Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II

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Abstract

This chapter is second part of the bi-chapter devoted to various aspects of metabolism. The basic topics is TGD inspired view about brain metabolism and molecular motors. I have included to the end of the chapter some rather weird sounding ideas such as an explanation of super-luminality in terms of remote metabolism.

1. Dark matter hierarchy, sensory representations, motor action, and metabolism

The vision about a hierarchy of generalized EEGs associated with dark matter hierarchy gave a decisive boost leading to new views about quantum metabolism. The crucial new element is that at higher levels of dark matter hierarchy photons with arbitrarily low frequencies can correspond to energies above the thermal threshold. This explains the observed mysterious effects of ELF radiation on living matter and implies that magnetic bodies are key participants in the metabolism. The equally mysterious findings about the ionic membrane currents can be understood if these currents are essentially non-dissipative and that ionic channels and pumps are actually ionic receptors. Hence it seems that generalized EEGs could take a lion share of the metabolic energy rather than ionic currents as thought usually. This picture allows to understand various strange findings about neuronal metabolism.

2. Holy trinity of red blood cells, neurons, and astrocytes

The vision about dark matter hierarchy and various ideas about quantum metabolism allow to develop a general view about how the sensory representations and motor control are realized in terms of MEs. Time mirror mechanism is the basic elements in the general model for how magnetic body controls biological body and receives sensory information from it.

A model for motor control and sensory representations based on the trinity of red blood cells, astrocytes, and neurons emerges and raises astrocytes from a status of passive energy storage to an active link in the quantum control of brain by magnetic body. One can also identify mechanisms for the generation of coherent locomotion construct a quantum view about how ATP serves as a universal energy currency.

This view also allows a deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of "telepathic" quantum communications. In fact, I introduced already few years ago the notion semitrance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

For a long time glial cells were believed to play a rather passive role in the functioning of brain taking care of basic services such as providing metabolic energy and serving as supporting structures for neurons. During the recent years the views about the role of glia have however changed dramatically. In TGD framework the very fact that metabolism relates very closely to the re-organization of negentropic entanglement forces to recheck this view. Also the slowness of glial dynamics as compared to neuronal dynamics suggests that large values of Planck constant responsible for long time time scales and therefore also for the highest levels of consciousness (including functions like long term memory) are assignable to glia.

3. Molecular motors

During last years molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept.

TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions. Also the real function of membrane potential can be understood and quantum model for nerve pulse and EEG constructed.

The fascinating ability of molecular motors to co-operate finds an explanation in terms of the notion of super-genome: super-genome consists of sequences of nuclei analogous to text lines at the pages of book represented by magnetic flux sheets. Also the magnetic bodies of molecular motors can integrate in a similar manner to larger structures so that the population of molecular motors becomes a society.

4. Remote metabolism and effective super-luminal velocities

After the pioneering experiments of Nimtz and his collaborators 1992 a lot of evidence for effective super-luminal signal velocities has been accumulating. A possible model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. This idea belongs to the class of ideas which look like curiosity after decade.

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

1 Introduction

This chapter was originally a part of the chapter devoted to TGD inspired ideas about metabolism. It however turned out a good idea to divide the chapter to two parts. The basic topics of this chapter are TGD inspired views about brain metabolism and molecular machines in many-sheeted space-time.

1.1 Quantum View About Energy Economy In Brain

The application of these ideas results in a rather detailed model for the energy economy of brain (I will use the word metabolism in the sequel in the meaning energy economy). As a byproduct more detailed models for the generation of projector MEs to the magnetic sensory canvases and for the realization of motor control from the sensory canvas emerge.

1.1.1 Magnetic bodies as key participants of metabolic activities?

As already explained, dark matter hierarchy forces to consider the possibility that magnetic bodies are majors users of metabolic energy, and that magnetic bodies suck metabolic energy from the biological body as they realize intentional actions using time mirror mechanism by sending negative energy dark photons at cyclotron frequencies to the biological body.

This might relate to the paradoxical findings that much more oxygen rushes to coherently firing neuron groups than needed to satisfy the metabolic needs but that neurons actually utilize only a small fraction of this oxygen. Could it be that blood provides the metabolic energy and magnetic bodies are the users the metabolic energy rather than neurons? Could glial cells communicate the EEG signal to the magnetic body. Could the usual ADP$\rightarrow$ ATP transformation provide the metabolic energy in this case?

Or is time mirror mechanism involved meaning that magnetic body sends negative energy signals to the biological body. Also in this case it could be that positive metabolic energy is generated by ADP$\rightarrow$ ATP transformation provide the metabolic energy.

The hierarchy of Planck constants allows to understand the unexpected use of metabolic energy: it could go to generation of EEG. Dark photons with ELF frequencies have energies in visible and UV range if their decay products are biophotons as assumed in the model of biophotons constructure years later than this chapter was written.

1.1.2 "Holy trinity" of red blood cells, astrocytes, and neurons

The model for the quantum metabolism of brain is based on the trinity of red blood cells, astrocytes, and neurons.

1. The hypothesis is that red blood cell colony represents the state of the internal milieu ("how it feels") in corresponding magnetic body. Neurons in turn generate the representations corresponding to the sensory input from the external world or body as seen by an outsider ("how it looks"). Both red blood cells and pyramidal neurons are magnetic and the ability to act as compass needles makes them excellent candidates for magneto-receptors. This would make them able to represent information about the orientation of body with respect to the reference frame defined by the direction of the gravitational and magnetic fields of Earth. Even honeybees are known to utilize magneto-receptors for navigation purposes.

2. Blood-brain barrier could be seen as a counterpart for the body-environment boundary. One of the almost-predictions is that during sleep a delegation of the responsibilities from the cortical level to the lower levels occurs and these lower level structures, including red blood cells and probably also ordinary cells, generate sensory and motor representations. The cellular representations should be accompanied by a radio frequency counterpart of EEG corresponding to lower levels of dark matter hierarchy. This kind of radio static has been indeed identified as I learned when building a model for taos hum [K20].

3. Ca^{++} waves form a hierarchy with frequencies for their generation varying in enormous range. The interpretation as analogs of nerve pulse communications at $k \geq 3$ of dark matter hierarchy is attractive. Astrocytes serving as metabolic resources take a key role in quantum control based on the control of metabolic resources. Magnetic body would communicate its desires to the astrocyte synticia via synchronously firing neuron groups using Ca^{++} waves propagating along synticia. The frequency for the generation of Ca^{++} waves is few/minute, which suggests that they relate to quantum motor control at $k_d = 54$ level of dark hierarchy for two minute period. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. This and the fact that also short term memory corresponds to in this range encourages the interpretation that natural language and internal speech corresponds to signals communicated from magnetic body to synticia as Ca^{++} waves.

4. Sound waves are known to couple directly to Ca^{++} waves. Astrocyte synticia have endfeet to blood vessels. Blood vessels can mediate endogenous sound waves to synticia, where they give rise to Ca^{++} waves propagating along gap junction connected astrocyte structures (synticia). There are reasons to believe that physiophonic sounds and taos hum relate very closely to this kind of endogenous sounds. Dark matter hierarchy suggests that there is an entire hierarchy of "internal speeches" effectively giving rise to a Fourier analysis of the control signals from the magnetic body and transformed in turn to mechanical, chemical, and electrical control signals representing concretely the Fourier components.

5. The general vision about realization of intentions are using time mirror mechanism and remote metabolism provides also concrete ideas about how the coherent locomotion is realized. The basic problem is to understand how coherent momentum generation in macroscopic length scales is possible and the proposed solution to this problem is based on the notion of many-sheeted space-time. Interestingly, the same mechanism explains a bundle of anomalies related to the over-unity energy production and strange facts about electrolysis of water discovered already a century ago by the nobelist Irving Langmuir. Therefore, somewhat surprisingly, a direct connection with the new energy technologies and quantum biology emerges.

1.2 Molecular Machines In Many-Sheeted Space-Time

Molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept. TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The phase transitions changing Planck constant and inducing shortening or lengthening of the magnetic flux tubes connecting molecules could be the basic mechanism behind various motor activities.

The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions.

1. ATP molecules are certainly in a key role in the energetics of life but one might argue that the notion of high energy phosphate bond is not theoretically sound. In TGD framework the dropping of protons from atomic space-time sheets to super-conducting space-time sheets liberating zero point kinetic energy .49 eV is the fundamental mechanism generating usable energy. This leads to a new view about the role of ATP forcing to give up the notion of the high energy phosphate bond.

2. In quantum mode molecular motor receives its energy as a single photon with energy .49 eV emitted when a proton drops to the super-conducting space-time sheet. In classical mode the dropping of the proton to high n cyclotron state generates a cascade of ELF photons with frequencies equal to multiples of the cyclotron frequency of proton giving rise to a radiation pressure forcing the motion of the motor molecule.

3. The model explains the homeopathic $f_h/f_{ELF} = 2 \times 10^{11}$ scaling law: the ratio in question could correspond to the ratio of the zero point kinetic energy and cyclotron energy of ion. Quantum model for molecular motors predicts correctly the order of magnitude for the velocities of these motors and the general time scale of molecular motors is predicted correctly as the time scale defined by the proton cyclotron frequency $f_c \simeq 300$ Hz. The phase transition $\hbar_0 \to 2 \times 10^{11}\hbar_0$ could transform photons with cyclotron frequency and extremely small frequency to photons possessing zero point kinetic energy which is above thermal threshold.

4. The model allows to understand cell membrane as a barrier preventing the leakage of proton Cooper pairs from $k = 139$ super-conducting space-time sheets to the magnetic flux tubes of Earth's magnetic field and a new view about nerve pulse and EEG results. Besides proton also electron and heavier ions can in principle serve as providers of energy and the latter could make possible more refined bio-energetics.

What looks really mysterious in the conceptual framework of the standard bio-chemistry, where proteins are nothing but inanimate molecules, is that nano-motors are able to co-operate and behave like an advanced society rather than a collection of dead and autistic robots colliding continually with each other. Dark matter hierarchy makes it easier to understand what is involved. Dark matter hierarchy leads to the notion super-genome and hyper-genome [K8] : these generalizations could make sense also in the case of nucleus and cell. Super-genome integrates the genomes of individual nuclei to sequences analogous to lines of written text: the page of the book corresponds to a magnetic flux sheet traversing through DNA strands of several nuclei. Super-genome would make possible to interpret organs and societies of nano-motors as motor instruments of magnetic bodies.

I have been forced to learn a lot of new things about the metabolism of brain and molecular motors and do not pretend of being more than a novice in the field. Despite this I dare hope that the power of the general vision compensates the lag of professional rigor as far as biological knowledge is considered.

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L1].

2 A General Model For Metabolism

The general strategy in attempts to understand metabolism is based on the assumption that a very large class of anomalous phenomena rely on same basic mechanism. This includes life as a phenomenon, water memory and homeopathy, free energy phenomena involving over-unity phenomena related to the dissociation of water, lightning and ball lightning, anomalous effects associated with rotating magnetic systems, phenomena related to UFOs (light balls), even remote mental interactions. One must have a unified explanation for all these phenomena based on a real theory.

Plasmoid as primitive life form would the underlying connecting thread between these phenomena so that all the listed phenomena would involve life and prebiotic (or possibly postbiotic!) life. This gives very strong constraints on the model. Plasmoid should consists of the analogs of linear biomolecules, it should metabolize and communicate, in TGD Universe it should have magnetic body, and even genetic code might be realized. In particular, the simplified analog of biological metabolism would be at work. In living matter photosynthesis relies on the splitting of water whereas cell respiration relies on the reversal of this process producing carbon di-oxide and water. Something very similar should happen in free energy systems involving electrolysis,

and the fact that water splitting occurs also in several free energy phenomena suggests that these processes are analogous to photosynthesis and store energy to "molecules" analogous to various linear biomolecules, in particular sugars. Even the counterpart of ADP-ATP process might be realized.

TGD suggests a very general model for the metabolism of pre-biotic systems (or post-biotic ones: the identification depends on what general vision about evolution is adopted) identified as plasmoids consisting of cyclic linear structures formed by exotic water molecules. For a dark water molecule one proton would be dark and dark protons of the neighboring exotic water molecules would bind to form a linear structure identifiable as dark nucleus: this picture is a direct generalization of nuclear string model [K11, K9, K17]. These linear structures would define the analogs of linear biomolecules. This metabolism would be more fundamental than ordinary biochemical metabolism and form a yet unknown part of the latter. One cannot exclude the possibility that also other than water molecules contain dark protons: the signature would be the presence of apparently non-allowed covalent bonds due to the fact the dark proton is not visible. In the following I will discuss the basic principles involved.

The old view about the metabolic energy quanta as energies liberated as particle "drops" to a larger space-time sheet is modified. Metabolic energy quanta are liberated when the space-time sheet at which the particles reside expands in a phase transition increasing its p-adic prime and reducing the value of Planck constant correspondingly so that the net result is that the size of the space-time sheet remains the same. This condition implies a close relationship between p-adic and dark matter hierarchies. This process is automatically coherent since all particles suffer the change simultaneously. It applies also to a situation in which particles are in magnetic field: in this case the scale of cyclotron energies changes since the strength of the magnetic field is scaled down to guarantee the conservation of magnetic flux. This transition is not cyclotron transition but liberates essentially the same energy as coherent cyclotron transition so that magnetic fields (their "motor actions") become essential players also in metabolic activities.

2.1 Three Possible Models For Liberation Of Metabolic Energy

One can imagine three different models for the liberation of metabolic energy.

1. The simplest TGD based model is as a phase transition increasing the value of p-adic prime p assignable to the space-time sheet at which particle is topologically condensed:

   (a) Particle drops to a larger space-time sheet with larger p-adic prime p_1 with $p_1/p \simeq 2^k$. The problem is that different particles need not drop simultaneously so that coherent liberation of energy is not automatic consequence of the assumption.

   (b) The space-time sheet itself suffers a phase transition increasing its p-adic length scale. In absence of interactions (particles in box) the energies are scaled down by factor 2^{-k} and the difference is liberated as usable energy. Coherent liberation of energy is achieved automatically. If the particle insider the space-time sheet is free in good approximation a model as particle in box applies, and if the expansion of the space-time sheet takes place adiabatically, the quantum numbers characterizing the state of the particle do not change in the transition. As a consequence, the energy $E_{\{n_i\}} = k\sum_i n_i^2\hbar^2/2mL_p^2$ is reduced as $L_p \propto \sqrt{p}$ increases to L_{p_1}, where $p_1/p \simeq 2^k$ holds true. The difference of vacuum energies is liberated as usable energy in coherent manner: this is of special significance in living systems. This has led to the identification of p-adic length scales that would correspond to fundamental metabolic quantum with value about.5 eV. Entire hierarchy of metabolic quanta is predicted.

2. The space-time sheet could also carry magnetic energy and particles are expected to be in cyclotron states and perhaps form a cyclotron Bose-Einstein condensate. In this case the phase transition reduces the value of B but preservers the magnetic flux so that $B \to B/2^k$, $p_1/p \simeq 2^k$, takes place. This scales down the energies of cyclotron states by the same scaling factor 2^{-k} as in the case of free particle. The liberated energy is in good approximation just the cyclotron energy for large enough values of k. Coherence is achieved automatically. The value of the fundamental metabolic energy quantum and the value of endogenous magnetic

field of about $B_{end} = .2$ Gauss deduced from the experiments of Blackman and others [J5] fix the value of h_{eff}. It would be proportional to particle mass number A.

3. The earlier model for the liberation of cyclotron energy was based on the assumption that the value of B is not changed but that the value of magnetic quantum number n changed. If n is reduced one achieves liberation of energy. Coherence of the transition might produce problems now. Both models can explain the observations of Blackman and others concerning the effects of ELF radiation on vertebrate brain since the spectrum of photons energies inducing effects correspond to cyclotron energies for the latter option and in excellent approximation to it for the previous model. The mechanism is however quite different.

This phase transition for the larger space-time sheet can take place in two steps.

1. First a phase transition increasing h_{eff} of the background space-time sheet by $n = 2^k$ occurs. This leaves ZPKE invariant but scales up the size of the space-time sheet by $2^{k/2}$. The interpretation would be as "electric expansion" of Brown's gas. No energy transfer takes place since both kinetic and magnetic energies are invariant under the scaling of $\hbar$. Note however than in the original situation the magnetic field can be very strong so that zooming up from microscopic scales can happen.

2. After this a phase transition reducing Planck constant back to h but increasing p-adic length scale by 2^k occurs. The size scale of the background space-time sheet is not affected but the zero point kinetic energy is reduced by factor 2^{-k} and liberated as usable energy. This phase transition would take place for the dark component of Brown's gas in the melting of the metal and other similar phenomena. Also the liberation of metabolic energy in living matter could correspond to this phase transition.

This model for electric expansion, implosion, and energy liberation assumes nothing about the particles involved since dark particle means ordinary particle topologically condensed on dark space-time sheet and having wave function de-localized in the n-sheeted structure. For instance, water can be dark in this sense. One could indeed consider the possibility that the vapour phase identified as charged water cluster is just water containing positive ions H_+^3 or protons and electrons and that phase transition to large $\hbar$ phase expands the space-time sheet at which water is topologically condensed at evaporates the water. Ordinary liquid to gas transition could proceed in the same manner and involve liberation of ZPKE at the second step of the process. In the general case the binding energy involved with the formation of the denser phase could compensate for the energy gain in the increase of the p-adic prime so that the melting would require energy feed.

2.2 Model For The Building Bricks Of Plasmoids

I have already earlier discussed a model for dark proton sequences as primitive life forms. The observation discussed by Moray B. King inspired a more detailed formulation of the model of plasmoids identified as primitive life forms in TGD framework.

1. The key observation was that the model for dark nuclei [K17, K13], in particular dark proton, predicts counterparts of DNA, RNA, tRNA, and amino-acids and also vertebrate genetic code follows naturally. This together with nuclear string model led to the vision that life appears already at the level of dark variants of nuclei. The observed anomalous $H_{1.5}O$ stoichiometry of water in atto-second scale supports the view that dark protons appear in ordinary water.

2. This model was first introduced to explain water memory and homeopathy. The basic idea was that the process creating homeopathic remedy induces the analog of molecular evolution for the dark proton sequences, which in turn provide representations for the molecules appearing in environment. These representations would be fundamental also for the functioning of immune system of living matter. The dark life could provide R&D laboratory for living matter allowing to test say various gene candidates and transcribe them to ordinary biological DNAs if they are successful in the virtual model world. Evolution would not be random but directed just as evolution of technologies.

3. The latest step in the process [K28] was the proposal that cell membranes involve dark proton sequences providing a representation of dark DNA and connected by magnetic flux tubes to the units of DNA in genome. These two DNA representations would be identical. Quite generally, dark and ordinary biomolecules might be connected by magnetic flux tubes.

This picture does not yet provide model for the metabolism of the building bricks of plasmoids. Something very much analogous to the splitting of sugars to carbon di-oxide and water is however expected. Since carbon is not present now, this leaves only the option that the linear dark structures are nothing but exotic form of water for which the proton of one hydrogen atom of each water molecule is dark. These dark protons would combine by strong interactions to a nuclear string and O-H groups would be attached to them. The cyclic analog of DNA, RNA, or amino-acid realizing genetic code would be the outcome. The stoichiometry $H_{1.5}O$ observed in atto-second time scale would be achieved in average sense if the portions of exotic and dark water are same. The prediction is that dark water is heavier than ordinary water: the molecular weight would correspond to average length of the dark water cycle. This is consistent with the observations about Brown's gas.

Plasmoid should also possess a magnetic body. This requires a currents rotating along the cyclic structures. The obvious identification of the current is as dark supra currents assignable to dark protons so that the building bricks of plasmoid would be analogous to super-conducting rings.

2.3 Model For The Metabolism Of Plasmoids

The proposed dark analogs of basic biomolecules would be created through the analog of photosynthesis involving the splitting of water to H + OH followed by $H \to H_{dark}$ and by recombination to a sequence of dark water molecules. The process would be analogous to translation of mRNA to amino-acids and could proceed by an analogous mechanism. The process would be spontaneous since the energy of cyclotron states would not change in $h \to h_{eff} = 2^k \times h$.

Metabolic energy would be liberated in the decay of the exotic water back to water with $h_{eff} = h$ and p-adic prime scaled by about 2^k. This process is completely analogous to the splitting of various linear biomolecules in metabolism in order to obtain metabolic energy. This process would explain the ability of cool Brown's gas to melt metal for instance. When fossil fuels are used, the outcome is carbon di-oxide and water. Now only water is obtained so that this form of free energy might not contribute to the warming of environment.

The process differs from ZPE in that it does not provide any endless source of energy. Since water is in practice an unlimited natural resource, this shold not be a problem. A closed cycle at the level of visible matter is obtained only if the reverse phase transition transforming the water with $h_{eff} = h$ and p-adic prime $p_1 \simeq 2^{k/2}p$ to that with $h_{eff} = 2^k \times h$ and p-adic prime p takes place spontaneously.

The irradiation with carrier frequency f_h and modulation frequency f_l such that one has $f_l/f_h = 2^k$ is one possibility which I have proposed. Dark solar radiation at magnetic flux tubes with magnetic field $B_{end} = .2$ Gauss (guess from the experiments of Blackman [J5] ; also many other values can be considered) could provide automatically the needed pulsed radiation inducing the phase transition. The most optimistic option is that this transition occurs even in the case of closed system in which water circulates.

Before attempting to identify reasonable candidates for f_l and f_h it is useful to consider estimates for $h_{eff}/h = 2^k$. Note that this assumption might be too strong: the vision about evolution as emergence of number theoretical complexity suggests that so called Fermat integers defining polygons, which are constructible using ruler and compass, define favored values of $h_{eff}/h = n$ [K11]. These integers are expressible as products of different Fermat primes $F_n = 2^{2^k} + 1$ and power of 2. The known Fermat primes correspond to $k = 0, 1, 2, 3, 4$ and are $3, 5, 17, 257, 65537$. Only the two lowest ones differ significantly from power of two.This raises the question whether also the scale hierarchies $\sqrt{3}L(k)$, $\sqrt{5}L(k)$, and $\sqrt{15}L(k)$ are important besides p-adic length scale hierarchy $L(k) = 2^{k/2}R_{CP_2}$. They could be associated with the algebraic extensions of p-adic numbers involving $\sqrt{3}$ and $\sqrt{5}$.

1. The condition that cold nuclear fusion is possible via the TGD based mechanism requires dark variant of weak interactions corresponds to scaled up p-adic length scale of order atomic

size. The condition that weak bosons are effectively massless in atomic length scale gives one estimate for h_{eff}/h. The condition that weak scale characterized by M_{89} is increased to that characterized by M_{127} gives $h_{eff}/h = 2^{48} \simeq 2.8 \times 10^{14}$.

2. Second estimate for h_{eff}/h follows from the condition that cyclotron energy for given charged particle is of the order of metabolic energy quantum. For proton $B_{end} = .2$ Gauss gives $f_c = 300$ Hz. The energy is about.5 eV for $h_{eff}/h = 1.37 \times 10^{14}$ rather near to $h_{eff}/h = 2^{47}$ which is by a factor of 1/2 smaller than the previous estimate. It is however clear that the estimates are internally consistent: skeptic would see this as a pure accident and some-one taking anthropic principle seriously as an outcome of evolution in very general sense. Note that for electron the metabolic energy quantum would be about 938 eV suggesting that keV energy scale assignable to the dark weak interactions has its own metabolic energy quantum.

   For ion of mass number A and ionization z the value producing the same value of metabolic quantum is $A/z \times 1.37 \times 10^{14}$. An alternative assumption is a hierarchy of metabolic quanta coming as z/A multiples of the fundamental metabolic energy quantum for a fixed value of h_{eff}/h. The condition that the metabolic energy quantum is above thermal energy of photon at physiological temperature for which peak wavelength for blackbody radiation corresponds to energy of .13 eV. This gives $A/z \leq .5/.13 = 3.84$. The estimate is too stringent since Ca^{++} with $A/z = 20$ should allow metabolic energy quantum above the thermal energy. This suggests that h_{eff}/h characterizes given ion and that its multiples coming as power of two are allowed.

3. For $h_{eff}/h = n = 2^{k_{dark}}$ with$k_{dark} \in \{47, 48\}$ dark electron would have p-adic length scale $L(k)$, $k = 127 + d_{dark} \in \{174, 175\}$. This corresponds to a Compton length $l_c \in \{28, 40\}$ μm. That this corresponds to the size scale of cell gives additional support for the vision. Note also that for electron the size scale of CD identified as secondary p-adic time scale associated with $M_{127} = 2^{127} - 1$ corresponds to.1 seconds, which defines a fundamental biorhythm. Proton Compton length would be scaled to the range $[15, 21]$ nm (10 nm defines the thickness of the cell membrane) and light current quarks with energy of 5-20 MeV to the size scale of cell nucleus.

A reasonable guess is that the candidates for f_h and f_l should satisfy the condition $f_h/f_l = 2^k$, $k = 47$ or $k = 48$. f_h can be deduced from the estimate for h_{eff}.

1. Schumann frequency 7.8 Hz is the first candidate for the modulating frequency. This would give UV frequency $f_h \simeq 1.1 \times 10^{15}$ Hz corresponding to energy of 9.7 eV for $k = 47$, which corresponds to the energy scale for covalent bonds. The energy scale of hydrogen atom is 13.6 eV.

