing a transition of cells to a dedifferentiated state? Or could DNA as tqc allow to understand the modification of gene expression as being due to the necessity to use tqc programs appropriate for regeneration? Or should cells and wounded body part be seen as intentional agents doing their best to survive rather than as passive parts of biochemical system?

2. Acupuncture and DC current generation are known to induce generation of endorphins. Do endorphins contribute to welfare by reducing the pain or do they give a conscious expression for the fact that situation has improved as a result of recharging of the metabolic energy batteries?

3. Could the continual charging of metabolic energy batteries by DC currents occur also in the case of cell membrane? The metabolic energy quantum would be around .07 eV in this case and correspond to p-adic length scale $k = 140$ for proton (the quantum is roughly a fraction 1/8 of the fundamental metabolic energy quantum .5 eV corresponding to $k = 137$).

3 Quantum model for effective semiconductor property

Becker [J2] summarizes his findings by stating that living matter is effective semiconductor. There are pairs of structures in positive and negative potential in various scales and the current between the plates of this effective capacitor flows when above some minimum potential difference. The current flows from positive to negative pole and could be electron current. Also proton current in opposite direction can be considered but electron current is experimentally favored. For instance consciousness is lost when magnetic field is used to deflect the current.

In TGD framework natural carriers of these currents would be magnetic flux tubes carrying also electric fields. A very simple deformation of the imbeddings of constant longitudinal magnetic fields gives also longitudinal electric field. With a slight generalization one obtains helical electric and magnetic fields. A crucial difference is that these currents would be quantal rather than ohmic currents even in the length scale of biological body and even longer scales assignable to the magnetic body.

The following argument allows to understand the physical situation.

1. A precise everyday analogy is vertical motion in the gravitational field of Earth between surface and some target at given height h. If the kinetic energy is high enough, the particle reaches the target. If not, the particle falls back. In quantum case one expects that the latter situation corresponds to very small probability amplitude at the target (tunneling to classically forbidden kinematic region).

2. Now electric field replaces gravitational field. Suppose that the classical electric force experienced by the particle is towards the capacitor plate taking the role of the surface of Earth. Below critical field strength the charged particle cannot reach the target classically and quantum mechanically this occurs only by tunneling with vanishingly small probability.

3. Particles with opposite value of charge experience force which accelerates them and classically they certainly reach the second plate. What happens in quantum situation? It seems that this situation is essentially identical with the first one: one has linear potential in finite interval and wave functions are localized in this range. One can equivalently regard these states as localize near the second capacitor plate.

4. A good analogy is provided by atoms: classically electron would end down to the nucleus but quantization prevents this. Also now one can imagine stationary solutions for which the electric currents for individual charges vanish at the plates although classically there would be a current in another direction. Also quantum mechanically non-vanishing conserved current is possible: all depends on boundary conditions.

3.1 Basic model

Consider now the situation at more quantitative level.

1. One can assign complex order parameters Ψ_k to various Bose-Einstein condensates of supra phases and obey Schrödinger equation

$$i\partial_t \Psi_k \quad = \quad (-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k E z)\Psi_k \quad . \tag{3.1}$$

   Here it is assumed that the situation is effectively one-dimensional. E is the value of constant electric field.

2. The Schrödinger equation becomes non-linear, when one expresses the electric field in terms of the total surface charge density associated with the plates of effective capacitor. In absence of external electric field it is natural to assume that the net surface charge densities σ at the plates are of opposite sign so that the electric field inside the capacitor is proportional to

$$\sigma \quad = \quad E = \sum \sigma_i = \sum_i q_i \overline{\Psi}_i \Psi_i \quad . \tag{3.2}$$

   This gives rise to a non-linear term completely analogous to that in non-linear Schrödinger equation. A more general situation corresponds to a situation in which the region interval $[a,b]$ bounded by capacitor plates a and b belongs to a flux longer tube like structure $[A,B]$: $[a,b] \subset [A,B]$. In this case one has

$$E_{tot} \quad = \quad E + E_0 \quad . \tag{3.3}$$

   This option is needed to explain the observations of Becker that the local strengthening of electric field increases the electron current: this would be the case in the model to be discussed if this field has a direct opposite to the background field E_0. One could also interpret E as quantized part of the electric field and E_0 as classical contribution.

3. The electric currents are given by

$$j_k \quad = \quad \frac{i\hbar q_k}{2m_k}\overline{\Psi}_k \partial_z^{\leftrightarrow} \Psi_k \quad . \tag{3.4}$$

   In stationary situation the net current must vanish:

$$\sum_k j_k \quad = \quad 0 \quad . \tag{3.5}$$

   A stronger condition is that individual currents vanish at the plates:

$$j_k \quad = \quad 0 \quad . \tag{3.6}$$

   It must be emphasized that this condition does not make sense classically.

3.2 Explicit form of Schrödinger equation

Consider now the explicit form of Schrödinger equation in given electric field.

1. The equation is easy to solve by writing the solution ansatz in polar form (the index k labelling the charge particle species will be dropped for notational convenience).

$$\Psi = R(aexp(iU) + bexp(-iU))exp(-iE_n t) \tag{3.7}$$

For real solutions current vanishes identically and this is something which is not possible classically. It is convenient to restrict the consideration to stationary solutions, which are energy eigen states with energy value E_n and express the general solution in terms of these.

2. The Schrödinger equation reduces with the change of variable

$$\begin{aligned} z &\rightarrow \frac{(z-z_0)}{z_1} \equiv x \ , \\ z_0 &= \frac{E_n}{qE} \ , \ z_1 = (\frac{\hbar^2}{2mqE})^{1/3} \ . \end{aligned} \tag{3.8}$$

to

$$(\partial_x^2 + x)\Psi = 0 \ . \tag{3.9}$$

The range $[0, z_0]$ for z is mapped to the range $[-z_0/z_1, 0]$. z_0/z_1 has positive sign as is easy to verify. The value range of x is therefore negative irrespective of the sign of qE. This is equation for Airy functions [B1]. Airy functions are encounterd in WKB approximation in the approximation that potential function is linear. These functions appear also in the model of rainbow.

The change of variable leads automatically to solutions restricted near the plate where the situation is completely analogous to that in gravitational field of Earth. For stationary solutions test charge in a given background field would be localized near capacitor plate with opposite sign of charge. A strong background field could be created by charges which do not correspond to the ionic charges defining ionic currents. Electrons and protons could define this field possibly associated with flux tubes considerably longer than the distance between capacitor plates.