2. For the cyclotron frequency of DNA (which depends only weakly on the length of the DNA sequence due to the constant charge density per unit length) of about 1 Hz (the frequency of heart beat) one would obtain $f_h = 1.4 \times 10^{14}$ Hz for $k = 47$, which corresponds to energy of 1.4 eV and is just below the visible range starting around 1.65 eV. The scaling of this energy by $\sqrt{3}/2$, $\sqrt{5}/4$, and $\sqrt{15}/4$ By multiplying the For $k = 48$ the energy would be to 3.3 eV, which is quite near to the UV end 3.36 eV of visible portion of spectrum. Again one can ask whether just accidents are in question.

   Allowing the generalization of the p-adic length scale hypothesis one obtains 7 photon energies in the visible range corresponding to the scalings of 1.4 eV by $[\sqrt{3/2}, \sqrt{5/4}, \sqrt{5/2}, , \sqrt{15/4}, \sqrt{3}, 2, \sqrt{15/8}, \sqrt{5}]$ giving $E/eV = [1.71, 1.57, 2.21, 1.91, 2.42, 2.71, 2.80, 3.13]$. Note that 2 eV corresponds to red light and metabolic energy quantum of.50 eV to $k = 51$. An interesting question is whether these special frequencies relate to the peak wave lengths for color vision.

A macroscopic variant of photosynthesis using the possibly existing dark photons at the flux tubes of $B_{end} = .2$ Gauss [J5] can be imagined. The flux tubes of B_{end} could correspond to those of B_E with nominal value.5 Gauss if a weakening of the field value takes place inside living matter. Note that in case of $h_{eff}/h \sim 10^{14}$ this field value would correspond to about 10^{10} Tesla for the ordinary value of $\hbar$ (a field strengths assignable to supernovas!) and assignable to electron Compton scale.

The sequences of these two phase transitions involved with dark metabolism would be very much analogous to..-ATP-ADP-ATP-... "Karma's cycle". There is also a strong analogy with breathing and even sleep-wake-up cycle and longer bio-rhythms. p-Adic fractality forces to ask whether all these rhythms involve the same dark metabolic cycle but in different scales. Increase of h_{eff} indeed corresponds to an increase of "IQ" in TGD inspired theory of consciousness and its reduction to its lowering. This could quite concretely correspond the experience of becoming tired. There is also a close analogy with the state function reduction sequence in ZEO. State function reductions occur alternatively at the opposite boundaries of causal diamond (CD) of given scale and I have proposed an interpretation in terms of generalized sleep-awake cycles.

2.4 Does Dark Biology Represent Pre- Or Post-Biotic Evolution?

The discovery of dark proton realization of genetic codons [K17, K13] was an accident and I am still puzzled about whether the vertebrate genetic code can really emerge from dark nuclear physics or is it only a curiousity or self deception. The first interpretation for the dark code is as a code associated with prebiotic evolution [K12]. This is suggested by the enormous simplicity for the analogs of counterparts of linear biomolecules, and the fact that the utilization of metabolic energy means that these "molecules" decay to ordinary water. In this view life would have migrated from dark space-time sheets to visible space-time sheets. This higher level life would be gradually migrating to lower levels in the hierarchy and taking visible matter to its control and that biological evolution represents a step in this process.

There are however some objections against this view. The dark code corresponds to vertebrate code, which can be seen as an outcome of along genetic evolution. There are also other codes, which are less perfect (thes are discussed in [K5] representing a number theoretic approach to genetic code). For instance, the meaning of the codeword is context dependent for some codons and Peter Gariaev has proposed that this context dependence is a more general phenomenon. One would expect that prebiotic code is much simpler than genetic code and I have considered a model for how genetic code might have emerged from more primitive codes with 4 and 16 code words as a "product code" [K5, K12].

These objections inspire the question whether life could migrate from lower to higher scales. The dark genetic code would in this framework correspond to the emergence of a new level in evolution - perhaps identifiable as cultural evolution. This would explain why dark variant of the genetic code corresponds to vertebrate code. One could also solve Fermi paradox [K24] due to the fact that no signs of intelligent life have been observed in cosmos and probabilistic estimate suggests that cosmos is full of life. The answer could be very simple: in some stage the civilization transforms to dark matter invisible to us! The civilizations are there but living on magnetic flux quanta and probably communicate with us telepathically. The higher evolutionary level would also conform with the fact that the spatial and temporal scales of consciousness are much longer than for the consciousness assignable to visible manner. This could allow also to understand also the mystery of crop circles. To my opinion many of them are genuine, and the interpretation as some kind of cognitive representations analogous to those realized in brain is highly suggestive. Certainly these representations would represent mental images of conscious entities, which are at higher evolutionary level than us [K6, K7].

Many great leaps in evolution have occurred via crisis periods involving extinction. Could it be that gradual transition to dark matter based life could be begin as a response to the recent crises of human kind? The gradual transition of life to the dark matter level would indeed solve the energy problem by coupling us to the energy sources assignable to the dark matter hierarchy at various magnetic bodies. It would also solve the problem caused by the climate warming if it is indeed is due to the liberation of CO_2 as fossil fuels are used. The dark matter "molecules" as analogs of biomolecules and hydrocarbons would produce only water when used.

What has been bothering me somewhat are the messianic elements of free energy movement: something totally new is believed to be emerging even at the level of consciousness and ethics and moral rules. Skeptic scientist finds it difficult to accept the idea that new form of energy could have so wide implications: the fundamental problems of the society relate to ethics and moral. On the other hand, if one interprets free energy phenomena as manifestations of post-biotic life forms realizing genetic code at the level of dark matter, it becomes possible to defend the messianic view about free energy. The transition to dark matter dominated world would mean also leap in the

level of consciousness.

The belief in ZEP has also some features that worry me. I believe that there is some great intuition behind this view but to me its realisation in terms of ZEP is wrong thing to do: the existing mathematical physics simply fails to provide the needed language and concepts. My own proposal is zero energy ontology (ZEO) in which physical states are replaced with physical events and continual re-creation becomes possible without giving up the symmetries and laws of physics.

I find it also alarming that some advocates of free energy also have a hostile attitude towards science. This is easy to understand as a reaction to the arrogant attitude of the academic world towards free energy and actually all visions challenging the basic dogmas of the standard science. Christianity emerged as the Roman Empire collapsed and something similar seems to happening now: at this time free energy movement might take the role of Christianity. It would be a pity if also now blind beliefs would replace rational thinking for almost two millenia.

2.5 Quantum Model For Metabolism

First it is good to list some basic facts about energy metabolism.

1. ADP→ ATP meaning the addition of phosphate to ADP is believed to be the fundamental step of metabolism. The process occurs when protons flow through the ATP synthase, which can be regarded as a nano-motor with a rotating shaft. During single turn three ADPs are phosphorylated and 3 protons flow through the "turbine" of the nano-motor and give up their Coulombic and chemical energy parameterized in terms of chemical potential difference. There is clearly a strong analogy with power plant. High energy phosphate bond is believed to receive the metabolic energy transferred from the flow of protons through the mitochondrial membrane.

2. The nominal value of metabolic energy quantum about.5 eV. The Coulomb energy associated with the mitochondrial membrane is 50-80 meV and by almost order of magnitude too small. The large chemical potential difference is believed to explain the large metabolic energy gain. This requires that the process is regarded as purely thermodynamical. This is a questionable assumption even in standard physics context and does not conform with the TGD based idea that transmembrane proteins such as ATP synthase act as large h_{eff} Josephson junctions. The square root of thermodynamics forced by zero energy ontology suggests itself as a proper description of cell membrane as macroscopically quantum coherent system.

3. The notion of high energy phosphate bond is not well understood. The storage of energy dark cyclotron energy at the magnetic body of phosphate suggests itself as TGD based description.

2.5.1 How to understand the value of $heff$?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

1. The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [K27].

   The findings of Pollack and the difficulties to understand metabolic energy quantum of nominal value.5 eV in the simplest model for cell membrane as Josephson junction as Josephson energy for Cooper pair equalto to $ZeV = 10-10.6$ mV inspired the assumption that cyclotron energies at flux tubes traversing cell membrane can be different at the two sides of the cell membrane [K8, K18]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_AC$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC})$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_C$. Note that correct sign requires $\Delta f_C - f_{AC} > 0$.

2. The conjecture $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting

from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

3. $h_{eff} = h_{em} = Z_1 Z_2 e^2/v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory is in powers of $1/h_{eff}$) possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n-branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.

4. Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K14] when one requires internal consistency.

2.5.2 How metabolic energy is transferred?

The basic question concerns the mechanism of energy transfer from nutrients. It should be however emphasized that the transfer might not be the really important aspect. The transfer of negentropic entanglement from nutrient to the organism might be of equal importance.

1. Zero energy ontology (ZEO) suggests that magnetic bodies are carriers of the metabolic energy. What does this mean is not quite clear but cyclotron energies or ions or Cooper pairs of them proportional to h_{eff} are obvious candidates concerning energy storage. The value of $h_{eff} \simeq 10^{14}$ guaranteeing the energies of dark EEG photons are in the range of bio-photon energies would mean that storage as cyclotron energies is very effective and the liberated energy quanta can directly induce molecular transitions essential for bio-chemical reactions.

2. The liberation of metabolic energy could take place in a phase transition in which p-adic length scale increases and h_{eff} is reduced in such a manner that the length of flux tubes is not changed. This induces a coherent quantum transition in the sense that large number of particles can liberate cyclotron energy as cyclotron energy scale is reduced in the reduction of magnetic field strength. As protons flow from thinner flux tube with smaller h_{eff} to thicker one, similar reduction of cyclotron energy takes place and the energy is liberated, and would be received by ATP synthase to form ATP from ADP. This mechanism could be universal and at work also in other situations.

3. At quantitative level the identification $h_{eff} = h_{gr}$ of gravitational Planck constant with $h_{eff} = n \times h$ at microscopic level at least is an attractive hypothesis [K30, K18]. Gravitational Planck constant can be expressed as $\hbar_{gr} = GMm/v_0$, where v_0 is taken to be the rotational velocity of Earth. Assuming this for Cooper pairs of rotating super-conductor explains the gravimagnetic anomaly claimed by Tajmar et al [**?**, **?**]. It also predicts a universal energy spectrum of dark cyclotron photons in the range of bio-photon energies and gives thus support for the hypothesis that dark EEG photons decay to bio-photons. The metabolic energy quantum for proton of order.5 eV is consistent with the identification as cyclotron energy difference for proton over mitochondrial membrane. The hypothesis $h_{em} = h_{eff} = h_{gr}$ makes also sense for the nano-motor defined by ATP synthase transforming ADP to ATP.The interpretation would be that this condition makes possible the reconnection of electromagnetic and gravitational flux tubes.

One can imagine also different scenario involving phase transition changing the value of h_{eff} assignable to atoms. TGD indeed predicts also small values of h_{eff}. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems with nonstandard value of h_{eff}.

1. For dark atoms the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K31]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

2. Phosphorylation and de-phosphorylation could be interpreted in terms of reconnection of flux tubes so that the dark proton associated with phosphate is transferred to the acceptor molecule. I have proposed that the deeper meaning of metabolism is transfer of negentropic entanglement (NE). The reconnection of flux tubes would transfer NE between ATP and third party to NE between acceptor molecule and third party. There is a large number of alternative identifications for NE. It could be short range entanglement associated with $h_{eff} = h_{em}$ assignable to electron and nucleus of dark atoms, to pairs of atoms or molecules, or very long range entanglement between molecule and large scale structure with size scale of Earth or even galaxy and associated with $h_{eff} = h_{gr}$. Both forms of NE might be involved and distinguish between two evolutionary levels.

3. Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K31]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. The dark atoms in nutrients transforming to ordinary atoms could provide the metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the NE or be accompanied by dark magnetic flux tube. The transfer of NE would mean its disappearance followed by reappearance and it could happen that $h_{eff}/h = n$ is reduced in the process.

4. The simplest view about photosynthesis would be that the absorption of solar photons excites some atoms to dark states and that nutrients contain these dark atoms as stable enough entities. The contamination of nutrients could mean the decay of these dark atoms to the normal states.

2.5.3 Exclusion zones as prebiotic cells

TGD based model model [L2], [K26] for Pollack's findings [L2] provides further guidelines.

1. Pollack et al discovered what they call exclusion zones and fourth gel like phase of water. The phenomenon occurs when water is bounded by gel and is irradiated with say visible light. Exclusion zones are negatively charged regions of water with positively charged environment. They act like batteries and have rather exotic properties. For instance, various impurities are repelled from exclusion zone.

2. The observed $H_{1.5}O$ stoichiometry implies that every fourth proton or hydrogen atom is dark and is transferred to the region outside the negatively charged exclusion zone. If only protons are transferred, very high negative charge density is generated. The size of the exclusion zone varies up to 100 μm and is in the range of cell sizes.

3. Dark matter corresponds in TGD Universe to phases with nonstandard value of Planck constant: $h_{eff} = n \times h$ phases at the "magnetic body" of the system (negatively charged

region now). Magnetic body corresponds in Maxwell's theory to the magnetic fields generated by the system. Magnetic body consists of flux quanta (flux tubes and sheets).

4. If dark protons with say size scale of atomic size reside at flux tubes, one can assume that they form strings giving rise to dark atomic nuclei. Also ordinary nuclei consist of strings of dark protons and strings of neutrons. Various impurities are transferred from exclusion zone to the exterior suggesting that they become dark particles at magnetic flux tubes.

5. The quantum states of dark protons consist of 3 quarks and a simple model involving rotational symmetry around the axis of dark proton string predicts that the states of dark proton can be arranged into groups which correspond to DNA, RNA, amino-acids and possibly also tRNA molecules. Vertebrate genetic code can be realized as a natural correspondence between DNA/ RNA and amino-acids [K17, K13].

6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive prebiotic life form. The voltage would be the analog of the resting potential. The transformation of dark protons to ordinary ones would liberate metabolic energy so that primitive metabolism and photosynthesis would be realized. One can also consider a more general possibility that cyclotron energies are different at flux tube portions in the interior and exterior of the EZ analogous to cell membrane. This would increase the value of the metabolic energy currency by adding to Josephson energy ZeV the difference of dark cyclotron energies proportional to h_{eff}. One expects that dark counterparts of basic bio-polymers are still present in living matter and play a fundamental role.

2.5.4 What might happen in ADP→ ATP process?

The identification of the exclusion zone with magnetic body as a basic structure allows to speculate about what might happen in ADP → ATP process and how ATP might store metabolic energy.

1. The strings of dark protons [K13] would be analogous to basic bio-polymers serving as the basic fuel of metabolics hydrolysed in metabolism. Basic biopolymers tend to be negatively charged and could therefore be accompanied by dark proton strings and the liberated metabolic energy might be stored by these strings as cyclotron energy and as Coulomb energy.

2. The simplest guess is that metabolism has developed from the transformation of dark protons to ordinary ones as the analog of EZ transforms back to ordinary water and potential potential difference disappears. One cana also consider generalizations of this picture. A phase transition reducing h_{eff} and increasing p-adic scale such that the size scale of the flux tube remains fixed but cyclotron energy is reduced. This phase transition could also effectively accompany the flow of protons through the boundary of EZ if h_{eff} is smaller and p-adic scale longer at the other side. This mechanism could be stilla at work at the level of mitochondria for dark protons.

3. The notion of high energy phosphate bond is somewhat mysterious. ATP is negatively charged and one can wonder whether it could be accompanied by EZ assignable to the negatively charged phosphates. Also DNA strands and many other biomolecules carry negative charge due to the phosphates. Could the metabolic energy be stored to the magneti body of ATP or of phosphate and eventually liberated by flow of protons to flux tubes with weaker magnetic field?

One can ask why the rotation of ATP synthase motor is necessary. Could the centrifugal acceleration drive dark particles to the magnetic body or keep them there thus stabilizing the dark phase? The dark protons at the magnetic body rotating with the system would remain to magnetic body and would avoid transition to ordinary protons if it is induced by the vicinity of ordinary protons serving as seeds for phase transition. If this interpretation is in the right direction, the rotating magnetic systems might provide a manner to create dark matter [K2].

2.5.5 Energy metabolism as transfer of negentropic entanglement?

Negentropic entanglement (NE, see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) is 2-particle property (or more generally $n > 1$-particle property). One can argue that this is not consistent with the naive idea about systems carrying NE as a resource analogous to metabolic energy. If negentropy transfer is behind metabolism and if one accepts this objection, one must ask whether metabolism actually corresponds to a transfer of NE between nutrient A and some fixed system B so that NE transforms to that between receiver R and same fixed system B? If so, could this could B correspond some higher collective level of consciousness perhaps identifiable as gravitational Mother Gaia (MG) as suggested by the success of $h_{gr} = h_{eff}$ hypothesis at microscopic level?

1. Negentropic entanglement (NE) would be transferred. Nutrients would be negentropically entangled with something very crucial for life. MG is a good candidate in this respect. Even Sun can be considered. Gravitational NE with MG would make possible dark EEG, etc... Basic formula is $\hbar_{gr} = GMm/v_0$, v_0 the rotational velocity at surface at the surface of Earth.

2. Formula generalizes to em case: $h_{em} = Z_1 Z_2 e^2/v_0$ and would apply to ATP synthase being consistent with $h_{gr} = h_{em} = h_{eff}$. Em flux tubes could reconnect with gravitational flux tubes for $h_{gr} = h_{em}$.

3. Nutrient-MG NE can be transformed to molecule-MG NE by the sequence N-MG $\rightarrow$ P-MG $\rightarrow$ ATP-MG $\rightarrow$ R-MG (N for nutrient, R for receiver).

4. The basic mechanism would be the reconnection of magnetic U-shaped loops associated with various molecules serving as kind of tentacles: N/P/ADP/R would have this kind of loops.

One can represent a critical comment. The notion of personal magnetic body (PMB) controlling biological body (BB) is central for TGD inspired theory of consciousness. The above argument does not involve it at all. Can the notion of PMB be therefore consistent with MG hypothesis? Or is PMB in some sense part of the magnetic body of MG - say in the sense that the flux tubes of PMB could be inside flux tubes of MG? Mystics would perhaps equate MG with PMB but this leads to paradoxes.

1. An attractive guess is that $h_{em} = h_{gr}$ holds true for PMB so that it can interact with MG by forming reconnections. Nutrients are dead but have NE with MG so that metabolism allows BB to have NE with MG.

2. How PMB could generate NE with BB? Could it reconnect with the flux tube pairs connecting MG with BB? Do both MG and PMB have NE with BB during life-time. What happens in biological death?: does the NE between PMB and BB transform to that between BB and MG again and only the NE between PMB and MG remains? This would conform with what spiritual teachings say.

3. If the answers to these questions are "yes", the basic purpose of metabolism would be the transformation of gravitational NE between MG and nutrients to that between MG and biomolecules. Magnetic bodies would "steal" part of this NE by reconnecting between MG and BB to that between PMB and BB: note that this process would be something new besides molecular metabolism and could be interpreted as a higher level metabolism. All this would be basically transfer of information from collective level of consciousness to lower levels to be processed and further enriched and to be returned back to MG in biological death: nothing would lost! Biological death itself would be reconnection transforming flux tube bonds to PMB to bonds to MG.

2.5.6 Could electrons serve as nutrients?

The New Scientist article (see `http://tinyurl.com/ybd4g2kl`) about bacteria using electrons as nutrients is very interesting reading since the reported phenomenon might serve as a test for the TGD inspired idea about metabolism as a transfer of negentropic entanglement (NE, see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) at fundamental level discussed in [K18] (see `http://tinyurl.com/yat9bx9j`).

1. NE is always between two systems: nutrient and something, call it X. The proposal inspired by a numerical co-incidence was that X could be what I have called Mother Gaia. X could be also something else, say personal magnetic body. The starting point was the claim that the anomalously high mass of electronic Cooper pair in rotating supercounductor (slightly larger than the sum of electron masses!) could be due to a gravimagnetic effects which is however too strong by a factor 10^{28}. This claim was made by a respected group of scientists. Since the effect is proportional to the gravimagnetic Thomson field proportional to the square of Planck constant, the obvious TGD inspired explanation would be $h_{eff} \simeq 10^{14}$ (see `http://tinyurl.com/yb7rsct5` and `http://tinyurl.com/yat9bx9`).

2. Gravitational Planck constant $\hbar_{gr} = GMm/v_0$, v_0 typical velocity in system consisting of masses $M >> m$ and m was introduced originally by Nottale and I proposed that it is genuine Planck constant assignable to flux tubes mediating gravitational interaction between M and m. In the recent case v_0 could be the rotating velocity of Earth around its axis at the surface of Earth.

3. For electron, ions, molecules, .. the value of h_{gr} would of the order of 10^{14} required by the gravimagnetic anomaly and is also of the same order as $h_{eff} = n \times h$ needed by the hypothesis that cyclotron energies for these particles are universal (no mass dependence) and in the visible and UV range assigned to biophotons. Biophotons would result from dark photons via phase transition. This leads to the hypothesis $h_{eff} = h_{gr}$ unifying the two proposals for the hierarchy of Planck constants at least in microscopic scales.

   Thanks to Equivalence Principle implying that gravitational Compton length does not depend on particle's mass, Nottale's findings can be understood if h_{gr} hypothesis holds true only in microscopic scales. This would mean that gravitation in planetery system is mediated by flux tubes attached to particles. One non-trivial implication is that graviton radiation is dark so that single graviton carries much larger energy than in GRT based theory. The decay of dark gravitons to ordinary gravitons would produce bunches of ordinary gravitons rather than continuous stream: maybe this could serve as an experimental signature. Gravitational radiation from pulsars is just at the verge of detection if it is what GRT predicts. TGD would predict pulsed character and this might prevent its identification if based on GRT based belief system.

4. In the recent case the model would say that the electrons serving as nutrients have this kind of negentropic entanglement with Mother Gaia. $h_{gr} = h_{eff}$ would be of order 10^8. Also in nutrients electrons would be the negentropically entangled entities. If the model is correct, nutrient electrons would be dark and could also form Cooper pairs. This might serve as the eventual test.

This is not the only model that one can imagine. TGD predicts also small values of h_{eff}. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems. At this moment one cannot exclude the possibility that only short range NE is involved with living matter.

Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K31]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

Electrons are certainly fundamental for living matter in TGD Universe.

1. Cell membrane is high T_c electronic super-conductor [K18]. Members of Cooper pairs are at flux tubes carrying opposite magnetic fields so that the magnetic interaction energy produces very large binding energy for the large values of h_{eff} involved: of the order of electron volts! This is also the TGD based general mechanism of high T_c superconductivity: it is

now accepted that anti ferromagnetism is crucial and flux tubes carrying fluxes at opposite directions is indeed very antiferromagnetic kind of thing.

2. Josephson energy is proportional to membrane voltage ($E_J = 2eV$) is just above the thermal energy at room temperature meaning minimal metabolic costs.

3. Electron's secondary p-adic time scale is.1 seconds, the fundamental biorhythm which corresponds to 10 Hz alpha resonance.

2.6 Humble Origins Of DNA As Nutrient - Really Humble?

I received an interesting link (`http://tinyurl.com/ybv8xu9uDNA_May_Have_Had_Humble_Beginnings_As_Nutrient_Carrier_999.html`) about the indications that DNA may have had rather humble beginnings: it would have served as a nutrient carrier [I14]. Each nucleotide in the phosphate-deoxiribose backbone corresponds to a phosphate and nutrient refers to phosphate assumed to carry metabolic energy in high energy phosphate bond.

In AXP, X=M, D, T the number of phosphates is 1, 2, 3. When ATP transforms to ADP, it gives away one phosphate to the acceptor molecule which receives thus metabolic energy. For DNA there is one phosphate per nucleotide and besides A also T, G, and C are possible.

The attribute "humble" reflects of course the recent view about the role of nutrients and metabolic energy. It is just ordered energy what they are carrying. TGD view about life suggest that "humble" is quite too humble an attribute.

1. The basic notion is potentially conscious information. This is realized as negentropic entanglement for which entanglement probabilities must be rational numbers (or possibly also algebraic numbers in some algebraic extension of rationals) so that their p-adic norms make sense. The entanglement entropy associated with the density matrix characterizing entanglement is defined by a modification of Shannon formula by replacing the probabilities in the argument of the logarithm with their p-adic norms and finding the prime for which the entropy is smallest. The entanglement entropy defined in this manner can be and is negative unlike the usual Shannon entropy. The interpretation is as information associated with entanglement. Second law is not violated since the information is 2-particle property whereas as Shannon entropy is single particle property characterizing average particle.

   The interpretation of negentropic entanglement is as potentially conscious information: the superposition of pairs of states would represent abstraction or rule whose instances would be the pairs of states. The large the number of pairs, the higher the abstraction level.

2. The consistency with standard quantum measurement theory gives strong constraints on the form of the negentropic entanglement. The key notion is that if density matrix is proportional to unit matrix, standard measurement theory says nothing about the outcome of measurement and entanglement can be preserved. Otherwise the reduction occurs to one of the states involved. This situation could correspond to negentropic 2-particle entanglement. For several subsystems each subsystem-complement pair would have similar density matrix. There is also a connection with dark matter identified as phases with non-standard value $h_{eff} = n \times h$ of Planck constant. n defines the dimension of the density matrix. Thus dark matter at magnetic flux quanta would make living matter living.

   In 2-particle case the entanglement coefficients form a unitary matrix typically involved with quantum computing systems. DNA-cell membrane system is indeed assumed to form a topological quantum computer in TGD framework. The braiding of magnetic flux tubes connecting nucleotides with lipids of the cell membrane defines topological quantum computer program and its time evolution is induced by the flow of lipids forming a 2-D liquid crystal. This flow can be induced by nearby events and also by nerve pulses.

   Side-step: Actually pairs of flux tubes are involved to make high temperature superconductivity possible with members of Cooper pairs at flux tubes with same or opposite directions of spins depending on the direction of magnetic field and thus in spin $S = 0$ or $S = 1$ state. For large value of Planck constant $h_{eff} = n \times h$ the spin-spin interaction energy is large and could correspond in living matter to energies of visible light.

3. Negentropy Maximization Principle (NMP, [K15]) is the basic variational principle of TGD inspired theory of consciousness. NMP states that the gain of negentropic entanglement is maximal in state function reduction so that negentropic entanglement can be stable.

4. NMP guarantees that during evolution by quantum jumps recreating the Universe (and sub-Universes assignable to causal diamonds (CDs)) the information resources of Universe increase. Just to irritate skeptics and also to give respect for the ancient thinkers I have spoken about "Akashic records". Akashic records can be said to form books in a universal library and could be read by interaction free quantum measurement preserving entanglement but generating secondary state function reductions providing conscious information about Akashic records defining also a model of self.

   Side-step: Self can be identified as a sequence of state function for which only first quantum is non-trivial at second boundary of CD whereas other quantum jumps induce change of superposition of CDs at the opposite boundary and states at them). Essentially a discretized counterpart of unitary time development would be in question. This allows to understand how the arrow of psychological time emerges and why the contents of sensory experience is about so narrow a time interval. Act of free will corresponds to the first state function reduction at opposite boundary and thus involves change of the arrow of psychological time at some level of self hierarchy: this prediction is consistent with the Libet's findings that conscious decision implies neural activity initiated before the decision ("before" with respect to geometric time, not subjective time).

In this framework the phosphates could be seen as ends of magnetic flux tubes connecting DNA to cell membrane and mediating negentropic entanglement with the cell membrane. DNA as topological quantum computer vision conforms with the interpretation DNA-cell membrane system as "Akaschic records". This role of DNA-cell membrane system would have emerged already before the metabolic machinery, whose function would be to transfer the entanglement of nutrient molecules with some bigger system X to that between biomolecules and X. Some intriguing numerical co-incidences suggest that X could be gravitational Mother Gaia and flux tubes mediating gravitational interaction with nutrient molecules and gravitational Mother Gaia could be in question [K32]. This brings in mind Penrose's proposal about the role of quantum gravity. TGD is indeed a theory of quantum gravity predicting that gravitation is quantal in astroscopic length scales.

3 Does Constant Torque Induce A Phase Transition Increasing The Value Of Planck Constant?

The hierarchy of phases with effective value of Planck constant coming as an integer multiple of the ordinary Planck constant and interpreted as dark matter is crucial in the TGD inspired model of living matter. The challenge is to identify physical mechanisms forcing the increase of effective Planck constant h_{eff} (whether to call it effective or not is to some extent matter of taste). The work with certain potential applications of TGD led to a discovery of a new mechanism possibly achieving this. The method would be simple: apply constant torque to a rotating system. I will leave it for the reader to rediscover how this can be achieved.

The importance of the result is that it provides strong mathematical motivations for zero energy ontology (ZEO), causal diamonds (CDs), and hierarchy of (effective) Planck constants [K29]. Quite generally, the results apply to systems with external energy feed inducing generalized force acting in some compact degrees of freedom. Living matter represents basic example of this kind of system. Amazingly, ATP synthase enzyme contains generator with a rotating shaft: a possible TGD based interpretation is that the associated torque forces the generation of large h_{eff} phases. This conforms with the proposal that the basic function of metabolism is to produce large h_{eff} phases making also possible negentropic entanglement [K15] and generation of "Akashic records" as negentropically entangled states which are approximately invariant under quantum jumps if they are correspond to interaction free (approximately) measurements for the Akashic records [K21].

4 A Model For Brain Metabolism

Oxygen and glucose are absolutely essential for consciousness. Thus I find it somewhat astonishing that quantum consciousness theorists (with myself included!) have paid only a minor attention to the exceptional role of oxygen and glucose. The realization that the liberation of a usable energy and the generation of bound states giving rise to macroscopic coherence and binding mental images to larger mental images are two sides of the same coin encourages the hopes that one might understand why metabolism is so crucial for consciousness.

In the most conservative scenario the ordinary metabolism corresponds to a purely local liberation of energy whereas the generation of macroscopic bound states means a non-local liberation of usable energy and represents a new kind of metabolism involving time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book) and generalized four-wave interaction with the ensuing time non-locality and instantaneous generation of usable energy. Also ordinary metabolism might involve generation of macroscopic bound states and a non-local liberation of a usable energy as some paradoxical findings about energetics of neural activity suggest. Nanobiology has during last years demonstrated that existing Newtonian thinking does not be of much help in the understanding of the phenomena involved and might provide fascinating applications for the notion of bound state entanglement.

At the concrete level of models the TGD view about metabolism and consciousness would look like follows.

1. There are at least three important participants involved in the generation of conscious experience: the colony of red blood cells, the gap junction connected structures formed by astrocytes, and neurons: all these structures and their components can form bound state entanglement with each other.

2. Astrocytes serve as energy reserves of the brain and bound state entanglement allows a non-local liberation of the metabolic energy at the neuronal level. Part of this energy must go to the build-up of MEs serving as projectors to the sensory magnetic canvases at various levels of the hierarchy. The mysteriously low rate of the oxidative neuronal metabolism during a heightened neuronal activity might be partially due to the fact that the dissipation is very low, partially due to the fact that bound states are generated and binding energy is also liberated. Many-sheeted ionic flow equilibrium (supported by the findings challenging the notions of ionic channels and pumps [I15]) with non-dissipating supra currents generating evoked and invoked potentials might reduce dramatically the postsynaptic energy costs. Further support for this picture comes from a detailed model for the generation of MEs defining projectors to the sensory canvas explaining also the strange properties of the so called Brown's gas obtained by electrolysis from water as well as from the explanation of the anomalies found already century ago by nobelist Irving Langmuir.

3. Astrocytes are coupled by notile "endfeet" to neurons and are known to be in intense communications with them. There are reasons to believe that neuronal data are transsmitted to the gap junction connected structures of astrocytes, synticiums [J4, J6]. Astrocytes have also "endfeet" to blood cells. Blood cells rush where the neuronal action but as already noticed, oxidative metabolism is very low during heightened neuronal activity. Blood cells are magnetic structures and blood records the direction of the gravitational force. Hence thus blood cell sub-colonies are ideal candidates for generating the projector MEs to to the sensory magnetic canvases. The pyramidal cells which also contain magnetic crystals are second candidate for the projectors and now cellular water takes the role of blood. These two sensory representations are good candidates for the representations of "internal milieu" (what it feels) and external world and body as seen by outsider (what it looks).

4. A general vision about how generalized motor control is performed from sensory canvas emerges as a by-product. The proposed realization is based on the generation of sound waves on blood vessels by MEs from the sensory canvas. These sound waves interact with astrocytes generating Ca^{++} waves and induce "internal speech" serving as high level symbolic language in turn transformed into nerve pulse patterns by the memetic code. As a matter fact, entire hierarchy of "internal speeches" is predicted and correspond effectively the Fourier decomposition of MEs to frequency components by various parts of brain and body at various length

scales. The scaling law from homeopathy serves as a guideline leading to the identification of detailed mechanisms for how this Fourier analysis happens.

4.1 Metabolism In Brain

In order to detail the general vision about the relationship between metabolism and consciousness, it is good to learn the basic facts about the energetics of brain. At the level of biological body there are three interacting systems: blood flow, astrocytes, and neurons. In the sequel I provide the view of an innocent novice about these three systems and their interactions and try to identify anomalies serving as signatures for the presence of non-local energy liberation mechanisms. I hope that the power of the general vision to unify might compensate the un-precision at the level of details.

In the classical world the understanding of the energy and information currents between these three systems would be enough. In TGD framework the presence of the dark matter hierarchy of magnetic bodies changes the situation profoundly since magnetic bodies become key participants of the energy metabolism. Time mirror mechanism provides a tool of both remote metabolism, long term memory, and quantum control. The reduction of the charged entanglement induced by W MEs affects local charge densities, which induces ordinary currents. This quantum control mechanism would rely to the exotic ionization of dark bosonic ions, in particular Ca^{++} ions, and the appearance of Ca^{++} waves in a very wide velocity range suggests the universality of this mechanism. W entanglement provides also a mechanism making possible sharing of mental images: this mechanism could be realized during nerve pulse propagation, and could make also possible also quantum parallel superpositions of nerve pulse patterns and hence quantum computation like activities [K23, K19].

4.1.1 Magnetic bodies as key participants brain of metabolism

Dark matter hierarchy leads to a new view about neuronal metabolism where communications to and control by the magnetic bodies are key utilizers of the metabolic energy.

1. Many-sheeted ionic flow equilibrium

The prevailing view about neuronal metabolism is that in the resting situation most of the metabolic energy goes to the maintaining of the concentration gradients by pumping ions between cell interior and exterior. There is however empirical evidence challenging the notion of ionic pumps and channels and there are also theoretical objections against them [I15].

The notion of the many-sheeted ionic flow equilibrium relies on these observations. The basic idea is that cell interior and exterior correspond to disjoint space-time sheets and that the join along bonds connecting them appear and disappear by a quantum mechanism. Join along boundaries bonds allow the ionic currents to flow as non-dissipative quantal currents. This explains why ionic currents can flow during metabolic deprivation, the observed quantum character of these currents, and completely unexpected independence of the ionic currents on the details of the membrane in question [K4, K19].

Channels and pumps are identified as sensory receptors detecting ions and also membrane voltage allowing neuronal and cell membrane to perceive the nearby environment chemically. Only a negligible amount of ionic currents would flow through them. Synaptic contacts would play same role but now the primary sensory input would arrive from the external world. Note that also supra currents could provide metabolic energy as well as momentum when it leaks to the atomic space-time sheet and in the model of ATP this mechanism is assumed to be behind coherent locomotion.

2. The new view about neuronal metabolism

If this picture is correct, the view about the neuronal and also cellular metabolism changes profoundly.

1. The concentration of cytochrome oxidase measures the local metabolic activity and correlates with the number of synapses rather than with the number of neurons. This suggests that postsynaptic activity, whatever it is, is responsible for the use of metabolic energy.

2. In the usual book-keeping the ionic currents associated with the action potentials and post-synaptic activity would be main users of the metabolic energy. Cation fluxes increase by a factor of 100-1000 during action potential but they last for only 1 millisecond. Evoked and invoked postsynaptic potentials are accompanied by cationic fluxes which are 10 per cent of the range for action potentials but last for 10-1000 longer. If these ionic currents flow almost without dissipation the situation changes profoundly.

3. The cell membrane Josephson junctions generating coherent IR photons and the scaled up dark variants of this Josephson junction (in particular ordinary EEG) generating photons with the same energy scale would become main utilizers of the metabolic energy. This metabolic energy would be needed to the communication of sensory input to the hierarchy of magnetic bodies using dark photons with energies above the thermal threshold and the motor response of the magnetic body utilizing negative energy photons in same energy range would also require metabolic energy.

4. Metabolism is needed also for the synthesis, transport and recycling of the neurotransmitters. If these activities are control by neuronal magnetic body, they could proceed by a sequence in which neuronal magnetic body sucks energy from the motor instrument and this sucks energy from mitochondria or directly from from glial cells. This "repeated stealing" of energy does not look very attractive ethically but the monstrosities that we see in nature documents are in spirit with this hypothesis.

4.1.2 The three metabolic pools in brain

Brain metabolism [J10, J2, J3] forms 20 per cent of the total metabolism during wake-up state. There are three interacting systems: neurons, glial cells (astrocytes) and red blood cells. There are three metabolic pools corresponding to glutamate- and GABA-ergic neurons and glutamine-ergic astrocytes (X-ergic means that neuron uses neural transmitter X in synaptic transmission). The oxidative metabolism of the glutamate-ergic neurons is estimated to be roughly 70-80 per cent of the brain metabolism. The rate of the oxidative metabolism correlates with the glutamate production rate which could also mean that oxidative metabolism corresponds only to what happens in axons. The metabolism of the GABA-ergic neurons and glutamine-ergic astrocytes contribute both 10 per cent to the total brain metabolism.

Astrocytes signal glutamate-ergic neurons using glutamine as a transmitter: in neurons it is transformed to glutamate used in turn to generate de-polarization of astrocytes followed by Ca^{++} waves serving as a signalling mechanism inside astrocytes. Glutamate is in turn utilize glutamine by astrocytes. This gives rise to glutamate-glutamine cycle. The rate for the transformation of glutamine to glutamate as well as the rate of the anaerobic metabolism of the astrocytes in this glutamine-glutamate cycle correlate with the rate of the metabolism of glumate-ergic neurons.

Glutamine part of the cycle could be identified as a motor control of neuron group performed by magnetic body with the mediation of astrocyte synticia whereas glutamate part could correspond to a sensory input from neuron groups to astrocyte synticia to magnetic body.

4.1.3 Metabolic anomalies

There exists actually no consensus view about neuronal metabolism and there are many poorly understood and even mysterious looking aspects. The paradoxical finding is that much more oxygen rushes to coherently firing neuron groups than needed to satisfy the metabolic [J10]. What doubles the paradox is that the recent MRI studies show that the heightened neural activity uses only a very small amount of the extra oxygen [J7]. This would suggest that oxygen has some other function than providing metabolic energy in the standard manner.

That the cyclotron frequency of O_2^- radical is 9.4 Hz in Earth's magnetic field forces the question whether oxygen radicals could provide partially the metabolic energy used by $k_{em} = 4$ magnetic body as it performs bio-control by sending negative energy $k_{em} = 4$ dark photons in alpha band to the firing neuron group. The mechanism providing the metabolic energy would be the dropping from excited cyclotron states to lower cyclotron states. Free oxygen radicals would not be a mere nuisance in this framework.

4.1.4 Resolving the mystery of the ionic channels and pumps

The dark matter inspired view about metabolism is that ionic pumps and channels serve only as various kinds of ionic and voltage receptors of the magnetic body allowing it to receive information about the cellular environment. Only a minor fraction of ionic currents would flow through them. The main sink of the metabolic energy would be the photons and weak bosons associated with the generalized hierarchy of EEGs serving communication and control purposes of the hierarchy of magnetic bodies. The energy per ELF photon at $k = 4$ level of the dark matter hierarchy would be indeed above the thermal threshold so that already ordinary EEG would require a considerable expenditure of the metabolic energy.

4.1.5 The metabolic energy needed to build magnetic bodies

It is interesting to find what the proposed vision allows to conclude about the metabolism related to the construction of magnetic bodies.

1. The flux tube of Earth's magnetic field of length $L_e(167) = 2.52$ μm with quantized magnetic flux has rest energy L/S and if the area is $S = L_e(167)^2$ the rest energy is $E(167) = .4844$ eV, which is the energy released when single ATP molecule transforms back to ADP. The first question is whether the metabolism might take care about the regeneration of the magnetic flux tube structures, including also those associated with the magnetic sensory canvas. This does not seem to be the case: the reason is that magnetic flux tubes are expected to be rather stable structures and their continual generation would mean that the system would get drowned to magnetic flux tubes.

   Part of the magnetic flux tube structure might however be generated during the growth period of the system. A rough estimate for the power needed to generate the magnetic canvas during this period is in order. Yhe total rate of metabolism in a normal situation is about 10^4 kJ/day translating to $10^{12}m_p$/second, where $m_p \simeq 10^9$ eV is proton mass. Magnetic flux tube with a length of one Earth's circumference could thus be produced in 10 nanoseconds.

   This estimate corresponds to the $k = 0$ level of dark matter hierarchy. For higher levels of dark matter hierarchy flux tubes are expected to define r-fold coverings of ordinary flux tube and have r-fold energy, $2 = 2^{k_d}$ for Mersenne hypothesis. Time scales are scaled up by r which would suggest that the buildup of magnetic bodies is a process occurring in the same time scale as the evolution of biological body and requires considerable metabolic resources.

2. MEs represent classical radiation escaping from the system and have a finite duration at a given space-time point. Therefore MEs can and must be generated continually. Buy now-pay later mechanism at DNA and possibly other levels could and probably does generate MEs at least in alarm situation without metabolic costs. This corresponds to generation of bound states and the assumption that the energy costs must be paid later would mean that thermal noise sooner or later destroys the bound states. The classical estimate for the power involved with EEG gives an order of magnitude estimate about the metabolic energy involved.

4.1.6 Does brain delegate?

During wake-up state motor control from the magnetic body affects directly neuronal level. During sleep neurons the connection between astrocytes and neurons is off. This would suggest that during sleep red blood cells and astrocytes are involved in conscious processing of information using sensory representations about internal milieu generated mostly by red blood cells and feedback to the astrocytes. Also visual representations besides auditory ones are possible since red blood cells are also able to "see" bio-photons.

During wake-up period cortex takes care of a large amount of conscious information processing and the experience from what happens in human organizations suggests that during sleep this processing is delegated to the lower levels of the self hierarchy, in particular blood cell colony, while cortex is reserved for the purposes of the higher levels selves communicating and controlling at theta and delta EEG frequencies. Blood cells colonies of the entire body could be wake-up when we sleep. Of course, also other than blood cells could be in wake-up during sleep.

The bodily consciousness possibly activated during sleep would process the information from environment and wake-up cortex if needed. Red blood cells are indeed able to "see" at visible wave lengths and could provide for the body eyes allowing to perceive the radiation emitted by other living organisms (say predators). Also sounds could be transformed to em waves and amplified by the liquid crystals [D1] of the body acting as piezoelectrics. Blind sight and the strange feats of sleepwalkers might be due to the body vision and the role of red blood cells sensitive to visible light might be decisive.

One expects that red blood cells correspond to rather low level of dark matter hierarchy and thus rather high Josephson frequencies. One possibility are microwave frequencies assignable to the dynamics of protein conformations. Microwaves would serve as a correlate for the wake-up state of the red cell colony and cells in general.

While constructing a model for taos hum [K20] , [I16] I learned that after sunset there appears a radio static which has a biological origin and correlates strongly with taos hum [I16]. I identified this static as the analog of EEG for the sensory canvases associated with cells and proposed that the emergence of this radio static means wake-up at cellular level. The painful experience of taos hum presumably related to microwave hearing and inducing fatigue could be understood as a failure of the electromagnetic immune system to prevent the sucking of metabolic energy by other organisms using phase conjugate $k_{em} = 1$ radio waves. The radio noise generated by computers and other sources of radio waves need not cause troubles since these radio waves are expected to correspond to $k_{em} = 0$ and positive energy photons. To test this hypothesis, one could look whether a radio static analogous to EEG sets on after sunset and disappears after sunrise as the observations about taos hum suggest.

4.2 Astrocytes And Quantum Control Of Brain

4.2.1 Astrocytes

Astrocytes form 50 per cent of the total number of brain cells whereas neurons make only 10 per cent. The view about the function of astrocytes has changed dramatically during the last half decade thanks to the progress in the experimental side. The earlier view was that astrocytes have only two roles: they are kind of a motile skeleton of brain keeping neurons on place and serve as energy stores of brain. The new view is that astrocytes support, monitor, integrate and regulate neuronal activity [J6].

The existing understanding about astrocytes combined with TGD views encourages to think that astrocytes, neurons and red blood cells form kind of a "holy trinity" in which astrocytes allow the magnetic bodies to perform motor control in very general sense. In computer metaphor according to which me is computer sitting at its own terminal astrocytes correspond to the computer keyboard used by magnetic body corresponding to $k_{em} = 5$ level from the frequency of Ca^{++} waves. Red blood cells *resp.* neurons in turn project somatosensory sensory input *resp.* sensory input from external world to the magnetic body with blood brain barrier representing the boundary between body and external world. Blood cells would represent somatosensory information about body including the orientation of the body whereas external world and third person view about body would be represented by neurons.

1. Basic facts about astrocytes

Astrocyte have typically a stellar shape with size of at least 10 micro-meters. Astrocytes form gap junction connected structures, synticiums, consisting of several millions of astrocytes and having sizes of order millimeter which is also the size of the coherently firing neuron groups in cortex. Astrocytes have processes or "endfeet" which envelope either groups or neuronal synapses or blood vessels. The neuronal endfeet make possible bi-directional communication between neurons and astrocytes and extended control of neuronal activity and modulation of neuronal synchronization. Also in case of capillaries control activity is possible and there is no good reason of not believing that also now bi-directional communications are possible.

The endfeet of astrocytes are motile and tend to move to the direction of the most active neurons. Astrocytes can also swellandthe resulting change of the intercellular volume probably plays a control role since it changes both ion and transmitter concentrations.

Astrocytes and neurons communicate by neural transmitters. Astrocytes have large number of

various receptors [J6] and there are good reasons to believe that astrocytes have complex chemical communications with neurons. For instance, glutamate-glutamine cycle involves reception of glutamate from neuronal synapses and chemical signalling by glutamine received by neurons. Glutamate induces de-polarization in the synticium of astrocytes propagating through it and accompanied by Ca^{++} wave. Ca^{++} is known to excite synaptic transmission, the dependence of transmission efficiency being proportional to the fourth power of Ca^{++} concentration. The sucking of Ca^{++} by Ca^{++} waves from synaptic regions near endfoot has thus inhibitory effect on them. The resulting Ca^{++} sooner or later returns Ca^{++} with opposite effect on synaptic efficiency. Now however the effect occurs simultaneously to a large number of neurons and this is believed to support and modulate neuronal synchronization.

The typical frequency for inhibitory-excitatory action is few times per minute, which suggests that Ca^{++} waves relate to the quantum control by $k_{em} = 5$ level of dark matter hierarchy for with Josephson period is about 3.6 minutes (.2 seconds for $k_{em} = 4$). Also short term memory relates to this level in the proposed vision [K8]. The scaling law $v = Lf$, with v taken to be the velocity of Calcium waves, L the size of synticium, and f the frequency of wave, deserves a testing. The law would give very small velocity of order mm/minute for $L = 1$ mm.

It has been proposed that a control circuit neurons-astrocytes-blood exists and that neurons could communicate for blood circuit the desire about increased blood flow. NO diffusion activated by a signal from neurons and in turn affecting blood circuitry via endfeet is one possibility. In TGD framework the control hierarchies magnetic body-astrocytes-neurons-blood flow and magnetic body-astrocytes-blood flow and sensory hierarchies resulting as their reversals seem natural.

2. The role of the astrocytes as metabolic reserves

Astrocytes act as the energy reserves of brain [J6] and should therefore act as metabolic censors limiting the intensity of conscious experiences expected to correlate directly with the amount of the binding energy liberated in the experience. The astrocyte-to-neuron ratio increases in the brains of the higher animals. The narrowest interpretation is that this reflects the increasing metabolic needs as higher levels of dark matter hierarchy emerge for each of which energies of dark EEG photons are above thermal threshold.

Astrocytes both synthesize, store and catabolize glycogen molecules. An obvious question is how this fuel is transferred from astrocytes to neurons. According to [J6] "It is very likely that there is astrocytic export of fuel substrates such as lactate to neurons". The oxygen consumption in the activated neurons is very low [J7]. Is there *any* transport mechanism? Brain has probably not taken the risk of not getting fuel in case that the quantal transport mechanism based on the generation of negative energy bio-photons by neuron groups and received by astrocyte synticiums fail.

3. Astrocytes as an instrument of motor control

The known role of astrocytes as metabolic controllers and the gardener metaphor vision about control as a selection of existing activities is consistent with the identification of the astrocytes as mediators of generalized motor control performed by magnetic $k_{em} = 5$ magnetic bodies.

This motor control would be high level control involving presumably symbolic representations: instead of detailed commands only names of complex motor activities are given. A reference wave generating a complex hologram is basic example of this kind of quantum control. This would suggest that the frequency of the carrier wave generation is rather low. Ca^{++} waves indeed appear with low frequencies of order few/minute. This frequency would be analogous to the kHz frequency associated of neural synchrony.

According to the TGD based models of EEG [K8] and nerve pulse [K19], gap junction connected structures can carry standing EEG waves and their scaled up variants. Also W MEs inducing charge entanglement are possible and would induce deviations from charge equilibrium and currents tending to compensate them. Ca^{++} would represent basic example of this and could be also seen as higher level variants of nerve pulses. In case of astrocytes $k_{em} = 5$ level suggests itself. Perhaps $k_{em} = 5$ magnetic body controls via synchronically firing neuron groups the metabolc activities of astrocyte groups. The scaled up variant of memetic code with the durations of memetic codon about $T = \lambda \times .1 \simeq 200$ s and single bit of codon about $T/127 \simeq 1.6$ seconds suggests itself.