3. Using the polar representation $\Psi = Rexp(iU)$ Schrödinger equation reduces to two equations

$$\begin{aligned} \left[(\partial_x^2 - U_x^2 + x)R\right] cos(U) &+ \left[U_{xx} + 2\partial_x R \partial_x U\right] sin(U) = 0 \ , \\ \left[(\partial_x^2 - U_x^2 + x)R\right] sin(U) &- \left[U_{xx} - 2\partial_x R \partial_x U\right] cos(U) = 0 \ . \end{aligned} \tag{3.10}$$

Note that both (R, U) and $(R, -U)$ represent solutions for given value of energy so that the solution can be chosen to be proportional to $cos(U)$ or $sin(U)$. The electric current j is conserved and equal to the current at $x = 0$ and given by

$$j = \frac{\hbar}{2m}\frac{U_x}{z_1}R^2 \ , \ z_1 = (\frac{\hbar}{2mqE})^{1/3} \ . \tag{3.11}$$

The current vanishes if either U_z is zero or if the solution is of form $\Psi = Rsin(U)$.

3.3 Semiclassical treatment

In semiclassical approximation potential is regarded as so slowly varying that it can be regarded as a constant. In this situation one can write the solution of form $Rexp(iU)$ as

$$\Psi = R_0 exp\left(\frac{i}{\hbar}\int_0^z \sqrt{2m}\sqrt{E-qEz}dz\right) = R_0 exp\left(i\int_0^x x^{1/2}dx\right) \quad . \tag{3.12}$$

The plate at which the initial values are given can be chosen so that the electric force is analogous to gravitation at the surface of Earth. This requires only to replaced coordinate z with a new one vanishing at the plate in question and gives to the energies a positive shift $E_0 = qE_0h$.

1. The semiclassical treatment of the equation leads to Bohr rules

$$\frac{\oint p_z dz}{\hbar} = \frac{2}{\hbar}\int_0^h p_z dz = n \quad . \tag{3.13}$$

   This gives

$$\frac{\oint p_z dz}{\hbar} = \frac{2\sqrt{2m}}{\hbar}\int_0^h \sqrt{E_n - qEz}dz = 2\int_0^{x_0} x^{1/2} = \frac{4}{3}x_0^{3/2} = n \quad . \tag{3.14}$$

   Note that the turning point for classical orbit corresponds to $z_{max} = E_n/qE$.

2. One obtains

$$E_n = \frac{1}{2}(\frac{nqE\hbar^2}{r\sqrt{m}})^{2/3} \quad , \quad r = \int_0^1 (1-u)^{1/2}du = \frac{2}{3} \quad . \tag{3.15}$$

   The value of z_{max} is

$$z_{max} = \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}}(\frac{\hbar^2}{qEm})^{1/3} \quad . \tag{3.16}$$

3. The approximation $R = R_0 = constant$ can make sense only if the position of the second plate is below z_{max}. This is possible if the value of n is large enough ($n^{2/3}$ proportionality), if the mass m of the charged particle is small enough ($m^{-1/3}$ proportionality raising electron and also proton to special position, or if the strength of electric field is small enough ($E^{-1/3}$ proportionality). The value z_{max} is proportional to $\hbar^{2/3}$ so that a phase transition increasing Planck constant can induce current flow.

3.4 Possible quantum biological applications

The proposed model for quantum currents could provide quantum explanation for the effective semiconductor property of DC currents of Becker.

1. The original situation would be stationary with no currents flowing. The application of external electric field in correct direction would reduce the voltage below the critical value and currents would start to flow. This is consistent with Becker's findings if there is background electric field E_0 so that the applied field has direction opposite to E_0 so that the field strength experienced by charged particles is reduced and it is easier for them to reach the second plate. This is of course a possible objection against the proposal.

2. Becker's DC currents appear in several scales. They are assigned with the pairs formed by CNS and perineural tissue (this includes also glia cells) and by frontal and occipital lobes. Acupuncture could involve the generation of a DC supra current. The mechanism would be essential in the healing. Also the mechanism generating qualia could involve generation of supra currents and dielectric breakdown for them. The role of the magnetic flux tubes in TGD inspired biology suggests that the mechanism could be universal. If this were the case one might even speak about Golden Road to the understanding of living matter at basic level.

Even the generation of nerve pulse might be understood in terms of this mechanism. One can argue that neurons have higher evolutionary level than the system pairs to which only electron currents or electron and proton currents can be assigned. This because the value of Planck constant is higher for the magnetic flux tubes carrying the quantal ionic currents.

1. For Bose-Einstein condensate the simplest choice is $n = 1$ at both plates. The energy eigenvalues would naturally differ by the shift $E_0 = qE_0h$ at the two plates for given particle type. Under these assumptions the current can flow appreciably only if the voltage is below the minimum value. This is certainly a surprising conclusion but brings in mind what happens in the case of neuronal membrane. Indeed, hyper-polarization has a stabilizing - something difficult to understand classically but natural quantum mechanically.

2. The reduction of membrane potential slightly below the resting potential generates nerve pulse. Also a phase transition increasing the value of Planck constant might give rise to quantal direct currents and generate flow of ionic currents giving rise to nerve pulse. Stationary solutions are located near either capacitor plate. What comes in mind is that nerve pulse involves a temporary change of the capacitor plate with this property.

3. If electron and proton currents flow as direct currents, one encounters a problem. Nerve pulse should begin with direct electronic currents and followed by direct protonic currents and only later ions should enter the game if at all. The existing model for nerve pulse however assumes that at least electrons flow as oscillating Josephson currents rather than direct quantal currents. This is quite possible and makes sense if the cell membrane thickness small - that is comparable to electron Compton length as assumed in large $\hbar$ model for the nerve pulse. This assumption might be necessary also for proton and would make sense if the Planck constant for protonic flux tubes is large enough. For ions the Compton length would be much smaller than the thickness of cell membrane and direct currents would be natural.

   If the Planck constant is same for biologically important ions, direct quantum currents would be generated in definite order since in $h < z_{max}$ one has $z_{max} \propto m^{-1/3} \propto A^{-1/3}$. The lightest ions would start to flow first.

   (a) Nerve pulses can generated by voltage gated channels for potassium and calcium. Voltage gated channels would correspond to magnetic flux tubes carrying electric field. For voltage gated channels Na^+ ions with atomic weight $A = 23$ and nuclear charge $Z = 11$ start to flow first, then K^+ ions with atomic weight $A = 39$ and $Z = 19$ follow. This conforms with the prediction that lightest ions flow first. The nerve pulse duration is of order 1 millisecond at most.

   (b) Nerve pulses can be also generated by voltage gated Ca^{+2} channels. In this case the duration can be 100 ms and even longer. Ca has $A = 40$ and $Z = 20$. The proper parameter is $x = r^2/qA$, $r = \hbar/\hbar_0$. One has

$$\frac{x(Ca^{++})}{x(Na^+)} = (\frac{r(Ca^{++}}{r_(Na^+)})^2 \times \frac{23}{2 \times 40} \quad . \tag{3.17}$$

   $r^2(Ca_{++}) \sim 2r^2(Na_+)$ would allow to compensate for the increased weight and charge of Ca_{++} ions.

4. The objection is that Na^+ and K^+ are not bosons and therefore cannot form Bose-Einstein condensates. The first possibility is that one has Cooper pairs of these ions. This would imply

$$\frac{x(Ca^{++})}{x(2Na^{+})} = (\frac{r(Ca^{++}}{r_(Na^{+})})^2 \times \frac{23}{20} \quad .$$

Ca^{++} and Na^{+} pair would be in very similar position for a given value of Planck constant. This is a highly satisfactory prediction. Another manner to circumvent the problem is more science fictive and assumes that the Na^{+} ions are exotic nuclei behaving chemically as Na^{+} but having one charged color bond between nucleons [K3].

It remains to be seen whether this model is consistent with the model of cell membrane as almost vacuum extremal or whether the vacuum extremal based model could be modified by treating ionic currents as direct currents. In the vacuum extremal model classical Z^0 gauge potential is present and would give a contribution to the counterpart of Schrödinger equation. The ratio $x(Ca^{++})/x(2Na^{+})$ for the parameter $x = r^2/q(A-Z)A$ (em charge q is replaced with neutron number in good approximation) equals to 1.38 and is not therefore very far from unity.

The many-sheetedness of space-time is expected to play a key role and one should precisely specify which sheets are almost vacuum extremals and which sheets are far from vacuum extremals. One expects that magnetic flux tubes are far from vacuum extremals and if voltage gated ionic channels are magnetic flux tubes, the proposed model might be consistent with the model of cell membrane as almost vacuum extremal.

3.5 Negentropic entanglement, metabolism, and acupuncture

It is interesting to try to develop a detailed model of acupuncture in TGD framework. Consider following assumptions.

1. ATP (metabolic energy) - negentropic entanglement connection is true and formation of high energy phosphate bond generates somehow negentropic entanglement.

2. Pain means loss of negentropic entanglement and healing at the fundamental level - in particular pain relief - involves regeneration of negentropic entanglement.

3. Fundamental metabolic energy currencies correspond to zero point kinetic energies $E_0 \simeq \pi^2/2mL^2$ at space-time sheets labelled by p-adic primes determining their size scale $L = (\hbar/\hbar_0)L_p$. Therefore the generation of metabolic energy storages means at fundamental level driving charged particles to smaller space-time sheets (the smaller the space-time sheet, the higher the zero point kinetic energy). The driving force is basically electric force so that electric fields are needed.

4. Metabolic energy storage - generation of ATP - means generation of negentropic entanglement. Assume that this entanglement is assignable to the smaller space-time sheet.

   (a) The simplest possibility is that the electrons at this space-time sheet form Cooper pairs and negentropic entanglement is between them. The decay of Cooper pairs would make ATP unstable and the decay to ADP would mean use of metabolic energy quantum and also a loss of negentropic entanglement. This conforms with the generalized form of the second law allowing generation of genuine negentropy but predicting that it does not last for ever. The lifetime of ATP - about 40 minutes [I8] - gives an estimate for the life time of the electronic Cooper pairs. The negative charge of ATP would be due to the electronic Cooper pairs.

   (b) A simple estimate for the order of magnitude of Kähler magnetic energy of the flux tube assuming far from vacuum extremal and quantization of the Kähler magnetic flux ($B_K S = n\hbar$ for constant magnetic field in a flux tube of cross section S) shows that the Kähler magnetic energy is much higher than zero point kinetic energy of electron pair. Especially so for large values of $\hbar$ since magnetic energy behaves as $E_B \propto \hbar^3 L_0/S$ by the proportionalities $B \propto \hbar B_0$ and $L = \hbar L_0$. In this case the magnetic flux tube should be pre-existing and correspond to acupuncture meridian emerging from the node.

(c) For near vacuum extremals the flux tube could be generated in the process. The use of the metabolic energy would mean dropping of electrons to larger space-time sheet and possibly even the disappearence of the magnetic flux tube in this case. This option does not look too plausible however.

5. The generation of metabolic energy storages (ATP) requires energy feed. In the formation of ATP from ADP the acceleration of protons and electrons in the electric of cell membrane plays a key role. The electric energy gained in the process is transformed to metabolic energy and could means the formation of a flux tube carrying the Cooper pair. Assume that a similar process occurs also in much longer length scales for weaker electric fields scaling like $1/\hbar^2$ for given p-adic prime (and $1/L_p^2$ as function of p-adic length scale) so that electric potential between the ends of the flux tube remains the same. Assume that quantum direct currents are in question. If so, the function of the direct currents of Becker can be identified as a manner to generate metabolic energy and negentropic entanglement. This is natural since healing is involved.

Armed with these assumptions one can try to understand why metal needles are essential for acupuncture.

1. The basic idea is that the presence of the needle makes possible the generation of direct quantal currents accelerating electrons in electric field which is sum of pre-existing field and the field possibly generated by the needle. After gaining some minimum energy electrons can jump to a smaller space-time sheet and give rise to negentropically entangled Cooper pairs.

2. The needle could serve as a mere donor of electrons giving rise to a quantal direct current in turn leading to the generation of metabolic energy and negentropic entanglement.

3. Second possibility is that the needle also generates a strong additional contribution to the existing electric field.

   (a) Basic wisdom from from electrodynamics is that any sharp conducting charged object - such as metal needle- tends to create a strong electric field around the tip. This is the reason for why one should not go below a tree during thunder storm. Suppose that acupuncture needle becomes charged when touching the skin. One could test this assumption by replacing acupuncture needles with non-conducting material to see whether the healing effect is lost. One could also test whether the metal need is in non-vanishing potential with respect to Earth or measure directly the electric field in the vicinity of the needle tip.

   (b) If the needle generates negative charge, an opposite charge must be generated somewhere else and electric field lines connecting the needle and its end to it. These field lines could be along magnetic flux tubes carrying also longitudinal electric field. The natural assumption is that the flux tubes correspond to meridians emanating from the acupuncture node to which needle is sticked to. Another possibility is that needle remains neutral as total but develops a density of surface charge via polarization in existing electric field. Also in this case an additional electric field is generated and should be analogous to that of a a thin electric dipole in external electric field.