If astrocytes are involved with the generalized motor control in the proposed manner, the astrocyte-neuron coupling should be on only during wake-up and turn off during sleep and relaxed

states. This is indeed what has been observed according to [I3]. During sleep astrocytes would control mostly blood flow and receive sensory information also from blood flow through endfeet. This picture suggests that neuronal level delegates the responsibilities to the lower levels of the self hierarchy during sleep. This means that lower level magnetic bodies take care of bodily functions. The prediction is that astrocyte-neuron connection should be active during verbal dreams.

4. The role of astrocytes in information processing

During the last years it has become clear that astrocytes express most neurotransmitters and receptors expressed by neurons so that complex communications between astrocytes and neurons are expected to occur. The already mentioned glutamine-glutamate cycle involving the generation of Ca^{++} waves represents one example of astrocyte-neuron communications.

For instance, according to [J4] astrocytes have an active role in the information processing in the association areas, which have been identified as $k_{em} = 5$ levels of dark matter hierarchy in [K8], and the neuronal sensory information is represented at the level of astrocytes by patterns that activate Ca^{++} waves and that astrocytes in turn infotropically encode the information with resulting synchronously firing synaptic domains. The role of astrocytes associated with associative regions in the generalized motor control in TGD based model is as an interface transforming high level symbolic control signals (internal speech) from $k_{em} = 5$ level to lower level signals modulating nerve pulse activity via metabolic control.

Astrocytes also receive and gather information about blood flow through the endfeet in blood vessels and very probably also control the blood flow metabolically. One can ask whether sound waves in blood vessels or capillaries could allow the magnetic bodies associated with blood flow to communicate with astrocytes. Sound waves would be generated by MEs projecting to brain from sensory canvas coding the generalized motor commands as internal speech.

4.2.2 The holy trinity of blood, astrocytes, and neurons

The foregoing observations conflicting with the standard beliefs about how reductionistic and materialistic brain should function can be understood in the framework of TGD inspired theory of consciousness. I have already introduced the basic ideas of the model piece by piece but it is worth to develop it more systematically.

The computer sitting at its own terminal metaphor, the gardener metaphor, puppet on string mechanism, hologrammic control by reference waves, identification of features as synchronously firing neuron groups are the notions which lead to view that neurons, astrocytes, and blood form a "holy trinity" with sensory canvas representing the subjective me identifying itself with the physical body; astrocytes representing the computer terminal mediating motor control from the level of sensory canvas to brain level; neurons representing the processors of computer; and blood and pyramidal cells (at least) generating the projector MEs to our sensory canvas. Of course, blood allows an entire hierarchy of sensory canvases.

4.2.3 Calcium waves as a tool of generalized motor control

The basic facts about Calcium waves are summarized in [J8]. Ca^{++} waves appear at all control levels in living matter and there are both mechanical, chemical, and electric mechanisms for the propagation. This suggests that the motor control mechanism based on MEs generating various kinds of waves at resonant frequencies is utilized by living matter in a very wide range of time and length scales. For a given mechanism of conduction the value of the velocity varies in rather narrow limits. The spectrum of the possible conduction velocities however spans nine orders of magnitude from few nm/s to about one m/s. The velocities of the ultraslow waves vary in the range 1-30 nm/s and they accompany developmental processes. Slow waves move with velocities 1-3 μ m/s. Fast waves move with velocities 10-30 μ m/s and move by reaction diffusion mechanism. Ultrafast waves move with velocities of about 15-40 cm/s and propagate electrically. In accordance with fractality, the ratio of the upper and lower limits for the velocities equals to 3 in all these cases.

If the entire astrocyte synticium is excited, the frequency f is smallest and should be of order few/minute: this together with the size estimate $L \sim 1$ mm for the size of the astrocyte gives estimate for the velocity v as $v \sim 16$ μm/s. This velocity belongs to the range of the fast Ca^{++} waves propagated by reaction diffusion mechanism. If only single astrocyte with size about 20

micro-ns responds, the frequency is of order $f \sim .8$ Hz. This would mean that the frequency interval to which astrocytes respond via Ca^{++} waves would be below the EEG range. Of course, it is highly plausible that there is entire hierarchy of responses in various frequency ranges and this would mean that the signal sent by ME would be effectively Fourier analyzed to various responses in various frequency ranges.

For ultrafast waves the frequency spectrum would vary roughly between .5 kHz and 50 kHz. The resonant kHz frequency involved with the synchronous firing of nerve pulse patters belongs to this frequency range. Slow and ultraslow waves would correspond to frequency scales of order few/10 minutes and 1/month and interpretation in terms of biorhythms is suggestive. Interestingly, EEG range remains outside the frequency bands associated with Ca^{++} waves. This could mean a sharing of the frequency bands such that the frequency bands used for the generalized motor control do not have overlap with the frequency bands involved with the em MEs and responsible for projecting information to the sensory canvases.

4.2.4 Are astrocytes above neurons in the hierarchy?

The question is whether magnetic body uses astrocytes to control neurons or whether it uses neurons to control astrocytes. Or more precisely: does magnetic body use synchronously firing neuron groups to induce Ca^{++} waves in astrocyte synticia or use Ca^{++} waves to modulate neuronal firing? Astrocytes have "endfeet" on neurons and red blood cells and there are good reasons to believe that that the end feet act as switches to control and integrate information. Astrocytes are present already in invertebrates so that there is not obvious answer to the question.

That astrocytes are above neurons in the hierarchy is suggested by following observations.

1. Since astrocytes are metabolic resources it would be very natural for magnetic body to suck energy directly from astrocytes. Also the fact that the frequency for the generation of Ca^{++} is few/minute, $k_{em} = 5$ is a natural identification for the dark matter level involved so that astrocytes seem to correspond to a higher level in dark matter hierarchy whereas nerve pulse activity would correspond to $k_{em} = 3$.

2. Astrocytes are known to "behave" (morphological change, motility, myelination, mitosis), which suggest a role that they are at higher level of hierarchy than neurons. The fraction of astrocytes in vertebrate brain increases at higher levels of the evolutionary hierarchy.

3. Microtubules were regarded as passive support structures for a long time. Astrocytes play a role analogous to micro-tubuli, which give rise to cytoskeloton playing a role of CNS of cell, take care of logistic functions, and also declarative memory in TGD framework [K19]. This encourages the view that astrocytes act as motor instruments of the magnetic body to control the behavior of neurons and are involved with short term memories as the frequency of Ca^{++} wave generations suggests.

4. According to [I3], in deep relaxation states the switches from neurons to astrocytes are off whereas those from red blood cells are on. This would suggest that both neurons and red blood cells are at a lower level in the hierarchy. This would TGD based view suggests that astrocytes feet are essential link in the control of brain by magnetic body at $k_{em} = 5$ level of hierarchy. It is possible to assign to astrocytes also circadian rhythms that also $k_{em} = 6$ level is involved.

5. Since astrocytes are the metabolic stores of brain they naturally have a filtering role proposed also in [I3]. During altered states of consciousness this censorship temporally loosens and very intense euphoric moods can result. These "highs" however deplete sooner or later the metabolic reserves of astrocytes and are followed by "lows" as happens periodically in the manic-depressive disease. Quite generally, mental disorders could be accompanied by metabolic disorders at the level of astrocytes and due to the abnormalities in the blood flow.

4.2.5 Do higher levels of dark matter hierarchy use brain during sleep?

The absence of higher than delta bands in EEG spectrum during deep sleep is consistent with the assumption that dark photons in other than delta bands are absent. The frequencies around 1 Hz

correspond to DNA cyclotron frequencies which suggests that quantum control of DNA activities occurs during deep sleep.

The metabolic energy spent by the brain to sensory and motor activities in the day-time would be used by magnetic bodies at $k_d > 46$ levels of dark matter hierarchy during sleep ($k_d = 46$ corresponds to 10 Hz region). For instance, $k_d = 54$ corresponds to the time scale of few minutes assignable to short term memory and to astrocyte-neuron interaction which is absent during deep sleep.

Structures responsible for circadian rhythms should involve $k_d = 65$ level. The master circadian pacemaker in mammals is considered to be the suprachiasmatic nucleus (SCN) of the hypothalamus containing heterogenous population of neurons and glial cells: both express genes with circadian period [J11].

This would suggest that brains would be literally in a shared use. Higher level selves would use the brains of the average citizen mostly during night time whereas the brains of the people endowed with creative and meditative practices would be available to the higher level conscious entities also during daytime.

4.3 The Effects Of Endogenous Sound Waves As A Support For The Scenario

The effects of endogenous sound waves on consciousness provide some support for the suggested role of astrocytes as buffer between neurons and $k_{em} = 5$ magnetic body.

4.3.1 How the signals from magnetic body are transformed to control signals?

If the entire head of body receives the internal speech from $k_{em} = 5$ magnetic body, several amplification mechanisms are possible.

If this picture is correct, astrocyte synticia act as an interface between higher level symbolic and linguistic representation and neuronal representations. This would explain why the astrocyte/neuron ratio increases in higher organisms.

An interesting question relates to what differentiates between the natural sounds and spoken language. One might wonder whether hearing involves also the generation of internal speech involving the propagation of the speech sounds in blood vessels or some other cavities. Since body is liquid crystal it is also possible that muscles and collagen structures act as amplifiers of the weak sounds generated by MEs near vacuum extremals and carrying both em and Z^0 fields proportional to each other.

The size L of the excited part of the astrocyte synticium, which can be assumed to vary, and the propagation velocity v for the Ca^{++} waves, presumably controlled by the metabolic conditions, determine the ELF frequency which can interact resonantly with the astrocyte and generate high frequency oscillations in it (MEs with frequencies at multiples of $f_h = c/L > 3 \times 10^{11}$ Hz and directly controlling the molecular level). Each astrocyte synticium could respond to a characteristic ELF or ULF frequency determined by its internal state and metabolism. It is conceivable that astrocytes can control also the Ca^{++} wave conductances of the gap junctions and thus the size and shape of the Ca^{++} conducting regions and the the ELF or ULF frequency that they respond to. The increase of the metabolic rate presumably increases the velocity of propagation for Ca^{++} waves.

4.3.2 Are sounds transformed to endogenous sounds to Ca^{++} waves?

The following considerations force to consider seriously the possibility that endogenous sounds transmitted from blood vessels to astrocytes are involved with hearing and create the sensation of hearing.

Various structures of biological tissue form collagen networks which are liquid crystals [I19] and thus piezoelectrics [D1] and allow the transformation of classical em and Z^0 waves to sound waves and vice versa. The weak sound waves might be amplified also by the walls of the blood vessels and capillaries and also by other muscles. This amplification mechanism is expected to work in entire length scale range ranging from body size to atomic length scales. For instance, if the carrier wave

has kHz frequency, the wave giving rise to the neuronal synchrony, it has wave length of order head size, and the blood vessels and collagen networks inside head could serve as acoustic wave cavities.

There is empirical support for the endogenous amplification of sounds. Physiophonic sounds result in an electrical stimulation of the skin and speech represented in this manner is subjectively understood as speech: this could be due to the propagation of the sound signals through body. Note that meaningful signals coming from environment (created by say predator) can be transferred from skin directly to the astrocytes and stimulate wake-up. In light of this it would seem that deaf persons could learn to hear by feeding the sound signals directly to the body.

The sound waves could be mediated by blood to the endfeet of the astrocytes to blood vessels. Sound waves are indeed known to induce Ca^{++} waves [J4], which suggests that the mechanism explaining physiophonic hearing involves the transformation of endogenous sounds to Ca^{++} waves. Instead of magnetic body communicating internal speech as metabolic control signals to the astrocyte synticiums, the sound mediated from external world as physiophonic sound does the same. Also ordinary hearing could involve the transfer of sound waves of sounds as endogonous sounds to the synticiums such that spoken language would be transformed to Ca^{++} waves defining a representation experienced by the $k_{em} = 5$ magnetic body as speech.

That acoustic signalling could be present conforms with the fact the acoustic vibrations are indeed transformed to Ca^{++} waves. For instance, a very light blow in head generates acoustic waves which induce Ca^{++} wave patterns and can induce a loss of consciousness. The 1/minute frequency scale for Ca^{++} waves indeed suggests that the high level control using high level symbolic representation is in question.

4.3.3 Taos hum and endogenous sound waves

The victims of taos hum [I16] hear an intolerable humming sound with no identifiable external source containing also components reflecting the structure of acoustic environment could also involve the generation of physiophonic sounds. The most plausible identification of taos hum in terms of microwave hearing (amplitude modulation represents the sound) explains the failure of the attempts to identify the source for taos hum. The modulation of microwaves at audible frequencies would induce endogenous sounds which induce the sensation of hearing by generation Ca^{++} waves in astrocytes.

Taos hum starts immediately after sunrise and stops after sunset and seems to have biological origin. A possible explanation is that the magnetic bodies of (say) plant cells send $k_{em} = 1$ dark negative energy photons at microwave frequencies to satisfy their metabolic needs. An explanation for why the hum is intolerable and for extreme fatigue caused by it might be simple: the microwaves suck energy from its victim whose electro-immune system fails to insulate the body against this radiation.

4.3.4 Minor head trauma, epilepsy and endogenous sound waves

Minor head trauma and epilepsy provide a testing ground for the identification of endogenous sound waves as inducers of Ca^{++} waves in astrocytes. Minor head trauma does not cause any injury but is accompanied by a loss of consciousness. A possible explanation is that the endogenous sound waves contain the resonance frequency of head with high amplitude and induce a phase transition replacing $k_{em} = 5$ level with $k_{em} = 4$ level or even lower level so that consciousness at $k_{em} = 5$ level is lost.

One could try to understand also epileptic seizures in this framework. Hyperventilation increasing the oxygen content of blood is known to induce a petit mal in children. Petit mal is accompanied by the characteristic 3 Hz EEG rhythm in delta band. If motor control is mediated via the blood vessels as sound waves, the anomalously high concentration of oxygen in blood could somehow cause the petit mal.

1. In [J4] it is proposed that the mechanism involves the generation of Ca^{++} waves with 3 Hz frequency instead of few/minute frequency. Too much oxygen might induce a phase transition $k_{em} = 5 \to 4$ in which the frequency of Ca^{++} waves increases by a factor λ to about 3 Hz. This would also imply the increase of the velocity of propagation for Ca^{++} waves if scaling law $v = Lf$ is taken seriously. The resulting spatial and temporal incoherence would mean loss of consciousness at $k_{em} = 5$ level of the hierarchy.

2. This model for epilepsy is consistent with my own simultaneously frightening and fascinating night-time experiences in which the subjectively experienced volume of the sound of the refrigerator begins to get gradually amplified and I have a strong conviction that I am very near the border of an epileptic seizure and must wake-up fully as soon as possible. If theta and delta waves represent the frequency bands through which higher levels selves control our brain and receive sensory information, the amplification of the delta and theta waves above critical threshold could imply that these conscious entities take the cortex to their "possession" as also during sleep. Perhaps it is not an accident that prophets were often epileptics: trance could be an example of a situation in which higher level self operating at very low EEG frequencies uses brain to send motor commands and even communicate.

4.3.5 "Great experiences" and "blood consciousness"

I apologize for not saving the reader from the obligatory reference to my own strange visual experiences about complex hydrodynamics flow having usually a sink ("third eye") in the middle of the visual when I close my eyes in a highly relaxed state. Perhaps this flow could relate to blood flow or magnetic flux tubes structures associated with the blood flow represented at "my" magnetic sensory canvas and represent also visually the state of the internal milieu. Also representation in other modalities are possible. A possible interpretation is that this flow somehow represents the state of the central nervous system with the sink ("third eye")having identification as spine. An alternative possibility is that it represents directly the structure of the sensory magnetic canvas. The vortical structure of this flow could reflect the helical structure of the magnetic flux tubes associated with the sensory canvas and the canvas would be dynamical if this is the case.

The state of whole body consciousness accompanying sometimes this experience is characterized by the disappearance of the unpleasant noise usually present in the body and the generation of the thrill-in-spine sensation generated by good music and spreading over the entire body. Perhaps in this state both neuron and blood and possibly entire body are in a wake-up state simultaneously and use common sensory canvases at various levels. Maybe the entanglement with the higher levels of the self hierarchy makes possible the feed of the metabolic energy also from the external world in the form of electromagnetic energy carried by positive energy MEs during this kind of state.

I have also personal experiences about strange doubling of sound of breathing outwards just after wake-up or having run. What might happen is that the externally heard sound of breathing is heard as a copy slightly later. Perhaps the copy is nothing but the sound of breathing heard physiophonically. Another amusing (but not pleasant!) effect is to hear one's own snoring when body still sleeps. The subjectively experienced intensity of the sound is much stronger than usually and experienced as an outsider: body is indeed effectively outsider when decoupled from the motor system. Also this sound could be interpreted as a physiophonic sound.

The well-known correlation of the skin conductivity with the mental state is consistent with the idea of body consciousness. Skin is an important factor in paranormal abilities such as telepathy (I have a personal experience in which I experienced what I believe to be a remote event as happening at my skin as a miniature version!), healing by touch, and psychokinetic abilities in which PK-able person holds some object in her hands and gradually releases it so that it remains "hanging" in the air.

5 Molecular Machines In Many-Sheeted Space-Time

Biophysics in nano scale looks like a miniature society populated by molecular citizens in their many duties. The basic problem is to understand how these molecular creatures are able to fight against thermal fluctuations so that their motion does not degenerate into mere Brownian randomness and how they can can so effectively transform metabolic energy to a usable energy. The existing models rely on the so called ratchet principle: Brownian motors [I6, I22, I11] rectify Brownian motion and pick up from it only the thermal momentum which is in the desired direction.

The idea of Brownian motor is ingenious but many-sheeted space-time concept suggests even cooler idea: why not move on the non-atomic space-time sheets where there is no thermal motion so that the dissipation is practically nil and the only energy needed is basically the difference of the zero point kinetic energies needed to kick the molecular ant or its leg back to the atomic space-time

sheet. Or expressing it in engineering terms: all moving parts of the quantum motors move at the non-atomic space-time sheets where the dissipation is minimal.

TGD provides also a new view about the energetics of molecular motors. The energetics of the living matter can be understood as being based on the ions flowing in an ohmic circuitry on the atomic space-time sheets (DC currents of Becker [J1]) and in a supra-current circuitry formed by the magnetic flux tubes. Energy is liberated in the dropping of protons and possibly other ions from atomic to super-conducting space-time sheets: the difference of the zero point kinetic energies is liberated as a usable energy. For chemical purposes this energy is emitted as a single photon whereas for mechanical purposes it could be liberated both as a single photon or as a cascade of ELF photons generated when high n cyclotron state of proton decays.

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

Amazingly, the velocities predicted by single photon mechanism for the motor enzymes turn out to be of correct order of magnitude! The zero point energy allows also ordinary dissipative motion if the proton drops to high n cyclotron state and decays by generating ELF MEs in turn building up a radiation pressure forcing the motion of the motor molecule. Thus one has two options, classical and quantum, for the molecular motors in TGD framework and both might be utilized depending on situation. The difference with respect to thermal ratchets in both cases is that the energy is liberated as a directed energy rather than mere heat energy rectified to a directed energy by ratchet.

The theory resolves several paradoxes, makes quantitatively correct predictions, and yields several pleasant surprises.

1. As far as molecular motors are considered both quantum and classical options seem to work. Quantum option is extremely predictive and easily killed by checking whether the velocities of motion for motor molecules scaling like $1/m$, m mass of the motor molecule, are what the theory predicts their precise values to be.

2. A new view about the real function of ATP molecule emerges: the questionable notion of the high energy phosphate bond is definitely wrong in TGD framework and the $F_0 - F_1$ machine generating ATP actually kicks up protons from super-conducting space-time sheets to atomic space-time sheets thus energizing them. Also other ions can serve as energy carriers and the DC currents of Becker [J1] would act as power lines.

3. The energy liberated in the dropping of a single proton from the atomic space-time sheet equals to energy about .5 eV liberated when single ATP molecule is consumed. On basis of the data about reaction kinematics [I21] it however seems that also second proton drops down so that the liberated energy would be ~ 1 eV and too large by a factor of two. A possible explanation for the discrepancy is that the energy is liberated with equal probability as a single quantum and as a cascade of ELF photons and that the cascade of ELF photons are not taken into account in the usual book-keeping.

   One can understand the duration of the ATP production step and the time scale for a single step of motion for molecular machines as being determined by proton's cyclotron frequency f_c about 300 Hz. The ratio $\Delta E/E_c$ of the zero point kinetic energy ΔE of proton at atomic space-time sheet to the proton cyclotron energy E_c equals precisely with the ratio $f_h/f_{ELF} = 2 \times 10^{11}$ of high and low frequencies appearing in the homeopathic scaling law stating that high and low frequencies implicating each other's presence [K13]. This supports the idea that both quantum and classical modes for the molecular motors are possible.

4. Ionic pumps and channels allow ions to run from atomic space-time sheets to magnetic flux tubes and vice versa: this resolves the paradox created by the empirical facts both supporting and challenging the existence of the ionic channels and pumps.

5. The TGD based vision about quantum neuron deepens considerably. The resting potential of the cell membrane (-63 meV) has an interpretation as a barrier preventing the flow of proton Cooper pairs from the $k = 139$ super-conducting space-time sheets in the cell interior to the magnetic flux tubes in the cell exterior. Nerve pulse is generated when the membrane potential drops below the critical value so that proton Cooper pairs start to flow from $k = 139$ super-conducting space-time sheet to the magnetic flux tubes of Earth's magnetic field. This induces the flow of various ionic currents, perhaps along same join along boundary contacts along which proton Cooper pairs flow in case of K^+ and Cl^- ions. EEG waves accompanying the propagation of the nerve pulse result when the high n cyclotron states of these ions decay. Also a novel view about the function of Ca_{++} waves emerges.

Already on basis of these examples, it seems to me that the understanding of what it is to be a proton in the many-sheeted space-time points out the Golden Road to the physics of the living matter. My hope is that these miracle like quantitative successes could help to break the reductionistic resistance against the new view about space-time and make possible collective effort to develop TGD based quantum theory of bio-systems.

5.1 TGD Inspired Questions And Ideas Relating To Coherent Locomotion

5.1.1 Does it make sense to store momentum?

An important aspect of doing work, not usually considered, is to generate or transfer momentum besides energy. An interesting question is whether also momentum could be stored just as energy is stored.

Chemi-osmotic phosphorylation involves the acceleration of the hydrogen ions in an electric field associated with an appropriate membrane structure. Part of the protonic momentum could be stored in a phosphate group related structure or directly to ohmic protonic currents perhaps identifiable as the DC currents of Becker [J1]. In photophosphorylation the storage of both photonic energy and momentum might be possible and the maximal momentum stored would be $p = E/c$ and by a factor $\sqrt{E/m_p} \sim 10^{-5}$ smaller than the maximal momentum $\sqrt{2m_pE}$ transfer in the chemi-osmotic phosphorylation.

If molecular storage mechanism of the momentum is same in both cases, the dominant fraction of the momentum must be absorbed by some larger structure, say by the catalyst cite or the appropriate membrane, in the chemi-osmotic phosphorylation. The rotation of the rotating shaft of the $F_0 - F_1$ machine [I20] generating ATP could dissipate large fraction of the protonic momentum. Thus photosynthesis would be dominantly an energy transfer process whereas the hydrogen ion flow occurring in the chemi-osmotic phosphorylation is also a candidate for a momentum transfer or –generation process involved with locomotion and various transport processes.

An order of magnitude estimate for the maximal momentum transfer rate (acceleration) is obtained by assuming that the whole mass 50 g of the ATP of human body is recycled in 20 seconds and that phosphorylation of each molecule is accompanied by a generation of parallel momentum equal to $p = 3\sqrt{2E/m_p}$ when it receives the momentum of about 3 protons. In this manner one finds that the acceleration of the body with mass of 50 kg would be roughly $5 \times 10^{-2}g$, where $g = 10$ m/s^2 is the acceleration of gravitation at the surface of Earth under average conditions. This value is certainly too low but this is for average conditions only: the acceleration can certainly be much higher. One must consider also the possibility that locomotion involves also protonic currents in which ATP is not produced.

5.1.2 Possible mechanisms of momentum, angular momentum, and energy transfer

One could try to understand the function of ATP by assuming that the usage of ATP involves generation of a photon with the energy .5 eV giving momentum to a motor molecule such as myosin or actin. The amount of momentum transferred to a motor molecule is $p = .5$ eV/c. The corresponding velocity $v = p/M \sim 10^{-14}c$ is of order one μm/sec and of the same order of magnitude as the velocities of the motor molecules like myosin and kinesin having masses $M \sim 10^5 m_p$. Therefore it seems that photon with energy $E = .5$ eV could indeed mediate the momentum to the motor molecules in the presence of ATP complex. The importance of this

observation is that molecular motors could be genuine quantum motors moving without momentum dissipation and obviously at non-atomic space-time sheets where dissipation is indeed practically absent.

This observation leaves a lot of freedom to imagine various mechanisms.

1. Energy is stored as the zero point kinetic energy of ions and atoms at the atomic space-time sheets: this energy would be liberated when an ion or atom drops on a super-conducting space-time sheet. The photon carrying the energy .5 eV would also carry corresponding momentum. If the user sends a negative energy photon to the energy storage in precisely defined direction, the momentum is indeed generated in a coherent manner. The transfer of a beam circularly polarized photons along ME in the direction of rotation axis would generate torque in the direction of ME. If photons have large value of $\hbar$ the unit of angular momentum would be large and large value of standard angular momentum currency would become possible. MEs are not however the best possible solution energetically. The target with mass m would receive the kinetic energy $\Delta E = E^2/2mc^2 < E$ and momentum $E = E/c$ so that most of energy would go to the internal degrees of freedom. Somehow the energy dissipation should be avoided and the seesaw mechanism to be discussed later could allow this.

2. There is a second manner to avoid energy dissipation and to avoid much larger momentum transfer. The mechanism is based on the induction of flux tubes making possible the flow of say electrons from the space-time sheet of the target to a larger space-time sheet generating the motion as a recoil effect. Also a phase transition of (say) electrons to their dark variants involves leakage to different page of the book like structure representing generalized imbedding space and would lead to similar recoil effect. There is experimental support for this kind of mechanism. This mechanism would differ from the first in that the energy of photon would go to energy of the receiver and the leakage of the particles would give rise to much larger momentum transfer $\Delta p = \sqrt{2mE}$. For instance, the system moving could send negative energy photon to the energy storage (say "many-sheeted laser") and the constraint forces would force the resulting momentum to be given by the previous formula. The moving system would act like rocket.

   Modanese and Podkletnov [H1] discovered that dielectric breakdown of a capacitor made of super-conducting and non-super-conducting electrodes induces unknown radiation inducing an oscillatory motion of penduli at large distances and that the effect does not weaken with distance as would happen if the penduli absorb the radiation. It was also found that absorption hypothesis would required the quanta of the radiation to be tachyonic. The explanation in terms of the proposed mechanism [K22] would mean that the MEs generated in dielectric breakdown would act as switches inducing the flux tues needed for the leakage of matter to larger space-time sheets and making the target to behave like rocket using its own fuel.

   It turns out that in the case of molecular motors this mechanism implies too high momentum transfers whereas the first mechanism predicts correct order of magnitude.

3. Parallel supra currents of massive charge particles at magnetic flux tubes as carriers of momentum are more promising energetically since the momentum to energy ratio behaves as $\sqrt{2m/E}$ for them and the transfer of energy to internal degrees of freedom of the target would be much smaller. The supra currents associated with Bose-Einstein condensate of ions moving with constant velocity and possessing constant value of angular momentum in the direction of magnetic flux tube could make possible angular momentum transfer. This would require a mechanism transferring the momentum and angular momentum from the sender to the beam.

5.1.3 Constraints on the model for a coherent momentum transfer

Consider now the constraints on the model of the coherent momentum transfer.

1. The coherence of the momentum transfer results if the protonic current results from a leakage of the protonic supra-current to the atomic space-time sheet and is induced by the generation

of flux tubes acting as Josephson junctions between magnetic flux tubes and atomic space-time sheets. The TGD based model for auroras [K4] suggests that this process is quite generally the mechanism destroying super-conductivity locally. A priori the magnetic flux tubes involved could correspond to the magnetic circuitry associated with the body or to much larger magnetic flux tube structure. This option does *not* require that the momentum of the ions of the protonic supra current is stored: the mere control of the process from this level is enough to guarantee coherence.

2. The extreme synchrony and coherence of the biological locomotion would be made possible by the fact that magnetic flux tubes and hence also electronic and protonic supra currents entering to the organism/organ/organelle/macro-molecule are parallel and are in the same phase. This allows simultaneous generation of the supra current leakage induced by the nerve pulse pattern in case of muscle cells. Since protonic supra currents have parallel momenta ATP molecules can transfer parallel momentum increment to about billion ATP molecules in billions of cells.

3. Magnetic flux tube structures with sizes of body seem to be enough to guarantee the coherence of the locomotion. The time scale of 1/200 seconds for the duration of single ADP-ATP-ADP process is of the same order of magnitude as protonic cyclotron frequency $f_c = 300$ Hz. If magnetic mirrors are involved also now, the wave length associated with the protonic cyclotron frequency 300 Hz in Earth's magnetic field suggests itself as the length of the magnetic flux tubes carrying the hydrogen ions and would thus be of order $L_p = 2\pi R/30$, where R is Earth's radius. The generation of the electronic charge attracting the protonic charge to the region between membranes is essential part of the process and now the leakage of the electronic supra currents to atomic space-time sheets should be involved. In case of electrons the lengths of MEs, if given by the wave lengths associated with the electronic cyclotron frequency, would be of order $L_e = 10^{-3}L_p/2 \sim 1.5$ km and corresponds to a time scale of 1.7 micro-seconds.

To sum up, if the proposed view has some seed of truth in it, super-conductivity in body length scale would be a central element of the functioning of organisms. Super-conductivity even in geophysical length scales could be crucial, not only for the realization of the sensory representations and motor actions, but also for the basic metabolic processes of life and for the coherent motion of living matter.

5.1.4 The phase transitions changing Planck constant as a basic mechanism

The phase transitions changing Planck constant induce change of the length of magnetic flux tube and this mechanism could serve, not only as the basic mechanism of bio-catalysis, but also as mechanism generating gel phase phase transitions typically inducing a change of the volume of the cytoplasm. These phase transitions could be one mechanism involved with locomotion. Also the reconnection of flux tubes making possible to modify the hardware of topological quantum computer defining also TQC program, is an attractive mechanism inducing this kind of phase transitions.

1. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning locomotion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large $\hbar$ is shot along the direction of the electric field along micro-tubule and stuck to a rachet followed by a phase transition reducing the value of $\hbar$ and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.

2. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting

amino-acids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect amino-acids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in "artificial protein" gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [I15]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

5.2 Some Facts About Molecular And Cellular Motors

Molecular motors are enzymes having typical size about 10 nm and mass about $10^5 m_p$ moving along DNA strand, micro-tubules, actin filaments, through cell membranes, etc. Of course, the terms "motor" and "machine" must be taken with a big grain of salt in TGD Universe, where bio-molecules are conscious and intelligent selves and more like molecular counterparts of ants rather than dead nanoscale robots.

During the last years it has become possible to monitor the activities of a single molecule by using laser traps and optical tweezers: also the the responses of the molecules to external forces can be studied routinely [I12]. With the advance of the experimental techniques molecular motors have become a hot research topic during last years [I6, I22, I11].

Molecular motors transform chemical energy with the mediation of ATP molecules to mechanical work, transport work, energy of electromagnetic fields, and various types of chemical work.

1. The functioning of the skeletal muscle is based on the sliding of the myosin molecules along actin filaments. Kinesin molecules are two-headed molecules moving along micro-tubuli and carrying molecular cargo.

2. Molecular motors can transport molecules along DNA, transport various molecules such as neurotransmitters through the cell membrane or along axon. There is a vast kit of motors enzymes affecting the topology of DNA: for instance, these enzymes can zip or unzip DNA double strand, past, unwind, translate, replicate, unknot and repair DNA.

3. There is evidence that ionic channels are transformed to ionic pumps by a mediation of single ATP molecule [I7] . In light of the experiments challenging the notions of ionic pumps and channels, one is forced to ask what is really occurring in this process and what its real function is. In TGD framework ATP molecules is a plug connecting two magnetic flux tubes and $ATP \to ADP + P_i$ would induce shortcut of this flux tube. This flux tube could effectively act as ionic channel.

4. Molecular motors transform chemical work to various other forms of chemical work. Consider only the assembly and breakdown of proteins and DNA replication as examples.

5. The machines producing the energy needed by the other machines are obviously exceptional and thus especially interesting. The generation of ATP, usually believed to serve as a universal energy currency (this view is challenged by TGD approach), involves a protein machine known as $F_0 - F_1$ machine [I20, I21].

Consider now general features of these machines.

1. A common denominator of all these activities (the F_0 machine producing ATP molecules forms an obvious exception) is that ATP complexes somehow provide the energy needed by the process and this energy is quantized. The time scales involved are very long, for instance 1/100 seconds for a single step of the kinesin along the micro-tubule or 1/20 seconds for the addition of a single amino-acid to a protein in the translation of mRNA. These time scales represent almost an eternity as compared to the time scale of the dissipative effects: for instance, for a protein in water the time scale τ defined by the frictional force $F_d = mv/\tau$ is of order $\tau \sim 10^{-13}$ seconds [I12].

2. If space-time is single-sheeted, the macroscopic time scales for these processes imply that classical mechanics based description relying on conservative force fields combined with Brownian and dissipative forces should be an excellent approximation. The chemical aspects of these processes should in turn be modellable by statistical models relying on thermal arguments. In the many-sheeted space-time and for a hierarchy of Planck constants the situation need not be this since molecular motors could move along cold space-time sheets and the constant velocity for this motion could be erratically interpreted as resulting from frictional forces.

3. Also definitely quantal aspects are present. The motion of the molecular motors is quantized to steps. For instance, the motion of the kinesin along micro-tubule is quantized with the length of single step being 8 nm. Kinesin uses always the same energy of about.5 eV provided by single ATP complex [I5]. Since the energy needed to perform a single step in the process is quite generally provided by the ATP complex and thus constant and independent on the properties of the fluid (viscocity, ionic concentrations, ..) which can be varied, one must conclude that the energy given by ATP complex is considerably larger than the energy needed by the process. The energy could be however used to kicking the molecule from the local potential well. Rather intriguingly, if kinesin molecule receives momentum of photon with energy of .5 eV, it gets velocity which is of correct order of magnitude. Thus quantum motor option might work!

4. Thermal ratchets for which the ATP molecule induces local heating with heat energy being rectified to directed kinetic energy, predict deterministic motion. The motion of a myosin molecule along the actin filament the motion is however effectively non-deterministic consisting of one to five steps and sometimes occurs also backwards but that always single ATP molecule is used [I13]. The average number of steps is three and the length of single step is 5.3 nm.

5.3 Molecular Motors In Single-Sheeted Space-Time

The experimental advances have generated vigorous theoretical activity involved with molecular motors. The basic challenge is to understand how the molecular motors are able to fight against the thermal motion.

To get some idea about the challenge provided by the thermal noise, it is good to have some order of magnitude view about the forces involved. A typical protein has mass $m \sim 10^6$ proton masses. In water it experiences friction force $F_d = mv/\tau$, $\tau = 10^{-13}$ seconds. The Brownian force experienced by protein, say kinesin, is of the order of magnitude

$$f_B \sim mv_T/\tau \ ,$$

where $v_T \sim \sqrt{kT/m}$ is the thermal velocity. The resulting typical Brownian force is of order one nN (nanoNewton). Let us compare this random force to the force associated with organized motion. Kinesin moves a distance $L = 8$ nm along micro-tubule during .01 seconds by using an energy of about $\Delta E = .5$ eV provided by a single ATP molecule. The average force is $F = \Delta E/L \sim 10^{-2}$ nN and by two orders of magnitude weaker than the typical Brownian force. This is like driving car pushed and pulled by random forces varying their direction in a time scale of 10^{-11} seconds and which are of same order of magnitude that the force usually needed to give the car a velocity of order 100 m/s!

From this estimate it is clear that the theoretical understanding of how molecular motors can cope with the thermal noise cannot be achieved by a routine application of the existing methodology. Something more is needed. The attempts to meet the theoretical challenge are based on the notion of ratchet rectifying thermal energy to a coherent motion. One school believes that various classical ratchets, which are actually more or less must in a single-sheeted space-time, are enough to explain everything. There are also those who believe that quantum ratchets might be needed but here the needed extremely low temperatures are the stumbling block in a single-sheeted space-time. The notion of many-sheeted space-time however suggests a simple solution to this problem: put all moving parts of a quantum motor to the cold space-time sheets.

5.3.1 Brownian ratchets

The standard thermodynamical approach is based on free energy diagrams telling only what is impossible. One can go however further and try to build models for the molecular motors. Hard-boiled reductionism, together with the observation that the relevant time scales are measured using a fraction of second as a natural unit, implies that molecular motors must be purely Newtonian mechanical motors using chemical energy. The basic challenge is to understand how these motors are able to fight against or rather, utilize, thermal motion which in the molecular length scales is dominating in the framework of standard quantum theory.

1. Basic framework and questions

The premises above lead to the following picture.

1. Molecules obey Newtonian mechanics and quantum effects manifest themselves only statistically and are buried in the parameters characterizing effective model (such as effective chemical kinetics). Besides conservative forces used to describe the interaction of the motor with the medium and the presence of the load, there is friction and randomly fluctuating forces characterizing the Brownian motion caused by the thermal effects. Fluctuation-dissipation theorem is used to relate dissipation constant to friction.

2. Basic question is how chemical energy is transformed to mechanical energy.

3. The questions related to how the motors are controlled and how macroscopic synchronous motion is achieved are not pondered in this approach, to say nothing about the possibility of macroscopic quantum states.

2. The notion of ratchet

The basic challenge is to understand how the thermal perturbations in the molecular length scales, which are of the same order of magnitude or even stronger than the amplitude of the ordered motion, can be tamed, circumvented, or utilized. The ingenious idea is the notion of Brownian motor rectifying Brownian motion (for material about Brownian motors see [I6, I22, I11]).

Ratchet is essentially a rectifier that picks up the component of motion that is in the desired direction. The asymmetric periodic saw tooth like structure characterizes ratchet. Screw-driver and the transformation of the motion of the clock pendulum to the motion of the hands of the clock rely on the ratchet principle.

One might naively think that thermal perturbations of a ratchet could be quite generally rectified and thus generate a macroscopic motion. This would obviously mean failure of the second law of thermodynamics and perpetuum mobile of the second kind. This is not possible as shown for the first time by Smoluchowsky in 1912 and also demonstrated by Feynman later in his Lectures in Physics. The situation however changes in case of far from thermal equilibrium systems.

One can invent myriads of ratchets once a sufficiently abstract definition of a ratchet is available. The asymmetric periodic structure of the cogwheel is abstracted to a potential which is periodic such that the potential well has the characteristic asymmetric shape.

1. In case of a thermal ratchet periodic heating (which requires energy so that one cannot circumvent the second law) causes the motion in case that the average distance diffused by a particle during the higher temperature period is shorter than the width of the asymmetric sawtooth like potential well. During the low temperature period particle ends up to the right, deeper end of the potential well. If the particle diffuses to the left during high temperature phase, it remains in the original potential well. If it diffuses to the right, it ends up to the next well before next heating. Thus there is a net motion to the right.

2. Also the ratchet potential might vary with time (note that this requires energy feed to the system so that the second law is respected also now). In an idealized situation potential varies from asymmetric saw tooth to constant potential and back. During the period of constant potential particle diffuses freely and if the length traveled in this manner is shorter than the width of the potential well, particle moves to the right.

3. Also oscillatory electromagnetic field containing higher harmonics of the fundamental frequency and coupled to a Brownian motor in a non-linear manner can induce the rectification of Brownian motion.

The ratchet mechanism is so general that one can invent practically endless number of Brownian motors. The basic signature of the ratchet mechanism is extremely loose coupling between the asymmetric periodicity of the potential function and the presence of a time varying external perturbation. This loose coupling is what makes the mechanism so rigid and universal and also testable. In fact, the experiments of Steven Block about the motion of kinesin along micro-tubule suggest that the coupling is *not* loose [I5].

In the case of molecular motors chemical energy liberated with the mediation of ATP molecule is the basic driving force. For a thermal ratchet the liberated chemical binding energy would induce local heating of the system and this in turn would lead to the ordered motion of the motor enzyme. One can imagine that also the ratchet potential, say the asymmetric periodic potential along micro-tubule or actin filament, could be modified by the chemical energy liberated by ATP molecule.

4. Mathematical modelling of Brownian motors

Material about the mathematical modelling of Brownian motors can be found [I6, I22, I11].

1. Newton's equations are used to model the motion of the motor molecule. The interaction with the medium in which molecule moves is characterized with an asymmetric periodic potential function. The load (second molecule carried by the molecule) is described by an additional term in potential function giving rise to constant opposing force. Friction is characterized typically by a force proportional to the velocity of motion and thermal perturbations are described by a randomly fluctuating force. In equilibrium situation in which the average acceleration of the particle vanishes, particle drifts with an average velocity proportional to the net force. Fluctuation-dissipation theorem relates friction coefficient to the diffusion constant D characterizing the Brownian motion and to temperature.

2. Probabilistic description using time dependent probability distribution for the position of the particle is used for pratical purposes. The basic equation states the probability for a given chemical compound to exist in a given infinitesimal volume element is affected by diffusion, by the flow caused by the drift force and by chemical reactions.

3. Chemical reactions, typically binding of ATP or some other energy carrier molecule and its hydrolysis, are modelled in a very rough manner in terms of effective reaction kinetics using effective rate constants. Thermodynamical arguments based on Gibbs free energy are central. The increment of Gibbs free energy $\Delta G = \Delta H - \Delta(TS)$, which determines to which direction the reaction proceeds and the ratio of the initial and final state concentrations in equilibrium situation. In constant temperature the increment ΔH of the enthalpy representing typically change of the electrostatic energy and $T\Delta S$ term representing entropy increment are competing factors.

4. In biological systems water is a crucial participant: before a charged ion can bind to, say amino-acid, both reactants must get rid of the waters of hydration surrounding them. Binding itself reduces entropy in the translational degrees of freedom whereas the liberation of molecules from hydration waters increases the entropy and more than compensates the reduction of entropy. Obviously the situation in question is very complex and only rough phenomenological parameterizations are possible.

In TGD view about functioning of ATP the coupling to water is especially non-trivial: ATP does *not* serve as energy currency but acts as a catalyst making possible to transform the zero point kinetic energy of proton of the hydration waters to a usable energy.

5. Criticism

One can critisize the approach for several reasons.

1. The use of the potential to describe the force is quite a strong idealization and breaks momentum conservation. A more explicit manner to model also the momentum economy would be highly desirable but not possible in the simple Newtonian framework.

2. Biological systems are extremely ordered and purposefully behaving systems: consider only the translation of DNA to proteins as an example. Their modelling using the approach originally developed for the description of dead matter, seems highly questionable.

3. The models for the molecular motors do not discuss control aspects at all. The actual presence of meso- and macroscopic coherence making possible macroscopic organized motion is neglected completely in the reductionistic approach in which everything is assumed to allow modelling at atomic and molecular physics level and believed to reduce to effective theories. In TGD framework these aspects are sides of the same coin and neglecting the presence of correlations in mesoscopic and macroscopic length scales might mean the neglect of something absolutely essential. Of course, it might be that with good luck the model for the motion of the motor enzyme along micro-tubule might be separated completely from its control but this is by no means obvious.

4. There exists empirical evidence against the notion of the thermal ratchet. Thermal ratchet seems to be the most realistic approach for the modelling of the motion of motor enzymes along micro-tubule and actin filament [I22]. In this model the energy liberated in the binding of the ATP molecule is used to increase the local temperature in turn allowing the particle to diffuse along the asymmetric and periodic ratchet potential. The basic qualitative predictions are that the motion occurs only single step at time and deterministically, and that the energy needed to carry out single step should depend on the state of the liquid unless the energy liberated with the mediation of ATP molecule is much higher than the energy needed.

However, the motion of the myosin along the actin filament involves one to five steps and can occur sometimes also backwards [I13]. This is not easy to understand if thermal ratchet is in question. The non-determinism can be understood classically as an apparent non-determinism if ATP gives also coherent momentum to the myosin (say via radiation pressure) and if the direction of momentum depends on the relative orientation of the ATP molecule and actin filament. The more radical option is that a genuine quantum motor is in question: in this case the motion would continue until it is stopped.

In the case of kinesin the energy liberated by single ATP molecule gives always rise to a single step of motion and the energy used per step does not depend on the state of the fluid [I5]. This can be understood if the energy liberated by the ATP complex is much higher than the actual energy needed: this seems indeed to be the case. According to [I22] the thermal ratchet fails also at quantitative level being unable to explain the speed of the motion.

5.3.2 Quantum ratchets

Classical ratchets rectify the Brownian motion. A simplest quantum variant of classical ratchet studied by Hänggi and Reimann [I17] is a spatially periodic lopsided potential in which electrons move. If one modulates this potential periodically, the electrons move inside the lopsided wells to either direction and this also modifies the shape of the wells. When the potential well is lowered, highest energy electrons can spill to the well on the right and are localized to the bottom of the well as potential well gets deeper. Thus one can make electrons to move up-hill.

Genuine quantum ratchets are however much weirder. They rectify quantum fluctuations and rely on quantum tunnelling. Also now the motion occurs in a ratchet potential with the characteristic asymmetric periodic structure and modulated by oscillating potential difference between the sequence of lopsided potential wells. Now however temperature is very low and the tunnelling of the electron is what leads from potential well to another one. Since tunnelling probability decreases rapidly when the tunnelling length increases, the tunnelling should occur when the well is deeper and electrons are at the left hand side of the well. Thus the electron current should flow to the left rather than right in this case.

Heiner Linke tested experimentally this effect by constructing a string of triangular shaped quantum dots [I9]. Linke saw the predicted effect but at much lower temperatures the direction of

the current became very sensitive to the strength the potential signal and effect became essentially unpredictable. The explanation is in terms of interference of electron waves. The occurrence of the tunnelling requires also that there is something which can tunnel. Thus a destructive interference can inhibit the tunnelling which could occur otherwise. Thus interference effects obviously provide an optimal control mechanism and the possibility of wireless electronic circuits has been suggested as a possible technological application. In TGD framework the interference effects caused by MEs provide a very attractive control mechanism of supra currents.

5.4 Molecular Machines In TGD Framework

Steven Block, one of the top researchers in the field of the molecular motors, summarizes the recent theoretical situation by saying "Everything you know about biophysics... is wrong!". Thus there seems to be some room for new physics and chemistry. TGD indeed brings in several new elements: the notion of many-sheeted ionic flow equilibrium and quantum control based on MEs and supra currents; hierarchy of Planck constants; buy now-pay later mechanism based on the generation of bound states and allowing effective over-unity energy production accompanied by automatic generation of meso- and even macroscopic quantum coherence; and finally but very importantly, the molecular motion along dark and non-atomic space-time sheets in principle allowing to dramatically reduce dissipative effects. Note that the second law is respected since (very!) far from thermal equilibrium systems are in question.

5.4.1 Questions

TGD approach stimulates several critical questions about the fundamental notions involved with the motor enzymes. The first group questions relate to the basic philosophy and fundamental working principles of molecular motors.

1. Is the highly mechanistic notion of the molecular motor really appropriate in TGD framework or should one regard motor enzymes as tiny but conscious and intelligent creatures forming a society able to co-operate and solve problems. In the following the notion of molecular motor is used but without the usual robotic coloring. Equally well one might call a highly specialized professional a robot.

2. How the living matter manages to cope with the thermal motion? Could molecular motors be able to minimize friction by using $\hbar$ increasing phase transitions.

3. How the quantum control is realized? How many-sheeted ionic flow equilibrium is involved with the control of the motion: in particular, how it determines the direction of the movement of a molecular motor around DNA strand, micro-tubule, or actin filament? Could it be that the direction of the supra current breaks the symmetry and fixes the direction of the motion? What is the role of Ohmic currents on atomic space-time sheets?

Second group of questions relates to the energy economy.

1. Is ATP indeed the universal energy currency or does it only connect the user of energy to its provider? The notion of high energy phosphate bond is indeed unconvincing and suggests that the understanding of ATP is far from complete. Is the ATP related energy source the only energy source or could the generation of macroscopic bound state entanglement make possible effective over unity energy production as suggested by the strange findings about neuronal metabolism [J9] ?

2. No consensus exists about how the chemical energy is transformed to mechanical energy or other forms of chemical energy. Is the energy per single step of a molecular motor always the same and provided by the ATP complex as in the case of the kinesin motion? What does the independence of the energy used per single step on the state of the cellular water mean and why the variation in the rate of dissipation does not change the amount of the energy needed? How so high an efficiency is possible in extremely dissipative circumstances: molecular motors have a better efficiency than ordinary motors although the situation should be just the opposite. In particular, $F_0 - F_1$ motor generating ATP molecules has essentially unit thermal and Stokes efficiencies [I21].

3. ATP complex should liberate energy used to perform chemical work as single quantum. If molecular motors behave classically the energy should be liberated in very small increments in order that the process is reliable and controllable. Could one think the possibility that chemical machines operate quantally whereas molecular motors are effectively classical machines? Or are both quantum and classical modes possible for molecular motors?

The third group of questions relates to the properties cell membrane.

1. What this the real function of the ionic channels and pumps? There is evidence both supporting [I7] and challenging these notions [I15] and somehow one might hope that the notion of many-sheeted space-time could resolve this apparent paradox. In [K19] the TGD inspired solution is discussed in detail.

2. What is the real function of the cell membrane resting potential? What is the real role of the ionic currents associated with nerve pulse activity? How the ionic currents generate EEG waves? The facts that resting potential is -63 mV and the zero point kinetic energy of proton Cooper pair at $k = 139$ super-conducting space-time sheet is 61.5 meV suggests that the real function of the resting potential is to prevent the leakage of the protonic Cooper pairs from $k = 139$ space-time sheets to the super-conducting space-time sheet.