   (c) Under these assumptions quantum currents can flow along the meridians and load the metabolic batteries provided the strength of the generated field is high enough. The situation could resemble quite closely to that for the generation of nerve pulse. There would be pre-existing electric field along flux tuve not too far from critical for the generation of quantal direct current. The field generated by the needle would induce depolarization so that quantal direct current of some minimal strength could flow between the ends of the flux tube with acceleration giving providing electrons with energy making possible transfer to the smaller space-time sheet.

Nanna Goldman et al have provided empirical evidence [I2] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily [I1]).

The group has found that adenosine is essential for the pain killing effects of acupuncture. For mice with a normal adenosine level acupuncture reduced dis-comfort by two-thirds. In special "adenosine receptor knock-out mice" acupuncture had no effect. When adenosine was turned on in the tissues,

the discomfort was reduced even in the absence of acupuncture. During and after an acupuncture treatment, the level of adenosin in tissues near the needles was 24 times higher than before the treatment. In the abstract of the article it is stated that it is known for long time that acupuncture generates signals which induce brain to generate natural pain killing endorphins but that also adenosine acts as a natural pain killer.

Adenosine is the basic building block of AXP, X=M,D,T (adenosin-X-phosphate, X=mono,di,tri). Therefore the findings suggest that the electric fields generated or amplified by the presence of acupuncture needles loads metabolic batteries by generating ATP. Adenosine could be partially generated as decay products of AXPs. Tissue itself could increase adenosine concentration to make possible its transformation to AXP utilizing electric field energy. From the popular article one cannot conclude whether the authors propose a connection with metabolism. The results are consistent with the assumption that the AXPs generated from adenosin accompany negentropic entanglement. This can occur in the scale of entire body and meridians could also make possible direct signalling with brain.

3.6 The effects of ELF em fields on vertebrate brain

The effects of ELF em fields on vertebrate brain occur both in frequency and amplitude windows. Frequency windows can be understood if the effect occur at cyclotron frequencies and correspond to absorption of large $\hbar$ photons. A finite variation width for the strength of magnetic field gives rise to a frequency window. The observed quantal character of these effects occurring at harmonics of fundamental frequencies leads to the idea about cyclotron Bose-Einstein condensates as macroscopic quantum phases. The above considerations support the assumption that fermionic ions form Cooper pairs.

I have tried to understand also the amplitude windows but with no convincing results. The above model for the quantum currents however suggests a new approach to the problem. Since ELF em fields are in question they can be practically constant in the time scale of the dynamics involved. Suppose that the massless extremal representing ELF em field is orthogonal to the flux tube so that the ions flowing along flux tube experience an electric force parallel to flux tube. What would happen that the ions at the flux tube would topologically condensed at both the flux tube and massless extremal simultaneously and experience the sum of two forces.

This situation is very much analogous to that defined by magnetic flux tube with longitudinal electric field and also now quantum currents could set on. Suppose that semiconductor property means that ions must gain large enough energy in the electric field so that they can leak to a smaller space-time sheet and gain one metabolic quantum characterized by the p-adic length scale in question. If the electric field is above the critical value, the quantum current does not however reach the second capacitor plate as already found: classically this is of course very weird. If the electric field is too weak, the energy gain is too small to allow the transfer of ions to smaller space-time sheet and no effect takes place. Hence one would have an amplitude window.

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other frequency ranges might be possible. Fractality and the notion of magnetic suggests a possible explanation for the widely different frequency ranges. Both p-adic length scale hypothesis and the hierarchy of Planck constants suggest that some basic structures associated with the cell membrane have fractal counterparts in a wide length scale range and correspond to binary structures. Magnetic flux tubes carrying quantal DC currents of Becker would be the most natural candidate in this respect since these currents appear in several length scales inside organism. Also the counterparts of lipid layers of cell membrane could be involved. If so, one must include to the hierarchy of amplitude windows also fields in the range corresponding to the cell membrane resting potential of about 6×10^6 V/m. This is of course only a rough order of magnitude estimate since perturbations of these field are in order.

By fractality the most natural guess is that the voltage along the flux tube is invariant under the scale of Planck constant. This would mean that the electric field would behave as $1/L^2 \propto 1/\hbar^2$ as a function of the length scale characterizing the scale variant of the structure. If so the range $E = 1-10$ V/m assignable also to EEG would correspond to a length scale of $7.7 - 24$ μm corresponding to cell length scale. Perhaps the direct currents run between cells layers. $E = 10^{-7}$ V/m would in turn correspond to 7.8 cm which corresponds to size scale of human brain hemisphere (experiments were carried out for vertebrates). Could the direct quantum currents in question run between brain hemispheres along corpus callosum?

3.7 Effects of 50 Hz magnetic fields on living matter

The vision about the role of cyclotron Bose-Einstein condensates was inspired by the effects of ELF em fields on vertebrate brain. The magnetic field strength explaining the effects was about .2 Tesla, 2/5 of the nominal value for the strength of Earth's magnetic field.

There are also other experiments have demonstrated that oscillating electromagnetic fields have effects on living matter. In particle oscillatory magnetic fields with frequency of 50 Hz and with field strengths typically in the range .1-1 mT are used: these effects are summartized in [J4]. Even fields of order .14 Tesla are used.

It is interesting to look at the values of basic parameters associated with these fields.

1. For 50 Hz oscillation frequency the wave length λ is 6000 km to be compared with the radius of Earth which is 6371 km. If one takes seriously the notion of magnetic body this need not be an accident. I do not know how essential it is to have just 50 Hz frequency. The magnetic field is nearby oscillating dipole field up to distances of order λ and radiation field at much longer distances. Therefore the field in question is in good approximation nearby field as fart as biological body is considered. For magnetic body the radiation field could dominate

2. For the endogenous magnetic field $B_{end} = .2$ Gauss cyclotron frequencies of ions are in EEG range: Ca^{++} cyclotron frequency is 15 Hz. The scaling up to r= .1-1 mT means scaling of cyclotron frequences by a factor $5 - 50$. For Ca^{++} this would give frequency range 75-750 Hz. For K^+ and Cl^+ ions the frequency range would be about 35-375 Hz.

3. The magnetic length $r = \sqrt{2/eB}$ characterizing flux tube thickness for flux quantization with minimum value of flux is for $B = .05$ mTesla equal to 5 μm. For the fields in the range .1-1 mTesla it is in the range 3.5 μm- 1.1 μm. 2.5 μm corresponds to p-adic length scales $L(k)$ associated with Gaussian Mersenne $M_{G,k} = (1+i)^k - 1$, $k = 167$, and Gaussian Mersenne correspondng to $k = 163$ would correspond to p-adic length scale .36 μm. .14 Tesla corresponds to magnetic length of 9.4 nm rather near to cell membrane thickness of 10 nm which corresponds to p-adic length cale L(151) assignable to Gaussian Mersenne $M_{G,151}$.