5.4.2 Many-sheeted molecular machines

The TGD based solution to the problem of coping with the thermal noise is simple: increase the value of Planck constant. This means essentially zooming up of the quantal scales to longer ones, even macroscopic. There are however several options whose realism can be judged by using simple order of magnitude estimates. Basically one must choose between whether momentum or energy is used as a fuel. If momentum of exchanged photons is used as a fuel, one must invent a mechanism to avoid large dissipation of energy. If energy is used as a non-dissipative fuel the problem is how to avoid too large momentum transfer and this seems to require large friction forces.

1. Mountain climber mechanism

A rather plausible sounding option is based on the mountain climber mechanism in which the motor action of magnetic body induces the motion of of molecule. The moving system induces an $\hbar$ increasing phase transition of flux tube. The flux tube attaches to the substrate along which the molecule is moving and after this a phase transition reducing the value of Planck constant and forcing the molecule to move takes place. The attachment of the rope could mean attachment of ATP molecule appearing as a plug in flux tube to F_1 and subsequent $ATP \to ADP + P_i$ cutting the flux tube. The energy would come from dropping of three protons to a larger space-time sheet and the direction of motion would be dictated by the direction of the flux tube along the linear structure. This direction could be statistically determined for single step but there would be a preferred direction determined most naturally by the electric field along the linear structure. The momentum gained by the moving system would be dictated by the proposed rocket mechanism and there would the dissipation of energy would be minimal.

2. Seesaw mechanism

Assume that the molecule gets the momentum $p = \Delta E/c = .5$ eV/c from ATP. In this case the velocity of the molecule is $v = p/M$ and for $M \sim 10^5 m_p$ the velocity is of order μm/sec which is of correct order of magnitude! Thus motor molecules could also act as quantum motors and their constant velocity would reflect the absence of dissipation rather than presence of it!

The velocity of the quantum motor is fixed completely to $v = p/M$ for this option. This is obviously very strong prediction and makes it easy to kill the model. The second testable prediction is that the ratio for the velocities of two quantum motor molecules is given by the inverse of the mass ratio.

Large dissipation can be avoided by using seesaw mechanism. The ADP molecule in the moving system sends negative energy photon transferring a proton in energy storage system to a larger space-time sheet and induces $ATP \to ADP+P_i$, and then energy storage system sends the negative energy photon back to the moving system inducing $ATP \to ADP + P_i$. At each step the moving system receives momentum $p = E/c$ but its net energy does not increase. This process could

correspond to $ATP \to ADP \to ATP$... for both systems involved. Obviously this mechanism can be combined with the mountain climber mechanism.

The seesaw mechanism applies in the case of quantum rotor. In the ideal case the angular momentum is not dissipated and only an exchange of few negative energy photons between ATP: s and polarized in the direction of the rotation axis is enough to gain the needed angular momentum. In the presence of dissipation continual exchange is required. The rotation of the shaft of F_1 machine could be due to this mechanism.

4. Quantum motor mode is required to perform chemical work

ATP complex is involved also with the performance of chemical work. In this case the zero point kinetic energy of the proton *must* be liberated as a single quantum (this actually supports the view that molecular motors indeed act also in quantum mode). Thus ATP complex must act both in effectively classical and genuinely quantal manner. Enzymes are the most important molecular machines and their poorly understood action could involve the notion of many-sheeted space-time in an essential manner. For instance, ions could avoid Coulomb walls by approaching other reactants at atomic space-time sheets along larger space-time sheets. Perhaps eve chemical reactions could occur at cold space-time sheets: this would mean that the dropping of the chemicals to cold space-time sheets rather than heat could excite intermediate states.

4. Could classical motor run with the energy provided by ATP complex?

Assume that the energy .5 eV goes to the kinetic energy of the motor molecule rather than to the environment of the molecule. The average velocity of a typical motor molecule like kinesin during single step is $v = s/t$, where $s \sim 10$ nm the length of single step and $t \sim 10^{-2}$ sec the duration of single step. The movement with dissipation requires energy feed

$$\Delta E_d = F_d s = \frac{mvL}{\tau} = 2E_{nd}\frac{t}{\tau} \ ,$$

where $\tau \sim 10^{-13}$ sec characterizes time scale of friction and E_{nd} is the energy needed in the absence of dissipation. This energy is by a factor $t/\tau \sim 10^{11}$ larger than the energy when the movement occurs without friction. Thus quantum motor option does not make sense if motor molecule receives the entire energy .5 eV from ATP complex.

5.4.3 New view about $F_0 - F_1$ machine

$F_0 - F_1$ is in certain sense a universal machine. It acts as a ionic channel for protons and in the reverse mode as a protonic pump. It generates also ATP and in reverse mode uses it. Besides this $F_0 - F_1$ acts as a rotary motor. The model for $F_0 - F_1$ machine allows to resolve the paradoxical situation raised by the experiments challenging the notions of ionic pumps and channels [K4].

$F_0 - F_1$ motor is certainly an extremely complex structure [I20, I21] and I confess of being deeply ignorant of its intricate chemistry and functioning. Despite this I cannot avoid the temptation to understand the basic purpose and working principles of this machine. My only excuse is that this kind of exercise could promote the understanding of the basic principles of the many-sheeted molecular engineering.

1. $F_0 - F_1$ machine as ATP synthesizer

As mentioned the machine producing ATP is different from other machines since it cannot use ATP as an energy currency (except in the reverse mode!). This machine works somewhat like a hydro-electric generator or actually pair of them turning the shaft to opposite directions [I1, I20, I21, I12]. The proton flow induced by F_0 subunit rotates the shaft and this induces the stator like subunit F_1 to synthesize ATP whereas ATP hydrolysis in F_1 causes a reverse rotation of the shaft and reverses the flow of protons.

Protons are accelerated in an electric field generated by electrons and, according to the standard view, the machine transforms the energy produced by the oxidative metabolism to the energy of the high energy phosphate bonds of the ATP molecule. TGD view however suggests that ATP molecule does not carry energy but acts as a switch allowing the liberation of energy when protons drop from atomic space-time sheet the super-conducting space-time sheets. Thus F_0 machine would generate usable energy by kicking up protons to the atomic space-time sheet.

2. $F_0 - F_1$ machine as a rotary machine

$F_0 - F_1$ acts also as rotary motor rotating the so called γ shaft
[I20, I21] and thus transferring the momentum of the supra currents at super-conducting space-time sheets. The accelerated super-conducting protons flowing through the space-time bridges through the region defined by the inner membrane of the mitochondria obviously provide momentum rotating the shaft. There are reasons to believe that this mechanism is very general and behind various rotary machines in the living matter. The beauty of this mechanism is that the generation of coherent momentum becomes possible since supra currents form a coherent macroscopic quantum systems.

3. Does the coupling $F_0 - F_1$ machine to actin filament make it classical machine

$F_0 - F_1$ machine can work also in reverse direction and a lot has been learned about the functioning of this machine. In this mode the machine becomes a proton pump. By attaching an actin filament to the shaft of the machine it has been found that both the thermal efficiency and so called "Stokes efficiency" are very near to one for F_1 motor acting as proton pump [I21]. According to the analysis of [I21] this implies that the torque generated by the binding of ATP molecule to the catalyst and the liberation of the phosphate group cannot liberate the Gibbs free energy instantaneously but with a constant rate. This argument is based on a simple model of F_1 pump with the friction losses caused by the actin filament attached to the shaft modeled as a linear friction. This result is obviously a theoretical challenge.

1. If the protons provide their energy instantaneously, the hydrodynamic efficiency becomes effectively zero: ΔG is concentrated to a single moment of time and the angle of the shafts changes instantaneously by angle $\Delta\theta = 2\pi/3$. According to the formula of [I21] this would give vanishing rather than maximal "Stokes efficiency". Or putting it otherwise: the torque would be instantaneous rather than constant as also direct experimental data suggest.

   There is however an important caveat involved here: constant torque corresponds experimentally to a constant rotation velocity and constant rotation velocity characterizes also non-dissipative quantum motion. The classical rotation velocity $\omega = L/I$ (I denotes the moment of inertia and $L = \hbar$ angular momentum) is indeed of correct order of magnitude $10^2/s$ for $I \sim MR^2$, $M \sim 10^7 m_p$ and $R \sim 10$ nm.

2. That Stokes efficiency equal to unity came as a surprise in the standard chemical model where one also expected that the Gibbs free energy is liberated essentially instantaneously. The explanation for the phenomenon proposed in [I21] is based on the tight coupling between mechanical and chemical degrees of freedom (should be loose for Brownian machines in general) predicting nearly unit thermal efficiency and a continual liberation of the Gibbs energy with a constant rate. The latter was assumed to be due to a gradual generation of the Gibbs free energies associated with the hydrogen bonds binding ATP to the catalyst site. In case of phosphate molecule one must assume that the energy liberated when the phosphate molecule is released from $F_1 \cdot ATP \cdot P_i$ complex remains to $F_1 \cdot ATP$ and is liberated at constant rate. Mechanism would be similar to that in case of ATP. One can criticize this view: the time scale of 1/200 seconds for the buildup of hydrogen bonds instead of the time scale of 10^{-13} seconds suggested by Uncertainty Principle looks unrealistic.

As found, in TGD framework the problem disappears since molecular motors would be almost dissipation free quantum machines.

5.4.4 Examples of many-sheeted molecular motors

TGD by no means excludes the thermal ratchet model but suggests the radiation pressure based classical motor and quantum motor options as a more plausible alternatives. Myosin moving along an actin filament and kinesin moving along a micro-tubule provide two basic examples of molecular motors and they could serve as a testing ground selecting between these models. Rather remarkably, quantum option predicts correctly orders of magnitude for the velocities of the molecules. Perhaps both quantum and classical modes are possible and which mode is chosen depends on whether the molecule moves along atomic space-time sheet or larger space-time sheet.

1. The motion of a myosin molecule along actin filament

The motion of the myosin molecule along actin filament involves one to five steps each of length about 5.3 nm (this length scale is somewhat longer than the p-adic length scale $L(149)$). This is not consistent with the thermal ratchet paradigm. As already found quantum motor option based on mountain climber mechanism and seesaw mechanism using $ATP \to ADP \to ATP...$ is most plausible in TGD framework. The following provides a simplified sketch about how the motion could take place.

1. Suppose for definiteness that the motion is to the right with "right" defined as the direction of electric field along actinin molecule. At each step flux tube containing ATP would the thrown like a rope along actinin filament to the right and get attached to it after which the myosin molecule would follow. This process would be essentially tunnelling between two potential energy wells. The direction of electric field along actinin molecule would select "right" as the more probable direction. This is to be expected if myosin molecule is charged.

2. At the first step ADP_1 attached with the myosin molecule would send negative energy to ATP_2 at left and get the recoil energy inducing $ADP_2 + P_i \to ATP_1$ allowing ATP_1 to attach with the flux tube to tunnel from the potential well and move to the right as a result of recoil momentum. This would induce the decay $ATP_2 + \to ADP_2 + P_i$.

3. At the next step ADP_2 would complete itself to ATP_2 by sending negative energy and momentum to the ATP_1 and inducing $ADP_1 + P_i \to ATP_1$. At this step the myosin molecule itself should move to the next potential well to the right.

2. The motion of a kinesin molecule along micro-tubule

It is known that the motion of the kinesin molecule occurs in steps of total length of 8 nm and that single step lasts for 1/100 seconds. Kinesin molecule has two heads and the motion resembles the movement of a molecular Tarzan along a horizontal rope by alternately placing one hand over the other. According to [I10], head 2 leapfrogs over the firmly fixed head 1 a distance of 8+5 nm and begins to rock back and forth. Then ATP molecule liberates the energy causing head 1 to wobble un-controllably and head 2 proceeds additional 3 nm and is firmly fixed at the surface of the micro-tubule. Then head 1 repeats the same and each step means progress of 8 nm giving velocity of 800 nm per second which, by the way, is rather near to the velocity of slow Ca^{++} waves in astrocytes. The more ATP there is around, the harder it is to stop the motion of the kinesin [I5]. It is of some interest to notice that the numbers 3, 5, 8 and 13 are Fibonacci numbers appearing almost everywhere in living matter.

The mechanism should be a generalization of the mechanism discussed. The simplest idea would be that the heads exchange a negative energy metabolic quanta back and forth. This is however not quite enough: also a third ATP molecule outside the kinesin molecule is needed to perform the basic step. The necessary presence of ADP_3 explains why it is hard to stop the motion when ATP is present. One manner to fill in the details could be following.

1. ADP_2 at head 2 attached to the flux tube sends a negative energy photon to ATP_1 and transforms to ATP_2 molecule. Recoil momentum kicks ATP_2 attached at flux tube a distance $8 + 5$ nm to the right. The recoil energy received by ATP_2 puts it in rocking motion in local potential well. $ATP_1 \to ADP_1 + P_i$ in turn puts head 1 in wobbling motion.

2. ADP_3 to the left of kinesin molecule transforms to ATP_3 by sending a negative energy photon to ATP_2 inducing $ATP_2 \to ADP_2 + P_i$. The received momentum pushes it 3 nm to right and negative energy stops rocking motion and fixes head 2 to the surface of the microtubule.

3. Head 1 repeats the same process.

4. The velocity $v \sim \mu$m/sec is predicted if the mass of the kinesin molecule is of order $10^5 m_p$.

A decisive test for the quantum motor option is to look whether the motion of the molecular motor could be induced by irradiating it with coherent light with photon energies around .5 eV. By the universality of the ATP mechanism irradiation at this frequency could have several kinds of effects on living matter.

5.4.5 Flagellar motors

Bacterial motors operate in much longer length scales than molecular motors and the principles might differ from those utilized by the latter. In particular, quantum motor mode might be impossible now. The motion of bacteria, say Escherichia Coli, is based on flagellar motors involving a rotating helical propeller. When the spin is in anticlockwise direction, flagella come together and the motion the motion propels the cell through the fluid. When the spin is in clockwise direction, the flagella fly apart and a tumbling motion results. The binding of a phosphorylated CheY protein to the portion of the motor located in cytoplasm induces promotes counterclockwise rotation by inducing a conformational change of flagella.

The friction between water and bacterium making impossible slipping makes possible the propelling motion. A rotating helical propeller induces in the general case a motion of the fluid. This motion is minimal when the helical propeller as an abstract surface remains locally stationary during the motion so that the energy dissipation is only due to the frictional losses implied by the fact that the fluid near the propeller must co-move with it. For a helical curve $z = a\phi$ describing idealized flagellum this means that the motion is a combination of a translational motion in the direction of the axis of the motor and rotational motion with rotation and thus of the form $z = vt, \phi = \omega t$, $v = a\omega$ implying that the motion is along the curve $z = a\phi$.

$F_0 - F_1$ motor in the reverse mode induces the rotation of $F_0 - F_1$ shaft in reverse direction and thus acts as a rotary motor. The functioning of flagellar motor might be based on the same principles as $F_0 - F_1$ motor.

A possible quantum mechanism generating the torque of quantum rotor is inspired by the work in attempts to understand the claimed strange effects in rotating magnetic systems [H2] in TGD framework [K2]. The mechanism might apply to both molecular and bacterial motors [I2].

1. Consider a molecular rotor attached to the cell membrane and having its rotation axis orthogonal to the cell membrane. Assume that there is a magnetic field along the axis of the rotating shaft and that the system can also generate a pulse of line charge along the axis of the shaft. The pulse of line charge creates a pulse of radial electric field inducing a Josephson current along radial flux tubes assumed to be present. The oscillating Josephson current continues as a DC current after the disappearance of the line charge. The lines of Lorentz force experienced by (possibly dark) charge carriers at flux tube rotate along the axis of shaft and the result is a torque in the direction of the axis of the shaft.

2. The control parameters are the amplitude and duration of the charge pulse. These parameters determine the sign and the magnitude of the DC Josephson current proportional to the factor $sin(\int 2eVdt)$ but do not affect its maximum value. Using this kind of pulses the system can control the direction and magnitude of the torque.

3. The mechanism generating the line charge could be following. There is a strong electric field defined by membrane potential along the axis of the shaft and Josephson currents are running along the axis. The period of these currents depends on the magnitude of Planck constant for the flux tubes carrying the currents and the period can correspond even EEG time scale. The net charge density associated with the Josephson currents is expected to vanish. Suppose that the system is able to generate a resistance. The resistance experienced by various charge carriers are different so that the net effect would be a temporal generation of charge density on the axis creating the desired charge pulse. One can even consider effective cutting of the flux tubes at either side of the membrane so that charge begins to accumulate at the flux tubes.

4. In the model of DNA as topological quantum computer this kind of shortcut of flux tubes initiates topological quantum computation and the mechanism is the reconnection of the flux tube with the flux tube representing hydrogen bond between water molecules so that currents through flux tube goes effectively to ground. $ATP \to ADP + P_i$ would be the basic example of this kind of shortcut and should be involved also now. ATP can be regarded as a plug in flux tube connecting two molecules. The flux tube coming to adenosine aromatic ring from the first molecule continues via O = atoms of phosphates to the target molecule. The shortcut splits the flux tube between second and third O = atoms of ATP and induces $ATP \to ADP + P_i$. In the ideal situation this shortcut would be the only source of dissipation.

5.4.6 Transforming ionic channels to pumps

Just like the notion of high energy phosphate bond, also the concepts of ionic pumps and channels are both supported and challenged by empirical facts. As already explained, the paradoxes disappear in TGD framework. For supra currents running along super-conducting space-time sheets, no metabolic energy is needed to move through the cell membrane. Cell must however transport also ions form atomic space-time sheets to atomic or from atomic to super-conducting space-time sheet. In atomic-atomic case the intelligent solution is to drop the ions to the super-conducting space-time sheet and kick them back at the second side of the cell membrane (this might occur also spontaneously) if ions have enough energy. The ions indeed receive energy when they drop to the magnetic flux tubes from the atomic space-time sheets. The identification of the super-conducting space-time sheet would be as a magnetic flux tube having large value of Planck constant. ATP molecule would be attached to this flux tube and the splitting $ATP \to ADP + P_i$ would cut the flux tube and change ion channel to ion pump.

A test for this picture comes from a mechanism transforming channel to pump [I7]. Channel is a funnel like channel protein with a tip at outer membrane and mouth opening to the cell interior. When the mouth is open to the inside of the cell, there is a strong interaction of ions with interior. When the mouth is closed, the ions in the channel are released to outside. ATP binding favors the opening of the mouth and the release of the hydrolysis products favors the closing of mouth (in other words, the decay $ATP \to ADP + P_i$ splits the flux tube). It is found that alternating electric field induces pumping even without ATP [I7].

Previous considerations suggests that the two protons dropping in ATP binding opens the mouth and the proton dropping in the breaking of the phosphate bond closes it. One could also interpret the mouth as a system inhibiting the spontaneous flow of ions to the super-conducting space-time sheets. The fact that also single step of kinesin motion has a similar two-step structure encourages to generalize: perhaps all processes involving ATP could have this characteristic two step structure.

6 Miscellaneous

To make things easier to the reader, I summarize briefly the earlier ideas related to quantum control up to the crucial ideas related to the dark matter hierarchy. I also include a section about possible realization of four-wave mechanism under "attribute" miscellaneous since this mechanism makes rather strong assumptions and is probably not generic enough in its present form. I have still not been able to throw away a weird looking idea about connection between superluminality and remote metabolism. Reader can safely skip over this section at the first reading.

6.1 Older Ideas

6.1.1 Homeopathy in many-sheeted space-time and scaling laws

The attempt to understand homeopathy the framework provided by many-sheeted space-time [K13] leads to a general vision about the role of MEs, magnetic flux tubes and magnetic mirrors allowing to understand the fundamental recognition mechanisms of bio-molecules in terms of electromagnetic bridges defined by MEs and magnetic flux tubes. This vision allows to build a general model for paranormal phenomena and the same fundamental mechanisms seem to be behind astonishingly wide repertoire of poorly understood phenomena in the borderlines of the existing science.

An important piece in the puzzle comes from the scaling law of homeopathy [K13]. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest situation (the ratio can actually vary). The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Micro-wave (in particular) MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as "food" of the plasmoidic life forms at the receiving end. This mechanism would be behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis.

Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain. This picture which in fact emerged from a model of a rather exotic event (Fatima Marian apparition) provides a view about how low and high frequency MEs are involved with the bio-control, sensory representations, and remote mental interactions. Also a general view about UFO experiences emerges.

One can imagine several interpretation for the scaling law of homeopathy discussed in [K13]. The following interpretation is one of them.

1. The $v = L \times f_{low} = c \times (f_{ELF}/f_h)$ scaling law, which first emerged in the quantum model of EEG and later in the model of homeopathy, can be understood and generalized. What the scaling law means that system with size L and generating MEs with frequencies coming as multiples of $f_h = c/L$ is sensitive to only few low frequencies f_{low} and this is essentially due to the fact that various mechanical, chemical, or electromagnetic wave phenomena propagate only with preferred velocities v.

2. EEG waves and the wave motion associated with homeopathic effects are only special instances of the scaling law. Ca^{++} waves which proliferate living systems provide an especially important realization for the law: the velocity v varies from one nm/s to one m/s and thus spans nine orders of magnitude but varies around a given value typically only by a factor of order three.

3. Given scaling law allows a concrete interpretation in terms of mechanisms transforming low frequency MEs to high frequency MEs generating coherent photons and vice versa. This means transformation of macroscopic control commands to molecular control commands and molecular sensory data to macro-sopic sensory representations. $f_h \leftrightarrow f_{low}$ transformation is central in both the generation of the low frequency em MEs defining sensory projectors and the realization of the motor commands represented in terms of low frequency MEs transformed to high frequency MEs via $f_{low} \rightarrow f_h$ transformation.

4. A much deeper explanation for the scaling law of homeopathy is based on the quantization of Planck constant. Number theoretical arguments suggest a general formula for the allowed values of λ [K11] as $\lambda = n$ where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [K25]. The values of n for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17, F_3 = 257, F_4 = 2^{16} + 1$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales.

The scaling factor 2×10^{11} corresponds with 1.5 per cent accuracy to the integer $n_F = 2^{36} \times 3 \simeq 2.03 \times 10^{11}$ defining a Fermat polygon. This suggests an interpretation in terms of a decay of dark photon with a given wave-length to a bundle of n_F ordinary photons with the same wavelength. The energy of the dark photon would be by a factor n_F higher. This process could serve as an effective tool of bio-control. Dark photon could also transform to an ordinary photon with wavelength shorter by factor $1/n_F$. Quite generally, integers n_F defining Fermat polygons are a reasonable guess for the generalization of the scaling law of homeopathy and the search for these scaling factors could provide an experimental means of identifying the values of Planck constant relevant for living matter.

The time units of everyday life could reflect the properties of the dark matter hierarchy responsible for the control of living matter, in particular those of the sub-hierarchy defined by Fermat polygons. Indeed, one year corresponds to $n_F = 4 \times 3$ months, one month to $n_F = 2 \times 3 \times 5$ days, one day to $n_F = 8 \times 3$ hours, one hour to $n_F = 60 = 4 \times 3 \times 5$ minutes, and one minute to $n_F = 60$ seconds.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. p-Adic length scale hypothesis favors powers of two as values of r. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ are expected to be physically highly interesting and up to $k =$

127 indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton scales $L_e(k) = \sqrt{5}L(k)$ ($k \in \{151, 157, 163, 167\}$) are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$. The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$. This proposal will be referred to as Mersenne hypothesis.

6.1.2 The model of bio-photons

The model of bio-photons emerged as a natural application of these ideas. Simple mathematical facts about the decay of the delayed luminescence induced by an external perturbation like light signal, lead to a model in which pairs of positive and negative energy MEs transversal to and moving in opposite directions along DNA strand and it conjugate generate coherent bio-photons. What is important is that a rather detailed model for how MEs and supra current circuits interact results. And most importantly, it becomes clear that negative energy MEs, perhaps the most science fictive piece of the new physics predicted by TGD, are indeed there and could be identified as space-time correlates for phase conjugate photons.

6.1.3 Topological self-referentiality

The longstanding problem has been the lack of understanding about how MEs relate to the existing physics and chemistry. Thus there has been a chronic uncertainty about whether MEs really are there or not, to say nothing about quantitative models for the dynamics and interaction of MEs with ordinary matter. This frustrating situation changed dramatically with the discovery of the topological self-referentiality, which means that topological field quanta of the classical fields, in particular MEs and magnetic flux tubes, associated with the material system provide a topological representation for the theory about the material system. In particular, and very importantly, negative energy MEs provide representation for the binding energies.

6.1.4 Generation of coherent quantum states and generation of usable energy as sides of the same coin

The generation of bound states with binding energy liberated as a usable energy allows one particular realization of the quantum credit card mechanism. In this case absorption of negative energy photons (or more general bosonic quanta) would lead to a formation of the bound state. The transition between two bound bound states is a more general manner to realize the mechanism.

A more concrete model is in terms of the time mirror mechanism. Negative energy topological light rays are expected to be accompanied by negative energy negative energy photons identifiable as phase conjugate photons. They represent a negative energy signal sent into the geometric past where it is reflected back and possibly amplified. This can occur for instance when negative energy (phase conjugate) photons are absorbed by a population inverted laser so that cascade like dropping of atoms to the ground state occurs and generates much strong positive energy signal received by the sender of the negative energy signal.