3.8 The effects of polarized light on living matter

Polarized light is known to have effects on living matter [J4]. For instance, Peter Gariaev has found that the polarized light generated by living matter sample irradiated by polarized laser light has effects on distant organism and there are even indications that genetic code might be realized in terms of radiation patterns [K6]. The quantum model for Becker currents suggest that these effects result as a modification of the voltage between the ends of magnetic flux tubes If the flux tubes are near criticality for the generation of quantal DC currents, polarized light could be utilized both communication and control purposes wheres the acceleration in the electric fields along flux tubes would serve as a provider of metabolic energy allowing to load metabolic batteries. This process could be initiated by an electromagnetic signal inducing generation of quantal currents. The same basic mechanism could be at work also in DNA transcription, replication and other similar processes.

If the polarized low frequency radiation corresponds to a massless extremal (ME) orthogonal to the flux tube such that the polarization of the radiation is parallel to the flux tube, the voltage is affected by a contribution given by $\Delta V = Ed$, d the thickness of ME. If the flux tube is near criticality to a generation of quantal currents this change of voltage could serve as a signal inducing the generation of quantal currents.

The maximal effect is obtained for the flux tubes having direction parallel to the electric polarization so that the effect is highly selective. In the case of DNA double strand the direction of flux tube changes so that the effect would be maximal on DNAs which correspond to the same angular position on the super-coil of radius of order 10 nm formed by DNA double helix. This allows to imagine signals for which temporal variation of polarization direction means scanning of DNA.

It is known that the energy of radiation can be transformed to metabolic energy. For instance, IR light for which photons have energies of order metabolic quantum has biological effects [I4]. The mechanism could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current

and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

Suppose that one takes seriously the model for remote replication of DNA [K6] involving flux tubes connecting identical DNA nucleotides and that the radiation propagating along them induces quantal currents along the receiving DNA inducing replication and perhaps even transcription. The direction of polarization for the emitted radiation should be parallel to the DNA strand locally and during its travel to the target the polarization should remain orthogonal to the flux tube so that one would have what might be called polarization window. Parallel translation of the polarization vector in the induced metric suggests itself.

3.9 Support for the proposed interaction mechanism of em radiation fields with flux tubes

The basic prediction of the interaction mechanism is that the effects of em field with a given frequency occur only at the second half period when the direction of electric field is "correct". This prediction might be testable. In fact, there is evidence for this interaction mechanism in the case of theta waves of EEG. The memory storage occurs only at the second half of the theta wave This is discussed from different point of view in [K1].

The place coding by phase shifts was discovered by O'Reefe and Recce [J3]. In [J6, J5]. Y. Yamaguchi describes the vision in which memory formation by so called theta phase coding is essential for the emergence of intelligence. It is known that hippocampal pyramidal cells have "place property" being activated at specific "place field" position defined by an environment consisting of recognizable objects serving as landmarks. The temporal change of the percept is accompanied by a sequence of place unit activities. The theta cells exhibit change in firing phase distributions relative to the theta rhythm and the relative phase with respect to theta phase gradually increases as the rat traverses the place field. In a cell population the temporal sequence is transformed into a phase shift sequence of firing spikes of individual cells within each theta cycle.

Thus a temporal sequence of percepts is transformed into a phase shift sequence of individual spikes of neurons within each theta cycle along linear array of neurons effectively representing time axis. Essentially a time compressed representation of the original events is created bringing in mind temporal hologram. Each event (object or activity in perceptive field) is represented by a firing of one particular neuron at time τ_n measured from the beginning of the theta cycle. τ_n is obtained by scaling down the real time value t_n of the event. Note that there is some upper bound for the total duration of memory if scaling factor is constant.

One can say that neurons in ensemble provide a representation for the external world and the location of the rodent in the external world is represented as a firing of a neuron in this landscape. Besides this also temporal scaling down by a factor about ten is carried out so that actual event is represented as much shorter copies of it. Obviously this represents temporal fractality.

This scaling down - story telling - seems to be a fundamental aspect of memory. Our memories can even abstract the entire life history to a handful of important events represented as a story lasting only few seconds. This scaling down is thought to be important not only for the representation of the contextual information but also for the memory storage in the hippocampus. Hierarchy of Planck constants and phase transitions changing Planck constant make this story building possible.

The finding of Yamaguchi and collaborators relevant in the recent context is that the gradual phase shift occurs at half theta cycle whereas firings at the other half cycle show no correlation [J6]. The proposed model for the interaction of theta waves with flux tubes could explain this naturally. The relevant neural sub.system would be critical to the generation of quantal DC current only when the direction electric field of synchronizing theta wave generated by magnetic body is correct. Hence synchronous neural activity would be induced only at second half cycle of theta wave and firing would be random during the other half cycle.

4 A model for remote gene expression based on Becker currents

If one accepts the notion of magnetic body as intentional agent, the basic challenge is to understand how magnetic body realizes its intents as remote mental interactions on biological body. This

model must of course apply also to the more conventional remote mental interactions such as remote realization of intent.

The hypothesis is that electromagnetic and possibly also other massless classical fields assignable to so called massless extremals are in a key role. Also cyclotron frequencies characterizing magnetic bodies play a key role. The vision is that magnetic flux sheets traverse many-sheeted DNA in various scales giving rise to a hierarchy of genomes and coherent gene expression in scales of cell, organelles, organism, and even population, and species. Hierarchy of Planck constants is in an essential role in realizing this hierarchy in terms of photons with energies above the thermal energy at physiological temperature and having spectrum of wavelengths coming as multiples $\lambda = n\lambda_0$, $n = \hbar/\hbar_0$.

The findings of Benveniste and followers relating to water memory and homeopathy, the recent work of group led by HIV Nobelist Luc Montagnier coupling the findings with genetics and suggesting a new nanoscale realization of genetic code (see this [L1]), the work of the group of Popp with biophotons identified as decay produces of large $\hbar$ photons with visible energies (in particular dark EEG photons), and the work of Peter Gariaev and collaborators supporting remote gene expression and replication discussed here suggest that electromagnetic radiation is indeed involved [K6]. In the case of water memory and homeopathy the spectrum of cyclotron frequencies for the chemical invader characterizes it and induces immune response trying to eliminate it. I have also proposed a model for how genes coding for proteins eliminating the invader could be generated almost automatically: the model is based on the predicted realization of vertebrate genetic code in terms of dark proton states (see this [K2]). DNA would like an animal which sniffs the invaders magnetic body and automatically reacts to the smell.

The discussions with Lian Sidorov and people who have realized that new era is beginning in biology have served as a driving force in the attempts to formulate in more detail TGD inspired view about how remote mental interactions - which are basic element of the model in TGD framework - might be realized. As a matter fact, I have added to my homepage a new book summarizing briefly the recent view about quantum TGD and its applications to quantum consciousness, quantum biology, to quantum neuroscience, and to remote mental interactions with some proposals for possible tests [K5]) (see this) .

To start with, suppose that in the case of biological target realization of intent in the simplest situation reduces to expression of genes. This is of course a strong limitation to the type of remote mental interactions. The challenge is to develop a model for remote realization of genetic activities like replication, and transcription. For some time ago I proposed a model with Peter Gariaev [K6] but it was still too clumsy since it required too much of information transfer between the genomes of sender and receiver. Much simpler model involving only sending of simple commands initiating genetic programs suggests itself. The following proposal tries to achieve this and involves three basic ideas.

1. The idea of password and addressing is familiar from ordinary computers. Collection of frequencies as password/address allows to reach tuned targets without specific targeting of the command. This is a dramatic improvement to the previous model.

2. Password and fractal addressing realized in terms of frequencies coupling resonantly (already in the original model: I did not however realize the implications of resonant coupling!) and the hierarchy of Planck constants to realize the hierachical addressing. I have discussed analogous addressing based on information molecules and their receptors at the biochemical level to realize magnetic flux tube connections between sender and target inside organism (hormonal action would be very analogous to what I am proposing here).

3. Becker's DC currents as supra currents flowing along DNA and activated optimally when the incoming laser light has polarization parallel to DNA's local direction, activation of super currents would mean activation of the gene. This is second new element to the original model.

In the following I discuss this with more details.

4.1 The analogy with ordinary computer

Consider first the analog of remote mental interactions for ordinary computer. Computer sends a password to the other computer and after that it can use it to run programs of the other computer.

Whisling to a dog is another example: extremely simple command activates arbitrary complex programs.

In the recent case electromagnetic radiation with a given frequency coupling resonantly like radio signal to a tuned radio receiver would be the simplest command activating the target. There would no need to specify the direction or distance of the target precisely since essentially mass communications would be in question: intent would be enough. Password could consist of several frequencies which must be received simultaneously by the target before it would activate and tunes to receive more frequencies representing simple commands - perhaps acting on the intronic portion of DNA and activating the genome to remote gene expression or something else such as activating DNAs of other cells by sending similar em addresses!

I have discussed topological quantum computer programs based on braiding could look like in this framework [L3]. Also here addressing but now realized as information molecule-receptor pair would play a key role.

4.2 Hierarchy of Planck constants and hierarchical addressing

Fractal hierarchy of frequencies (in Peter's experiment laser light induced generation of radiation at frequencies down to about 10 kHz) would allow to transform passwording to addressing. Very naively, the longest wavelengths: about 10^4 meters would reach the tuned receivers in nearly the same phase in a region of this size. One would have some subregions in tune. The shorter wavelengths would allow to pinpoint the tuned receivers inside each of these subregions and so on. This would be fractal addressing with most significant bits correspond to the longest wavelengths. Only those receivers which would be tuned to all frequencies would start to express the gene in the case of AND logic. Of course, also other Boolean functions of tuned-not tuned bits can be considered.

A good guess is that all photons correspond to same energy of visible photon and only Planck constant varies. For ordinary value of Planck constant one would have a photon with wavelength of order size scale of single cell, and the frequencies in this range would select single gene in the genome ofa particular kind of cell, say neuron within particular region of brain.

In Peter Gariaev's experiment involving 2 eV incoming red laser light the outgoing photons would have same energy but larger Planck constant so that also wavelengths would be longer and range down to at least 3×10^4 meters corresponding to radiofrequency scale of 10 kHz. What is interesting that 2 eV is 4 times the nominal value of the metabolic energy quantum of .5 eV identifiable as zero point kinetic energy of electron or proton for the p-adic length scale $L(151)$ corresponding to cell membrane thickness and Gaussian Mersenne $M_{151} = (1+i)^{151} - 1$. Could it be that 2 eV could be preferred photon energy or is its use simply due to the unavailability of continuous frequency spectrum for laser light. And why the laser light induces the generation of the command inducing remote gene expression?

This picture conforms with Peter's experiment and with the reports of Benveniste and followers about the possibility of representing homeopathic remedy using very low frequency spectrum - presumably cyclotron frequencies - assignable to remedy. These frequencies would be addresses for genes activating genes transcribing building bricks of biomolecules of immune response eliminating the substance from the organism. The proposal could be seen as a generalization of Benveniste's observation and realization of wave DNA proposal.

4.3 DNA supra currents and activation of genes by Becker mechanism

The third bulding brick of the model would be quantum model for Becker currents [L4] as supra currents or quantal DC currents [L4]: also this element is new. Assume - in accordance with the general vision - that these supra currents can flow also along the strands of many-sheeted DNA (flux sheets associated with the strand, entire hierarchy labelled by the values of $\hbar$). Assume also that the interaction of polarized photons addressing for genes with DNA is such that the electric fields of DNA flux tube and "massless extremal" representing laser beam superpose and charges (electrons) experience the superposition of field already present and the field of ME. If the net electric field is near criticality originally (think as analog neuronal membrane) and becomes over-critical, quantal Becker current starts to flow and the machinery responsible for gene activation is activated.

This means also the activation of metabolic machinery since the acceleration of electrons in the electric field gives them energy making possible a transfer to smaller space-time sheets where they

form Cooper pair like states with negentropic entanglement. Metabolic energy corresponds to zero point kinetic energy and negentropic entanglement is relevant from the point of view of consciousness: in the case of healing understood as a regeneration of negentropic resources this aspect is especially important. This mechanism generates high energy phosphate bonds in ATP and the decay ATP $\rightarrow$ ADP liberates the metabolic energy and destroys the negentropic entanglement possibly associated with ATP so that the second law in generalized form [L2] allowing local generation of genuine negentropy (but assigned to information carried by entanglement defining a quantum rule) wins after all.