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

Time mirror mechanism could make possible new technologies such as instantaneous remote energy utilization, instantaneous active remote sensing, and instantaneous communications over arbitrarily long distances. Time mirror mechanism is an essential element in the models of remote metabolism, long term memory, intentional generation of motor actions, sensory perception, and remote mental interactions.

The generalization of four-wave mechanism involving generalization of standing waves provides a more concrete model of time mirror mechanism and provides a mechanism of remote metabolism

in which system sucks energy from environment by sending negative energy particles such as phase conjugate photons. The geometric time reversal of second law is a signature of the process and the decay of system looks like self-assembly from the point of view of observer with standard arrow of geometric time. Generalized four-wave mechanism provides also a model over unity energy production and classical communications to the geometric past. In TGD inspired theory of consciousness and bio-matter this mechanism is central and underlies the models of metabolism, intentional action, and long term memory.

This observation leads to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement with accompanying emission of negative energy photons say. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy (brings in mind the stories about the feats of yogies!). Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just questioning the basic assumptions of the Newtonian biology.

6.1.5 Left-brain-right brain, DNA strand-conjugate strand

Second vision is that various binary structures such as DNA and lipid layers of the cell membrane apply a division of labor analogous to what happens between left and right brain hemispheres. The first member of the pair is specialized to generate bound state entanglement and is accompanied by negative energy MEs whereas second member is accompanied by positive energy MEs providing usable energy. This energy in turn makes possible processes like nerve pulse propagation and DNA transcription. The generation of ME pairs could be actually a universal mechanism of energy liberation in living matter. Even right and left brain hemisphere would apply similar division of labor: at this level bound state entanglement would be a quantum correlate for higher level notions like creativity and spirituality. This division of labor seems to continue even to the level of society.

6.1.6 Information molecules as quantum links in quantum web

The third vision relates to the deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of "telepathic" quantum communications. In fact, I introduced already few years ago the notion semitrance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

The bound state entanglement represented by the negative energy MEs is very much like a link to web in email and the transfer of the neural transmitters from the axon to the postsynaptic neuron is like an email message with a set of quantum links to the quantum web represented by the state of the neural transmitter + environment. Note that this means that information content of the message can be very high in this case, much higher than the single bit of the neural net models. Same should hold true for information molecules in general. In this chapter this vision will be touched only very briefly.

I cannot avoid the temptation to relate this new vision to the situation in what is called globalizing world. The proponents of the market economy emphasize the deterministic nature of world economy as justification for the breakdown of well-fare society relying on social justice and mutual caring. Rather, the game theoretic view about society as a collection of individuals competing furiously to steal maximum amount of money is the key piece of this philosophy. Commitment is a word often used by our leaders: this commitment is not however stable and continues only as long as the committing person has not found an organization guaranteeing even more astrophysical salary. The foregoing considerations suggests a different view about society. Suppose that the generation of bound states at the level of society is a physical correlate for commitment. If so, commitment would mean the ability to generate usable energy from "nothing". This view would provide more than a metaphorical justification for the belief that the society based on trust

and real commitment is able to solve problems which seem completely insurmountable when seen from the desperately narrow social-Darwinistic game-theoretic perspective of the modern market economy.

In this form the idea remains still at the level of philosophy. The model for DNA as topological quantum computer [K10], which in turn inspired a model for protein folding [K1], leads to a detailed realization of this idea.

1. The magnetic flux tubes connecting various biomolecules and act as braid strands carrying four different colors corresponding to nucleotides A, T, G, C and represented as quarks u, d and their antiquarks u_c, d_c. The flux tubes can end to donors of hydrogen bonds and in this case the flux tube corresponds to hydrogen bond.

2. Acceptors of hydrogen bonds (aromatic rings, O = atoms) act as plugs in the network in the sense that there is incoming flux tube and outgoing flux tube with the same color. The molecules XMP, $X = A, T, G, C$ and also their XDP and XTP variants could act as standardized plugs. A weaker hypothesis is that phosphates take this role. In this framework the ATP molecule moving to F_1 catalyst (molecular machine) would be a plug in the flux tube and $ATP \to ADP + P_i$ process would cut this flux tube and form a connection to the location of F_1. This process would be the basic process modifying the network defined by colored flux tubes and would typically initiate topological quantum computation. The process would also mean the formation of a link in the web defined by the flux tubes and the basic job of ATP molecules would be to carry these plugs to various places to form new connections. Reconnection mechanism for the flux tubes would be the mechanism allowing the modification of this web.

6.1.7 Earlier ideas about how motor control is realized

The basic ideas behind TGD based view of motor control developed before the discovery of dark matter hierarchy are following.

1. Computer sitting at its own terminal metaphor with astrocytes taking the role of keyboard.

2. Gardener metaphor: control means essentially a selection of patterns from primordial chaos constrained only by sensory input by amplifying these patters by providing the needed energy. Since astrocytes are metabolic sources of brain, they are good candidates for controllers. Also the need to cleanly separate motor control signals from sensory signals supports this view.

3. Quantum metabolism: quantum control involves also signals propagating to the geometric past having identification as phase conjugate photons and inducing transitions of subsystems of brain and body to lower energy levels. As a special case quantum bound states are formed and binding energy is liberated as a metabolic energy. This requires what might be called over-unity energy production. The anomalously low oxidative metabolism at neuronal level could be a signature of this mechanism.

4. Puppets in string mechanism: strings start already from the magnetic body. Indeed, to gain precise control it is necessary to locate the end of the ME precisely on the desired point in brain. This might be too strong a requirement: it could be that all parts of the brain receive the same control signal and interpret it in their own manner. Resonance is an essential element of the interpretation mechanism: various structures pick up only certain frequencies from the control command and amplify and transform the signal at these frequencies to various kinds of chemical, mechanical and electrical signals. Even in this case it seems that pre-existing p-adic or real MEs is the only reasonable option. p-Adic MEs would have interpretation as geometric correlates of intentions. Corresponding magnetic flux tube structures are pre-existing and real.

5. Motor control and sensory input must separate from each as completely as possible. If motor control relies on negative energy MEs and sensory representations on positive energy MEs, this is achieved. This would mean that magnetic bodies suck the metabolic energy needed to build photons associated with scaled up variants of EEG from brain and body. This energy

is an important factor in metabolism since the energies of photons involved must be above the thermal threshold at room temperature.

6. The communication of the control signals must be based on a highly symbolic representation. The prototype realization for this is monochromatic reference wave generating a complex hologram. For obvious reasons this is not a safe option: some kind of linguistic structure allowing to eliminate the possibility that undesired signals are interpreted as control signals must be present. Natural language is the highest level language that we know. This suggests that the signals represented by negative energy MEs are transformed to Ca^{++} waves and the frequency for their generation correlates with the level of dark matter hierarchy involved. Ca^{++} waves indeed appear in wide frequency scale.

Internal speech would very naturally represent this communication from the sensory canvas. Internal speech involves only single voice at time and this suggests that only one command is given at one time and all astrocyte synticia of the cortex receive it and interpret it in their own manner. There could be an entire hierarchy of internal speeches corresponding to various frequency and length scales and levels of dark matter hierarchy and also other wave forms than sound could define internal speeches.

6.2 Generalized-Four Wave Mechanism As A Basic Mechanism Of Remote Metabolism

Generalized four-wave mechanism provides a concrete realization for the more general time mirror mechanism underlying remote metabolism and many other mechanism important for the functioning of the living matter in TGD Universe. Generalized four-wave mechanism also provides a connection with the existing physics of phase conjugate waves.

6.2.1 Time mirror mechanism

Time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book) could make possible new technologies such as instantaneous remote energy utilization, instantaneous active remote sensing, and instantaneous communications over arbitrarily long distances. Time mirror mechanism is an essential element in the models of remote metabolism, long term memory, intentional generation of motor actions, sensory perception, and remote mental interactions. What happens that negative energy topological light rays propagating to the direction of the geometric past are reflected back in time direction and return as positive energy topological light rays (photons could accompany the rays.

This apparently paradoxical sounding language makes sense since the experienced time corresponds to a sequence of quantum jumps recreating space-time surface again and again and the correspondence between these times follows from quantum-classical correspondence: the contents of conscious experience in the essentially four-dimensional classical universe are dominated by contributions, which are sharply localized with respect to the geometric time. This creates the illusion that the classical universe is 3-dimensional. It is essential that the field equations determining the space-time surfaces as field analogs of Bohr orbits are not fully deterministic. Only this makes it possible for the classical dynamics to mimic the non-deterministic quantum dynamics.

Negative energy topological light rays can induce the dropping of ions from atomic to larger space-time sheets. The liberated zero point kinetic energy means that the system can act as an over-unity energy source. Negative energy topological light rays, presumably having phase conjugate laser waves as standard physics counterparts, would be accompanied by negative energy photons and these would induce the dropping of charged particles to larger space-time sheets without emission of photons. The experiments of Feinberg, in particular the experiment in which a chicken was irradiated by phase conjugate laser waves, demonstrate that the system was transparent to phase conjugate laser waves at visible lengths. Indeed, if the phase conjugate photons have negative energies above the thermal energy, say at energies corresponding to visible wave lengths, there is no excited atomic system able to absorb negative energy photons inducing the return to the ground state.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries

of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

The pairs of atomic and larger space-time sheets can act as many-sheeted population inverted lasers with frequencies which are universal constants of nature, and defined as differences of zero point energies whose values are predicted by the p-adic length scale hypothesis. If the intensity of the negative energy photons is above some critical value, the particles in the excited state of the many-sheeted population inverted laser drop to the ground state in a cascade like manner (the probability of dropping of charged particle is proportional to the number of charged particles already present at larger space-time sheet and thus to the intensity and duration of negative energy topological light ray irradiation). The time reflection thus involves an amplification and negative energy photons serve only the role of controller. The system becomes over-unity energy source making possible remote energy utilization.

6.2.2 Four-wave interaction and time mirror mechanism

Four-wave interaction is the basic mechanism producing phase conjugate laser waves, and TGD approach leads to a generalization of this [I8] [K3]. Four-wave interaction becomes the basic mechanism of intentional action and is behind the basic biological and brain functions like (actually remote) metabolism and long term memory. The findings of Tiller [J12] about physical correlates of intentional action find a nice explanation in this framework.

There are several open questions about four-wave interaction. Could four-wave interaction or its generalization provide a deeper understanding of the scaling law of homeopathy stating that low and high frequencies appear in pairs [K13] ? Could the basic function of probe and conjugate beams be the amplification of the standing wave interference pattern by remote metabolism? Does the standing wave formed by the reference beams serve as a kind of standardized hologram? Is it possible to generalize the notion of hologram in order to get rid of the reference beams?

The standing wave interference pattern represents a synchronous oscillation of the entire system and would be an excellent physical correlate for the ability of living organisms to act as coherent wholes. The standing wave resulting as the interference pattern of waves propagating in opposite directions would serve kind of a standardized hologram parameterized by the wavelength λ_h. The interference pattern can be also kicked into a motion by Lorentz boost, and the propagation velocity of the interference pattern is an additional characteristic of the pattern.

Probe and phase conjugate beams in four-wave interaction could in turn be interpreted in terms of remote metabolism. System sends negative energy topological light rays (or massless extremals, MEs) to the geometric past and receives as a response positive energy MEs, and amplification can occur in this process so that negative energy signal serves only a role of control signal. Its generation would utilize the energy provided by the remote metabolism. The emission of negative energy ME would switch on the positive energy laser of the geometric past generating probe beam. The energy source could be system in its geometric past or some system in the environment.

Standing wave is basic element of the mechanism and its generation would require energy obtained by emitting phase conjugate photons. Standing wave need not result only as an interference of classical em wave propagating in opposite directions, but could correspond to any standing wave. Plasma resonances are an especially interesting candidate for a standing wave since plasma frequency does not depend on wave vector at all in lowest approximation. This means that there is no dispersion and the pattern formed by plasma waves is oscillatory. I have indeed proposed that this kind of plasma wave patterns are in key role in living matter. The plasma wave pattern would get the energy of its self-organization by sending (say) negative energy photons.

One can imagine a metabolic hierarchy which is obtained by a time reversal from the dissipation hierarchy for which energy from long length scales gradually dissipates to short length scales. The dissipation of the energy of a hydrodynamic vortex by the gradual decay to smaller vortices is a basic example of this process. Now this kind of process would be replaced by a self-assembly starting from the most energetic level and involve radiation of phase conjugate waves with decreasing frequency scales. The lowest level would correspond to ordinary metabolic mechanism, magneto-static waves could be at the next level and the counterparts of magneto-static waves for Cooper

pairs at magnetic flux tubes could be also present and correspond to very low frequencies.

In living matter metabolic energy feed corresponds to the "pumping" and drives protons back to the atomic space-time sheets, and the same would be true now. This hints to a somewhat pessimistic conclusion from the point of view of over unity enthusiast: if the system gains its energy by dropping its own protons to larger space-time sheets, it cannot work for too long. This might relate to the continually occurring optimistic reports about free energy production followed by silence. The point of over unit technology would not be however tapping endlessly energy about vacuum but the possibility of remote metabolism which could make un-necessary for system to carry energy storages with itself and allow extreme flexibility and instantaneous generation of energy when needed.

6.2.3 TGD view about four-wave mechanism

It is not obvious what the description of four-wave mechanism is at the basic level in TGD framework. In Maxwellian approach one introduces non-linear F^4 term in the Lagrangian, where F is field strength. This approach must be replaced by something else in TGD level if one wants a microscopic description.

To end up with this description by making first the question how to understand amplitude modulation. Even this is not enough. One must ask what is the first principle description for the linear superposition of fields in TGD framework.

1. Superposition of fields in terms of flux quanta

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K33, K16]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative "pressure" causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that electromagnetic fields - say magnetic - fields superpose.

1. In Maxwell's linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity and with same local polarization. The easy solution would be to say that one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.

2. In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle

the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.

(a) Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are "on top" of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell's theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing he interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argument.

(b) Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also un-necessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear.

3. This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

2. The description of amplitude modulation and four wave action in TGD Universe

Also the phenomena of amplitude modulation and four-wave interaction would be effects appearing as quantal reactions of charged particles to the presence of space-time sheets carrying fields. They need not be present for induced gauge fields. One might perhaps even say that these effects appear only at the level of conscious perception involving quantum jumps but not at the level of classical fields.

The summation of effects of em fields can induce amplitude modulation. If charged particles have topological sum contacts to the two space-time sheets carrying classical fields with different frequencies, the rate for quantum jumps is proportional to the modulus squared for the sum of the forces caused by these fields, and one obtains amplitude modulation visible as different and sum of the frequencies involved. In the case of massless extremals the sum and difference of frequencies appear only if MEs corresponding to opposite directions of 3-momentum are present. This leads to an effect that would be regarded as being caused by a standing electromagnetic wave. MEs correspond to waves propagating in single direction for a given sign of frequency, and in TGD framework it is highly implausible that standing waves could be realized as classical gauge fields.

Similar description applies to four-wave mechanism. Four space-time sheets can give rise to the sums of four frequencies appearing with both signs in the sum and the temporally constant effect is obtained when the sum of the frequencies vanishes.

6.2.4 Fröhlich's coherent dipole oscillations and generalized four-wave mechanism

Any oscillation for which frequency is independent of the wave vector defines an ideal generalized standing wave able to suck energy from the environment by sending phase conjugate photons at the frequency of the wave. Plasma oscillations are basic example of this kind of waves. Magnetostatic waves, which might be relevant for the strange behavior of rotating magnetic systems and bifilar coils [K22], represent a second example. Now however the frequency depends on the angle θ between the wave vector and magnetic field. One can wonder whether magnetostatic waves could be replaced by their electret versions for which the permanent electric dipoles possessing spin oscillate around the equilibrium positions in self-generated electric field and experience the torque $p \times E$.

1. Dispersion relation for the magnetostatic waves of magneto-electret

The equations for magnetostatic waves [D3] can be generalized in a straightforward manner. The units in the sequel is chosen such that one has $\epsilon_0 = \mu_0 = c = \hbar = 1$.

1. The equation relating angular momentum J to magnetic momentum μ: $J = \gamma\mu$ and the expression for the magnetic torque $\tau_m = \mu \times B$ are central. Now also the electric torque $\tau_e = p \times E$ is present.

2. Assume that the dispersive medium is magnetically linear but as an electric has electric and polarization fields E_0 and P_0 satisfying $E_0 = -P_0$ even in the absence of external field D:

$$\begin{array}{lll} B = H + M \ , & D = E + P \ , & \\ H = \mu B \ , & D = \epsilon(E + P_0) \ , & P = (\epsilon - 1)E + \epsilon P_0 \ . \end{array} \tag{6.1}$$

   D clearly vanishes for the ground state.

3. Assume that ground state fields have constant values so that one has

$$\begin{array}{lll} M = M_0 + m(t) \ , & H = H_0 + h(t) \ , & \\ E = P_0 + e(t) \ , & D = \epsilon e(t) \ , & P = P_0 + p(t) = \epsilon P_0 + (\epsilon - 1)e(t) \ . \end{array}$$

   The further assumption is that M_0, B_0 and P_0 are in the same direction, say z-direction, and that m, b, p, e are orthogonal to z-direction.

4. The equations of motion for the magnetization follow from those for single magnetic moment

$$\begin{aligned} \frac{dm}{dt} &= \gamma(M \times H + P \times E) = \frac{\gamma e}{M}(M_0 \times h - H_0 \times m - \epsilon e \times P_0) \ , \\ \gamma &= \frac{ge}{2M} \end{aligned} \tag{6.2}$$

   M can be taken as a mass scale characterizing the electric dipole as a quantum system as a magnetic system. The first naive guess would be that M is identifiable as the mass of the dipole and g denotes the Lande factor appearing in the expression of the magnetic moment in terms of spin $\mu = geS/2M$, e denotes elementary charge. Note that the electric dipole need not possess a net charge and therefore the net charge q appearing in the formula in the case of elementary particle is replaced by $q = e$ and the generalized Lande factor g characterizes the spin of the atom or a molecule. In the case of quantum coherence in spin degrees of freedom, the magnetic moment of the molecule would in a reasonable approximation result by the summation of angular momenta of composite atoms determining also the net magnetic moment. Hence the mass scale could be actually given by the mass of nucleon or even electron whose contribution dominates over nuclear contribution by a factor of about $m_p/m_e \simeq 2\times 10^3$. In this case the mass scale M would correspond naturally to electron mass.

5. Maxwell's equation $\nabla \times E = -\partial_t B$ for plane waves gives

$$e = -\frac{k}{\omega} \times b \ , \tag{6.3}$$

and one can write $e \times P_0 = P_0 cos(\theta) b$ so that the equation of motion for the magnetization reads as

$$\begin{aligned} i\omega m &= \gamma \left[M_0 \times h - H_0 \times m - \epsilon P_0 cos(\theta) b \right] \\ &= \frac{\gamma e}{M} \left[(M_0 - \epsilon P_0 cos(\theta)) h - (H_0 + \epsilon P_0 cos(\theta)) m \right] \ . \end{aligned} \tag{6.4}$$

This equation differs from the equation in a purely magnetostatic case only in that one must replace the parameters H_0 and M_0 with modified parameters:

$$\begin{aligned} M_0 &\rightarrow M_0 - \epsilon P_0 cos(\theta) \ , \\ H_0 &\rightarrow H_0 + \epsilon P_0 cos(\theta) \ . \end{aligned} \tag{6.5}$$

6. From the equation above one can express m in terms of h using the so called Polder's susceptibility tensor

$$\begin{aligned} \begin{pmatrix} m^x \\ m^y \end{pmatrix} &= \begin{pmatrix} \chi & -i\kappa \\ i\kappa & \chi \end{pmatrix} \ , \\ \chi = \tfrac{\omega_0 \omega_1}{\omega_0^2 - \omega^2} \ &, \quad \kappa = \tfrac{\omega \omega_1}{\omega_0^2 - \omega^2} \ . \end{aligned} \tag{6.6}$$

In a purely magnetostatic case the parameters are counter parts of Larmor frequencies in fields H and M and satisfy $\omega_0 = \omega_H = e\gamma H_0/M$ and $\omega_1 = \omega_M = e\gamma M_0/M$, where M denotes the mass of the magnetic dipole. In the more general case one has

$$\begin{aligned} \omega_0 &\rightarrow \gamma(H_0 + \epsilon P_0 cos(\theta)) \ , \\ \omega_1 &\rightarrow \gamma(M_0 - \epsilon P_0 cos(\theta)) \ . \end{aligned} \tag{6.7}$$

7. Maxwell's equation $\nabla \cdot B = 0$ and the assumption $\nabla \times H = 0$ implying $H = -\nabla \Psi$ combined with $B = \mu \cdot H$, with dynamical permittivity tensor

$$\mu = \begin{pmatrix} 1+\chi & -i\kappa & 0 \\ i\kappa & 1+\chi & 0 \\ 0 & 0 & 1 \end{pmatrix} \ , \tag{6.8}$$

gives

$$(1+\chi)(\partial_x^2 + \partial_y^2)\Psi + \partial_z^2 \Psi = 0 \ . \tag{6.9}$$

For plane waves one obtains the dispersion relation

$$\chi sin^2(\theta) = -1 \ . \tag{6.10}$$

Substituting this to the expression of ξ one obtains the dispersion relation

$$\omega^2 = \omega_0(\omega_0 + \omega_1 sin^2(\theta)) \ . \tag{6.11}$$

2. Dispersion relation for a pure electret

Consider now the special case $H_0 = M_0 = 0$. The dispersion relation gives now

$$\omega = \frac{eg}{2M} P_0 cos^2(\theta) = \omega_L \frac{\epsilon P_0}{B} cos^2(\theta) \ . \tag{6.12}$$

The frequency depends only on the direction of propagation and for the wave vectors in the cone $\theta = constant$ frequency is same for all Fourier components so that the situation is almost ideal since the formation of 2-dimensional periodically recurring self-organization patterns is possible. Note that the allowed wave vectors form a double cone. The frequency coding of the angle θ occurs.

The external magnetic field is replaced by the polarization field in the formula for the Larmor frequency. In the expression for the magnetic moment in terms of spin ($\mu = gqS/2M$) the mass of the elementary particle is replaced by the mass M of the dipolar molecule. Recall however that in case of quantum coherence even electron mass would be more appropriate mass scale. For instance, if macroscopic quantum phase consisting of electron Cooper pairs is in question the mass scale would be $2m_e$ and spin could be rather large.

p-Adic fractality leads to an estimate for the maximal frequency of the waves as a function of the size of the electret molecule.

1. The idea that the non-quantum coherent physics of a many-particle system formed by smaller space-time sheets topologically condensed at a given space-time sheet is simulated in terms of quantum coherent physics of a space-time sheet containing them, encourages to consider the possibility that the space-time sheets of tubulin molecules possess a magnetic moment, which has an order of magnitude equal to a thermal expectation value of the magnetic moment in the shorter length scales. There would be of course hierarchy of temperatures involved. The magnetic moment could be due to a condensate of Cooper pairs of electrons at a magnetic flux tube structure accompanying the tubulin molecule.

2. p-Adic fractality encourages to think that the net electronic spin and thus magnetic moment is same in each p-adic length scale and thus of order of electronic magnetic moment. If similar scaling holds true for the electric dipole moment assumed to be $p = na$, $a = L(137)$ in atomic length scale, then the polarization in the p-adic length scale $L(k)$ would satisfy

$$P_0(L(k)) = \frac{n}{a^2} \times \left[\frac{L(137)}{L(k)}\right]^3 = \frac{n}{a^2} \times 2^{3(137-k)/2} \ .$$

Taking the Larmor frequency $f_0 = 12$ GHz of electron ($m_e = 10^{-3} m_p/2$) in the magnetic field of one Tesla ($Tesla \simeq 10^{-4}/a^2$, $a = .1$ nm for $\hbar = c = 1$) as as reference, one can write the estimate for the maximal frequency f_m as

$$f_m(k) = \epsilon ng \times 10^4 \times 2^{3(137-k)/2} \times f_0 \ .$$

For instance, for $k = 151$ corresponding to the length scale of 10 nm giving a good estimate for the size of a tubulin molecule, the estimate for the frequency would be $f \sim \epsilon ng \times .05$ GHz.

3. A possible connection with Fröhlich's hypothesis

If the mass scale M corresponds to the mass of the molecule, the result conforms with the hypothesis of Fröhlich [I18] that coherent electric dipole oscillations in the nanosecond scale are crucial for the functioning of the living matter. This hypothesis is a crucial piece of many quantum theories of consciousness. In TGD framework the interpretation would be different: coherent dipole oscillations would be responsible for the generation of periodically recurring (two-dimensional) mental images able to suck their energy from their environment by sending phase conjugate photons. The usual view that the energy is pumped to system by an external agent is in conflict with the goal of explaining consciousness from the first principles.