It could also happen that the decay of ATP generates dark photon or photons absorbed by cyclotron condensate at magnetic flux tube. The excited state is non-local single particle excitation and involves very simple negentropic entanglement between the particles of the condensate. In this case the negentropy of ATP would be transformed to the negentropy of the magnetic flux tube or even several of them if large value of Planck constant is associated with the photon. This mechanism could allow the generation of negentropic entanglement associated with attention. The storage of metabolic energy in photosynthesis could involve similar excitation of cyclotron state at the first step. The most plausible candidate is cyclotron condensate for electron Cooper pairs. Also electrons filling state up to some Fermi energy could be in question. In this case the excitations would be excitation in longitudinal degrees of freedom of the flux tube generating current.

5 DNA, speech, music, and ordinary sound

Peter Gariaev's group has made rather dramatic claims about DNA during years [I3, I6, I5, I7].

1. The group has proposed that the statistical distributions of nucleotides and codons in the intronic portion of DNA resemble the distribution of letters and words in the natural languages [I7]. For instance, it is proposed that Zipf law [J7] applying to natural languages applies to the distributions of codonds in the intronic portion of DNA. One can study the popularity of the words in natural languages and order them against their popularity. Zipf law states that the integer characterizing popularity is in constant proportion to the number of times it appears in given long enough text.

2. It has been also claimed that DNA can be reprogrammed using modulated laser light or even radio waves. I understand that reprogramming means a modified gene expression. Gariaev's group indeed proposes that the meaning of the third nucleotide (having a rather low significance in the DNA-aminoacid correspondence) in the genetic codon depends on the context giving rise to a context dependent translation to amino-acids. This is certainly a well-known fact for certain variants of the genetic code. This context dependence might make possible the reprogramming. The notion of dark DNA allows to consider much more radical possibility based on the transcription of dark DNA to mRNA followed by translation to aminoacds. This could effectively replaced genes with new ones.

3. Also the modulation of the laser light by speech is claimed to have the re-programming effect. The broad band em wave spectrum resulting in the scattering of red laser light on DNA is reported to have rather dramatic biological effects. The long wave length part of this spectrum can be recorded and transformed to sound waves and these sound waves are claimed to have the same biological effects as the light. The proposal is that acoustic solitons propagating along DNA represent this effect on DNA.

I do not have the competence to make statements about the plausibility of these claims. TGD view about quantum biology makes also rather strong claims. The natural question is however whether a justification for the claims of Gariaev and collaborators could be found in TGD framework? In particular, can one say about possible effects of sound on DNA. One intriguing fact about sound perception is that music and speech have meaning whereas generic sounds to not. Could one say something interesting about how this meaning is generated at the level of DNA?

5.1 Basic picture

Before continuing it is good to restate the basic TGD inspired ideas about the generation of meaning.

1. The generation of the negentropic entanglement is the correlate for the experience of the meaning. In the model inspired by Becker's findings, the generation of negentropic entanglement involves a generation of supra currents along flux tubes moving in the electric field parallel to them. This is a critical phenomenon taking place when the voltage along the flux tube is near critical value. The generation of nerve pulse near critical value of the resting potential is one example of this criticality. Becker's direct currents involved with the healing of wounds is another example.

   The flow of the supra current gives rise to the acceleration of charges along the flux tubes and generation of Cooper pairs or even many-electrons systems at smaller space-time sheets in negentropically entangled state and carrying metabolic energy quantum as zero point kinetic energy. The period of negentropic entanglement gives rise to a conscious experience to which one can assign various attributes such as understanding, attention, and so on. Negentropic entanglement would measure the information contained by a rule having as instances the state pairs in the quantum superposition defining the entangled state. When the period of negentropic entanglement ceases, the metabolic energy is liberated.

2. Remote activation of DNA by analogs of laser beams is another essential piece of TGD inspired quantum biology. In the proposed addressing mechanism a collection of frequencies serves as a password activating intronic portions of DNA. This would take place via a resonance for the proposed interaction between photons and dark supra currents flowing along magnetic flux tubes and perhaps also along DNA strands or flux tubes parallel to them. The superposition of electric fields of photons (massless extremals) with the electric fields parallel to flux tubes (so that massless extremals serving as correlates for laser beams would traverse the flux tube in orthogonal direction).

3. The flux tubes, and more generally flux sheets labelled by the value of Planck constant, and along which the radiation arrives would be transversal to DNA and contain DNA strands. This kind of flux tubes and sheets also define the connections to the magnetic body, and form parts of it. A given flux sheet would naturally select the portion of DNA, which is activated by the radiation: it could be a portion of intronic part of DNA activating in turn a gene. These flux tubes and sheets could be connected to the lipids of nuclear and cell membranes - also cell membranes of other cells - as assumed in the model of DNA as topological quantum computer [K1]. The sheets could also give rise to a hierarchy of genomes - besides genome one would have super-genome in which genomes are organelles are integrated by flux sheets to a large coherently expressed structure containing individual genomes like page of a book contains lines of text. These pages would be in turn organized to a book - hyper-genome as I called it. One could have also libraries, etc... There would fractal flux quanta inside flux quanta structure.

5.2 Phonons and photons In TGD Universe

Consider next phonons and their coupling to photons in TGD Universe.

1. Sound waves could quite well transform to electromagnetic radiation since living matter is piezocrystal transforming sound to radiation and vice versa. Microwave hearing represents an example of this kind transformation. This would require that photons of given energy and varying value of Planck constant couple to phonons with the same energy, Planck constant, and frequency.

2. Whether one can assign to phonons a non-standard value of Planck constant is not quite clear, but there seems to be no reason preventing this. If so, even photons of audible sounds would have energies above thermal threshold and have direct quantal effects on living matter if they have same Planck constant as the photons with same frequency.

3. Acoustic phonons represent longitudinal waves and this would require longitudinal photons. In Maxwell's electrodynamics they are not possible but in TGD framework photon is predicted to have a small mass and also longitudinal photons are possible.

4. For general condensed matter systems one can have also optical phonons for which the polarization is orthogonal to the wave vector and these could couple to ordinary photons. The motion of the charged particles in the electromagnetic field of massless extremal (topological light ray)

would be a situation in which phonons and photons accompany each other. This would make possible the piezo-electric mechanism.

Under these assumptions the collections of audible frequencies could also represent passwords activating the intronic portion of the genome and lead to gene expression or some other activities. If one believes on the hypothesis that DNA acts like topological quantum computer based on the braid strand connections between nucleotides in the intronic portion of DNA with the lipids of the nuclear and/or cell membranes, also topological quantum computation type processes could be activated by the collections of sound frequencies [K1].

5.3 What distinguishes speech and music from sounds without meaning?

Speech and music ares very special form of sound in that they have direct meaning. The more one thinks about these facts, the more non-trivial they look. For music - say singing - the frequency of the carrier wave is piecewise constant whereas for speech it remains constant and the amplitude modulation is important. In fact, by slowing down the recorded speech, one gets the impression that carrier frequency is actually modulated like in chirp (frequency goes down and covers a range of frequencies). What is the mechanism giving to speech and music its meaning and in this manner distinguishes them from other sounds?

Besides the frequency also phase is important for both speech and music experience. Speech and reverse speech sound quite different the intensity in frequency space is same. Therefore the relative phases associated with the Fourier coefficients of various frequencies must be important. For music simple rational multiples of the fundamental define the scale. Could it be that also the frequencies relevant to the comprehension of speech correspond to these rational multiples?

Suppose that one indeed believes on the proposed vision based on the fundamental role of negentropic entanglement in generation of meaning and takes seriously the proposed mechanisms for generating it. Can one understand why music and speech differ from general sounds and what distinguishes between them?

1. With these assumptions suitable collections of frequencies sound wave would indee activates the intronic portion of DNA by generating negentropic entanglement. Also other dark flux tubes than those assignable to DNA are involved. For instance, hair cells responsible for hearing of sounds around particular frequencies could involved flux tubes and utilize similar mechanism. Allowing only hair cells would define the conservative option. On the other hand, one could well claim that what happens in ear has nothing to do with the understanding of the speech and music, it could take place only at the level of neuronal nuclei.

2. Could the direct interaction of sound waves with magnetic flux tubes generate the experiences of speech and music? In other words, assign meaning to sounds? The criterion for sound to have an interpretation as speech or music would be that it contains the resonance frequencies needed to activate the DNA, or more generally generate dark super currents generating Cooper pairs in this manner loading metabolic energy storages. This would apply to both speech and musical sounds.

3. The pitch of the speech and musical sound can vary. We are aware of the key of the music piece and of modulations of the key and remember the starting key, and it is highly satisfactory to make a return to "home" defined by the original key. This would imply that the overall scale of the collection of frequencies can be varied and that the pitch of the speech defines a natural expectation value of this scale. For persons possessing so called absolute ear this scaling symmetry would be broken in a well-defined sense.

4. Musical scales involve frequencies coming as rational multiples of the basic frequency. Octaves - power of two multiples- of the frequency can be said to be equivalent as far musical experience is considered. One might understand the special role of rational multiples of the basic frequency if the Fourier components have same phase periodically so that the experience is invariant under discrete time translations. This requires commensurable frequencies expressible as rational multiples of the same fundamental frequency. The preferred role of p-adic primes comings as powers of two could relate to the octave phenomenon.

5. Are the relative phases of different Fourier components important for music experience? If one requires a periodical occurrence of maximal possible intensity (maximal constructive interference) then the relative phases must vanish at the values of time for maximal possible intensity. What seems essential that the presence of commensurate frequencies gives rise to time translation invariant sensation whereas speech consists of pulses.

5.4 Are speech and music quantum duals like position and momentum?

Frequencies are crucial for music experience. In the case of of speech the relative phases are very important as the example of reverse speech demonstrates. How a given phoneme is heard is determined to high degree by the frequency spectrum in the beginning of the phoneme (this distinguishes between consonants). Vowels are nearer to notes in vocalization. Speech consists of pulses and destructive interference between different frequencies is required to generate pulses and different pulse shapes so that phase information is important. At least the harmonics of the basic rational multiples of the fundamental are necessary for speech.

One can criticize the previous discussion in that it has been completely classical. Phase and frequency are in wave mechanics canonically conjugate variables analogous to position and momentum. Is it really possible to understand the difference between music and speech purely classically by assuming that one can assign to sound waves both frequencies and phases simultaneously - just like one assigns to a particle sharp values of both momentum and position? Or should one use either representation either in terms numbers of phonons in different modes labelled by frequencies or as coherent states of phonons with ill defined phonon numbers but well defined amplitudes? Could the coherent states serve as the analogs of classical sound waves. Speech would be as near as possible to classical sound and music would be quantal. Of course, there is a large variety of alternative choices of basis states between these two extremes as a specialist in quantum optics could tell.

Suppose that this picture is more or less correct. What could be the minimal scenario allowing to understand the differences between speech and music?

1. Only a subset of frequencies could activate DNA (or if one wants to be conservative, the hair cells) also in the case of speech. One could still pick up important frequencies for which the ratios are simples rational numbers as in the case of musical scale plus their harmonics If this assumption is correct, then speech from which all frequencies except for the harmonics of the simple rational multiples of the fundamental are removed, should be still be comprehensible as speech. The pitch of the speech would determine a good candidate for the fundamental frequency.

2. The harmonics of frequencies activating DNA would be crucial for speech. Harmonics are present also in music and their distribution allows to distinguish between different instruments and persons. The deviation of musical notes from ideal Fock states would correspond to this.

3. The naive guess is that the simple rational multiples of fundamental and the possibility of having their harmonics could be reflected in the structure of intronic portions of DNA as repetitive structures of various sizes. This cannot be the case since the wavelengths of ordinary photons would be so small that the energies would be in keV range. Neither is this expected to be the case. It is magnetic flux tubes and sheets traversing the DNA which carry the radiation and the natural lengths assignable to these flux quanta should correspond to the wave lengths. The larger, the flux quantum, the lower the frequency and the larger the value of Planck constant. Harmonics of the fundamental would appear for given flux tube length naturally.

   The DNA strands and flux tubes and sheets form a kind of electromagnetic music instrument with flux quanta taking the role of guitar strings and DNA strands and other structures such as lipids and possible other molecules to which flux tubes get attached taking the role of frets in guitar. This analogy suggests that for wave lengths measured in micrometers the basic frequencies correspond to the distances between "frets" defined by cell and nuclear membranes in the tissue in the scale of organism. This would relate the spectrum of resonance frequencies to the spectrum of distances between DNAs in the tissue.

   For wave lengths corresponding to very large values of Planck constant giving rise to frequencies in VLF and ELF range and corresponding also to audible frequencies, the preferred wave lengths

would correspond to lengths of flux quanta in Earth size scale. One should understand whether the quantization of these lengths in simple rational ratios could take place for the preferred extremals.

4. Could the pulse shape associated with massless extremals (MEs, topological light rays) allow to distinguish classically between speech and music at the level of space-time correlates? Linear superposition of Fourier components in the direction of ME is possible and this allows to speak about pulse shape. It allows also the notions of coherent state and Fock state for given direction of wave vector. Essential would be the restriction of the superposition of fields in single direction of propagation to be distinguished from the superposition of the effects of fields associated with different space-time sheets on multiply topologically condensed particle. Maybe this would allow to make testable predictions.

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