Living matter is populated by electrets but micro-tubules are perhaps the most prominent electrets from the point of view of quantum theories of consciousness. In this case the situation would be 2-dimensional from the beginning. As already found, the estimate based on the notion of many-sheeted space-time and p-adic fractality gives $f_m \sim \epsilon ng \times .05$ GHz, which is in GHz scale for $\epsilon ng \sim 20$. The di-electric constant of water is $\epsilon = 79$ for a pressure of 1 atm and temperature of 20 C so that there are good hopes that f_m corresponds to GHz scale. Of course, there is a fractal hierarchy of frequencies f_m scaling as $f_m \propto 2^{3(137-k)/2}$ ranging to the visible frequencies.

6.3 Explanation Of Super-Luminal Velocities In Terms Of Remote Metabolism

After the pioneering experiments of Nimtz and his collaborators 1992 [D4] a lot of evidence for effective super-luminal signal velocities has been accumulating [D6, D7]. These findings provide not only a challenge for TGD but also a means of developing the new views about time and energy to a more quantitative level. The simplest model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. Thus these experiments would give a firm grasp on phenomena at the border of dead and living matter.

6.3.1 General explanations for effective super-luminal velocities

Several explanations for the effective super-luminal velocities have been proposed. Quite generally, the explanations are marginally consistent with Maxwell's equations.

1. The explanation of super-luminality in terms of photon tunnelling

The explanation of Nimtz [D6, D7] for effective super-luminal velocities involves the notion of evanescent wave for which the component of the wave vector in the direction of propagation is by definition imaginary: $k = i\kappa$ so that the wave is exponentially attenuated. For one-dimensional evanescent em waves dielectric constant ϵ as a function of frequency must be negative so that also the energy density becomes negative and Nimtz suggests that this holds true generally. For 3-dimensional waves in waveguide, which are not constant in the transversal degrees of freedom, evanescent waves in vacuum are possible below cutoff frequency ω_c and are generated in a wave guide containing a narrowed portion in the original experiments of Nimtz.

The analogy with the Schrödinger equation allows the interpretation of evanescent waves in terms of photon tunnelling. The semiclassical model relies on the wave equation for non-allowed frequencies not propagating in the waveguide. The model predicts that asymptotically the time τ taken by the evanescent wave of mean frequency f to propagate through a narrowed section of length L of a waveguide does not depend on L and is $\tau \simeq 1/f$ so that arbitrary high effective signal velocities become possible in principle: note however that the exponential attenuation poses strong limitations. This effect is known as Hartman's effect, and generalizes to other geometries and also to electron tunnelling. The prediction is consistent with experiments [D4, D6, D7] so that the model provides a reasonable looking phenomenological approach to the situation. The objection is that the solutions describe stationary photon states rather than the process creating them so that the proposed interpretation of evanescent wave is correct only if the stationary solution codes in itself the process leading to it.

It has been proposed that the effective super-luminal velocities could relate to the breaking of local Lorentz invariance (LLI) [D6, D5] involving also quantum non-locality. The breaking of LLI at space-time level is possible in TGD since Poincare invariance is a symmetry of the 8-dimensional imbedding space. The induced metric of space-time surface can have even Euclidian signature, which might serve as the space-time correlate for the negative value of the dielectric constant.

Also the notion of anomalous interference and the notion of hollow wave analogous to the pilot wave of Bohm have been introduced by Cardone and collaborators [D5]. The phenomenological notion of hollow wave might allow precise formulation using the notion of many-sheeted space-time.

2. The explanation of effective super-luminality in terms of remote metabolism

TGD suggests a microscopic description in terms of many-sheeted space-time by utilizing the new energy concept allowing negative inertial energies. The explanation relies on time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book) realized in terms of the generalized four-wave mechanism and making

possible remote metabolism by sending negative energy phase conjugate photons to the geometric past.

Remote metabolism can explain not only the effective super-luminality but also the effects interpreted in terms of anomalous interference effects [D5]. Detector could be seen as a self-organizing system able to suck energy by radiating phase conjugate negative energy photons to some other part of system absorbing them. This is also TGD proposal for the fundamental mechanism behind the ordinary metabolism in living systems and the model predicts that the detectors in the experiments considered behave to some extend like living systems. One can even imagine that a competition for resources occurs and that two systems do their best to suck energy from each other. The general catastrophe theoretic model of remote metabolism developed to explain the behavior of Searl device [K22] provides a starting point for the attempts to model the situation quantitatively.

In the case of the pioneering experiments of Nimtz involving a narrowed portion of wave guide the model would look as follows. When the photons in the wave cavity encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. As the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground states. The shape of the signal received by detector is changed and the signal peak is shifted to earlier time and this gives rise to effective super-luminal light velocity. According to the figure 4 of [D6] the tunneled signal is not obtained as a time shift of ordinary reference signal but has slightly different shape. In accordance with observations the energy received by the detector is predicted to be larger than expected.

6.3.2 Experiments involving super-luminal velocities

The pioneering experiments on super-luminal velocities were done by Nimtz and collaborators in Cologne 1992 [D4] using microwaves. The configuration used was a wave guide containing a narrowed portion with cross section less than one half of wavelength in both transversal directions. The finding was that the tunnelling time is asymptotically equal to $\tau \simeq 1/f$, where f is the frequency of the microwave. More generally, photon tunnelling can be realized in wave guides containing a narrowed portion, in the forbidden frequency bands of dielectric hetero-structures analogous to one-dimensional lattices, and also as the frustrated total internal reflection of a double prism, where the total reflection takes place at the boundary from a denser to a rarer dielectric medium [D7].

3.Standard theoretical description of the findings

The interpretation proposed by Nimtz for super-luminal propagation is in terms evanescent waves representing semiclassically photon tunnelling. The quantum tunnelling of photons was first discussed by Wigner and later by Hartman who deduced the independence of the tunnelling time on barrier thickness [D8]. The article of [D2] [D2] summarizes the model.

Evanescent modes correspond to waves with imaginary wave number not satisfying the dispersion relation of free massless photon. The dispersion relation $\omega^2 - k^2 - \omega_c^2 = 0$ satisfied for free propagation in the waveguide is replaced by $\omega^2 + \kappa^2 - \omega_{c,1}^2 = 0$ in the narrowed portion of the waveguide. The photons satisfying $\omega_c < \omega < \omega_{c1}$ can propagate in the narrowed portion but are attenuated exponentially. The narrowing of the waveguide by a factor x means $\omega_c \to \omega_c/x$ so that evanescent modes appear, when x satisfies the constraint $x < \omega_c/\omega$.

In Maxwell's theory a system allowing *one-dimensional* evanescent waves must have negative dielectric constant ϵ ($c^2 = \epsilon_0\mu_0 \to \epsilon\mu < 0$) for the frequencies involved so that d'Alembert type wave equation changes to Laplacian and tunnelling cannot be regarded as a genuine propagation. A possible interpretation is in terms of breaking of Lorentz invariance. According to Nimtz, the evanescent modes seem to represent non-local fields. For one-dimensional propagation the energy density $\varepsilon = \epsilon E^2/2$ by $\epsilon < 0$ would be indeed negative. On the other hand, for 3-dimensional waveguide $\varepsilon < 0$ need not hold true. Evanescent have not been measured directly and they might represent fictitious quantities.

The so called phase time approach identifies the tunnelling time as $\tau = d\phi/d\omega$, where ϕ is the phase change over the barrier. In the examples listed above phase change is vanishing since the

wave number is imaginary implying $\phi = 0$. Experimentally it has been found $\tau \simeq 1/f$ and this is believed to be due to what happens at the barrier front boundary. A quantum mechanical model for photon tunnelling originally developed by Wigner and by Hartman predicts phase-time correctly. A semiclassical description is in question since electromagnetic field does not allow interpretation as a probability amplitude.

The tunnelling occurs only below certain length scale L. An interpretation as the size of the region inside which the breaking of Lorentz invariance at space-time level takes place, has been suggested. In the experiments of Nimtz and collaborators L corresponds to the $8.8 - 9.30$ cm variation range for the penetration length of evanescent wave [D4]. Second scale corresponds to an energy threshold of $E_{0,e.m.} = 4.5\ \mu V$ representing the difference of voltages induced in photodiodes in two experiments in which tunnelling occurs/does not occur. In [D5] the threshold is interpreted as an energy threshold for the breaking of local Lorentz invariance.

4. TGD based explanation of effective super-luminality in terms of remote metabolism

The general TGD based description of the effective super-luminal propagation is based on time mirror mechanism realized in terms of a generalization of the four-wave interaction involving standing wave composed of two waves propagating in opposite directions and waves representing incoming wave and phase conjugate wave. Phase conjugate negative energy photons would propagate inside negative energy massless extremals (MEs, topological light rays). Time mirror mechanism makes possible remote metabolism, and it is assumed that detector is able to remotely metabolize by sending negative energy photons to the walls of the wave guide whose atoms have been excited by the photons which have been excited.

In the following the consideration is restricted to the experiment [D4] of Nimtz in which waveguide contains a narrowed portion.

1. When the photons with frequencies below the cutoff frequency of the narrowed portion of the waveguide encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. When the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with the normal light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground state. The shape of the detector signal changes and the peak of the signal received by the detector is shifted to an earlier time. According to the figure 4 of [D6] the shape of the signal indeed changes. The outcome is an effective super-luminality.

   If the change of the shape is such that it corresponds in the frequency domain to the phase shift induced by the translation $t \to t - \Delta\tau$ in the argument of the Fourier component $exp(i\omega t)$, with $\Delta\tau$ given as the difference

$$\Delta\tau(\omega) \quad = \quad \tau_R - \tau = \frac{L}{c} - \frac{2\pi}{\omega} \tag{6.13}$$

   of the real time τ_R taken to propagate through the barrier and of the semiclassical tunnelling time $\tau(\omega)$, the theory makes same predictions as the semiclassical approach.

2. The prediction is that the detected signal is somewhat stronger than predicted by the standard theory. This has indeed been observed and is formulated in [D5] in terms of the effective energy threshold, which corresponds to the voltage difference $E_{0,e.m} = E_B - E_A \simeq 4.5\ \mu$V, where A (B) corresponds to the situation in super-luminal propagation occurs (does not occur). Why this should be the case, is not obvious in the semiclassical model.

5. Could strong breaking of local Lorentz invariance occur at the space-time level?

The quantum-classical correspondence states that many-sheeted space-time realizes also the phenomenological smoothed out descriptions of the physical system using a hierarchy of larger space-time sheets: many-sheeted physics performs self-mimicry. This philosophy might apply also to the description of photon tunnelling.

In TGD Poincare invariance corresponds to the symmetries of the imbedding space and TGD predicts the possibility of space-time sheets with Euclidian signature of metric and thus a dramatic breaking of local Lorentz invariance at space-time level. The physical interpretation of these space-time sheets has remained open. In spirit of quantum classical correspondence one can wonder whether the induced metric could have Euclidian signature for the standing microwave space-time sheet so that the negative value of dielectric constant $\epsilon(\omega)$ necessary for one-dimensional evanescent waves would have a direct space-time correlate in TGD framework. Even the effectively one-dimensional approximate description of the situation with length scale resolution larger than the transversal size of the narrowed portion of the waveguide could have this kind of space-time correlate.

If the standing microwave space-time sheets with Euclidian signature of the induced metric are vacuum extremals, the resulting flexibility gives good hopes about the correspondence with the tunnelling interpretation of the evanescent waves. Of course, TGD description remains a bundle of ideas and precise quantitative model is not yet possible.

6. Alternative explanation in terms of drift of negative energy MEs does not work

A second explanation imaginable in TGD framework would rely on the drift of the negative energy MEs generated at the end B of narrowed portion and send to the end A and to the direction of the geometric past quantum jump by quantum jump so that the field pattern inside MEs would shift towards geometric past and effectively move with super-luminal velocity. This would imply effective super luminal group velocity for the classical fields inside ME and also for the pattern of coherent photons. In this case the effective super-luminal light velocity would be most naturally constant irrespective of the length of the narrowed region. This is not consistent with the experimental findings. Note that the variant of this mechanism for positive energy MEs could provide the space-time correlate for the reduction of light velocity in dielectrics.

6.3.3 Experiments believed to involve anomalous interference

The experiments of Cardone and coworkers [D5] stimulated my own interest in the super-luminal propagation, a possible breaking of LLI, and non-locality. The experiments of Cardone were motivated by the notion of hollow wave analogous to the notion of pilot wave of Bohm. Hollow wave would not carry energy but would represent a deformation of Minkowski metric and its interaction with photons would somehow induce anomalous interference effects.

1. The experimental arrangement

The experimental arrangement discussed in more detail [D5] (see **Fig. 1**) is following.

1. The geometry of the experimental arrangement can be described in terms of a configuration of vertical lines V_1, V_2, and V_3 order from left to right and horizontal lines H_1, H_2, H_3 ordered from top to bottom. There are two identical sources S_1 and S_2 of IR photons, three identical slits F_1, F_2, F_3 and three identical detectors A, B, C (photodiodes sensitive to IR light).
   i) S_2, F_3, C was in the intersection of V_i, $i = 1, 2, 3$ with the line H_3 in this order. C was in front of F_3 and detected photons from S_2.
   ii) F_2, B was at the intersection of V_i, $i = 2, 3$ with H_2 in this order.
   iii) S_1, F_1 and A was at the intersection of V_i, $i = 1, 2, 3$ with H_1 in this order. The vertical line V_3 containing the detectors A and B could be moved in horizontal direction to five different positions.

2. F_2 was outside the cone of maximal intensity for the radiation from S_1 and in geometric optics approximation no photons was predicted to go through F_2. The expectation was however that the "hollow waves" accompanying photons emitted by S_2 could propagate through F_2 and induce anomalous interference effects.

3. The geometric arrangement was such that B was predicted to detect nothing in the geometric optics approximation and this was found to be the case. Detector A was expected to detect only photons from S_1: indeed, when S_1 was off and S_2 on, no signal was detected.

2. Findings

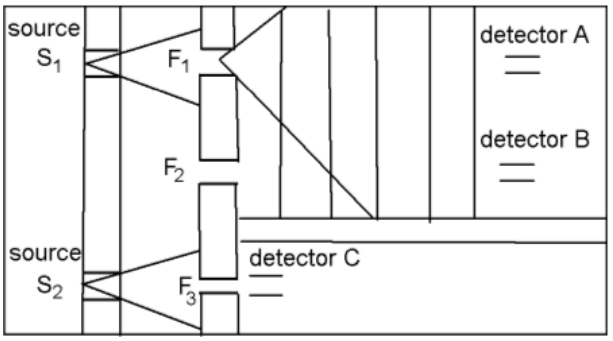

Figure 1: Schematic representation of the experimental arrangement of Cardone and collaborators.

Standard Maxwell's theory would predict that detector A should give same signal in the following situations:
i) S_1 on and S_2 off
ii) S_1 on and S_2 on.
What was found that when the distance d of the detector A from S_1 (on the same line parallel to x-axis) satisfied $d < 4$ cm, the two situations were different. The energy threshold defined as the difference of voltages in the detector A in situation i) and ii) was $\Delta_A(1-3) = 2.3\ \mu V$ for $d < 4$ cm. The proposed interpretation was in terms of anomalous interference effects caused by "hollow waves" accompanying photons and diffracting through the slit F_2.

3. TGD based model of remote metabolism as explanation of the effects

The general model of remote metabolism would look like follows.

1. The basic building blocks are negative and positive energy MEs containing phase conjugate IR photons. Although not separately mentioned in [D5], there are reasons to believe that the presence of the slit F_2 is necessary for the effect to occur. The interpretation would be that the standing microwave space-time sheet diffracts through F_2. Also negative energy IR photons would tunnel through F_2. Previous considerations allow to consider the possibility that hollow waves correspond to space-time sheets with an Euclidian signature of the induced metric so that physics itself would provide description of the situation with length scale resolution of the order of beam width. What is highly interesting that the critical distance d corresponds to the p-adic length scale $L(k) = 2^{(k-151)/2}L(151)$, $L(151) = 10$ nm for $k = 195$.

2. In order to develop the model further, a rough picture about the functioning of the detector A is necessary. When a photon is detected by A, it creates an electron hole pair in the active region of the photodiode. Conduction electron starts to move towards the n layer of the diode (catode) whereas hole moves towards the p layer (anode).

3. Detector A emits negative energy phase conjugate IR photons absorbed by S_2. The emission of negative energy photon from A means that electron becomes a conduction electron so that electron-hole pair is generated and a positive contribution to the voltage of the photodiode is generated. The absorption of photon by S_2 induce a transition of some atomic system in S_2 to a lower energy state without an emission of positive energy IR photon.

4. The "energy threshold" characterizes how efficiently photodiode at A generates negative energy photons and how effectively they are absorbed by S_2 and is a property of photodiode and photon source rather than of possible exotic interactions such as anomalous interference.

5. The model makes several predictions. Negative energy photons can be absorbed when their energies are sub-thermal so that mechanism might not work for photons with sub-thermal energies. The prediction is that the presence of the detector C is not necessary for the

mechanism to work. The number of photons detected by the C should be changed by the negative of the amount that the energy detected by A is changed.

6.3.4 The experiments involving crossed photon beams

In [D5] the privately communicated preliminary experimental results of Ranfagni and coworkers are analyzed. The experimental arrangement is illustrated in figure **??**. The primary microwave photon beam A_1 generated by a microwave antenna antenna splits into two beams A_{11} and A_2. A_{11} is amplified by a second microwave antenna. A_2, the secondary beam, propagates inside a waveguide, is modulated at 1500 Hz frequency by a chopper and passes to the detector. Either A_1 or A_2 is attenuated.

A_{11} and A_2 cross each other orthogonally and apart from very small interference predicted by QED (photon photon scattering), the effect of A_{11} to the detector should vanish.

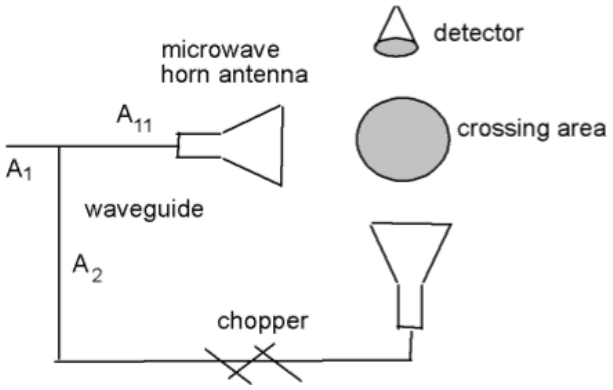

Figure 2: Schematic representation of the experimental arrangement of Ranfagni and collaborators discussed in [D5].

1. Findings

The experiment demonstrates that the signal generated by photons in detector A depends on whether A_1 or A_2 is attenuated. The experimenters interpret the finding in terms of an anomalous interference involving "hollow waves".

Figure 7 of [D5] depicts the voltage of detector A as function of attenuation and polarization for A_1 and A_2 attenuation. If A_2 is attenuated, the voltage of the photodiode as a function of attenuation stays positive. If A_1 is attenuated, signal changes sign somewhat below 10 dB but approaches in both cases asymptotic value of 5 μV above 30 dB of the size of the crossing beam region is less than 8-9 cm *resp.* 4 cm for microwave *resp.* IR photons. Asymptotic situation corresponds to a single photon condition. There is no detectable dependence on beam energy but photon polarization affects somewhat the situation.

The laser variant of the experiment performed by Meucci and coworkers uses IR light without modulation and a similar effect is detected.

2. An overview of the TGD based model

The picture behind the TGD based model is following.

1. The propagation of the microwave through a resistor in microwave circuit is the simplest manner to achieve attenuation. Electrons absorb the microwave energy and dissipate it. Attenuation is a process analogous to a detection since photon is absorbed also now.

2. There is a competition between detector D and attenuator A about energy. In the case of A_2 attenuation D wins and sucks more energy from A_2 than A_2 from D: photodiode voltage is positive. For A_1 the situation is opposite in a critical range $[8, 30]$ dB of attenuation

strength A so that the voltage of the photodiode becomes negative. Conduction electrons in the photodiode annihilate with holes and a negative voltage contribution is generated. Asymptotically detector wins in both cases and this explains positive 5 μV voltage at large values of attenuation A.

3. Generalized four-wave interaction occurs most naturally in the detector and in the attenuator. Standing microwave space-time sheet and IR MEs with negative energy correspond to the four waves involved. The size of the region in which four wave interaction occurs is determined by the size of the crossing region. The wavelength and width of the standing waves between detector and attenuator corresponds to the critical length parameter L, which corresponds to a microwave wavelength in both variants of the experiment. Negative energy IR photons propagate between attenuator and detector along the wave guide A_2. The branching of the A_1 induces also a branching of the beam of negative energy photons.

4. These length scales L corresponds to the p-adic length scale $L(197)$ for microwave photons and $L(195)$ for IR photons. This suggests that the microwave frequencies involve correspond to p-adic length scales. p-Adic frequencies are indeed expected to define "miracle frequencies" in TGD Universe and I have already proposed that these frequencies and corresponding p-adic codes might be used by more advanced civilizations of the geometric future to communicate with the civilizations of the geometric past (including ourselves). What is interesting that the attenuation need not make possible this kind of communications since time reflection of the signal back from geometric past instead of time transmission does involve attenuation.

5. The catastrophe theoretic model is inspired by the general model for Searl effect based on remote metabolism. Qualitatively the model is characterized by the numbers of state and control parameters. The voltage of photodiode of the detector is in the role of the state variable so that cusp, swallowtail, and butterfly are the candidates for the elementary catastrophes involved. At least $V = 0$ and $V \neq 0$ at the one photon limit represent steady states so that cusp catastrophe and less probably, the dual of butterfly catastrophe having both two steady states provide a possible model of the situation. Note that butterfly reduces to cusp in subregion of the parameter space.

3. The identification of the control variables

Consider now the possible control variables.

1. The attenuation of the beam A_1 or A_2, denote it by A, is certainly a relevant dimensionless control parameter. From figure 7 of [D5] one finds that the sign of V changes rapidly as a function of attenuation A below 10 dB and stays negative in certain range of values of A for F_1 attenuation. For A_2 attenuation V preserves its sign. This suggests an idealization in terms of a discontinuous dropping from the upper sheet of cusp to the lower sheet so that A would be identifiable as the normal factor of the cusp.

2. The index $i = 1, 2$ telling whether the primary or secondary beam is attenuated is also a natural control variable. The naive expectation is that some fraction of the beam of negative energy photons from A_1 leaks out when the secondary beam branches from A_1. It however turns out that "time refraction" in which negative energy signal is amplified in the branching must occur in order to explain the experimental findings.

3. The dimensional control parameters are following.

   (a) The width L of the beam is certainly a control parameter and determines the size of the crossing region, which as such has no relevance in TGD framework since anomalous interference is not assumed to be the underlying mechanism. The wavelength $\lambda = c/f$ of the photon beam is second candidate for a control parameter. The distance d from the detector to the attenuator also distinguishes between A_1 and A_2 attenuation. Together with the attenuation strength A this would make four control variables. The overall size of the system, call it X, is a further control variable which can be however eliminated if scaling invariance holds true by taking X as a length unit.

(b) The critical value of L is reported to be the same for $d = d_1$ and d_2. When L is below the critical value L_{cr} a steady state $V \neq 0$ becomes possible. Below it $V \to 0$ corresponds to the steady state at the one-photon limit. Hence L plays the role of the splitting factor of cusp catastrophe. The critical value of L for IR photons and microwave photons differs by a factor of order two (change of p-adic miracle wavelength) so that there is a weak dependence on the wavelength and λ acts as a non-trivial control parameter. In the first approximation one can forget λ as an active control variable.

(c) The variable d representing distance between attenuator and detector is a candidate for a further control variable. The experiments do not allow to decide whether d is a relevant control variable.

The minimum option is based on the identification of A, L, and discrete variable i as control variables.

4. A more detailed specification of the catastrophe theoretic model

The equation for the charge of the photodiode modelled as a capacitor reads as

$$\begin{aligned} \frac{dQ}{dt} &= C(V)\frac{dV}{dt} \\ &= I_B(A) + I_D(V, A, L, \lambda) - I_A(A, i, L, \lambda) \equiv F(V, A, L, i, \lambda) \ . \end{aligned} \tag{6.14}$$

Here $I_B(A)$ denotes the contribution of the beam of photons. In the absence of new physics it would be the only term at the right hand side. I_B is obviously proportional to A:

$$I_B(A) = A \times I_B(A = 1) \ ,$$

and thus decreases with attenuation. I_D corresponds to the current due to the spontaneous generation of negative energy photons by detector and received by attenuator. I_A is the corresponding current induced by the attenuator competing with the detector about energy resources. The first guess is that A_1 and A_2 differ in the sense that part of the beam of the negative energy photons from attenuator A_1 can split into two beams: hence the functional form of I_A is different for $i = 1$ and $i = 2$.

The asymptotic steady states satisfy

$$\frac{dQ}{dt} = F(V) = 0 \ . \tag{6.15}$$

This gives an expression of V as a zero of the function appearing at the right hand side. The dependence of C on V does not matter in the adiabatic situation. Since there is only one state variable involved, one can always write the right hand sided $F(V)$ as a gradient of a potential function Φ:

$$F(V) = \frac{d\Phi}{dV} \ , \tag{6.16}$$

so that catastrophe theory applies and irrespective of the form of potential the situation is diffeomorphic with a butterfly catastrophe with additional discrete control variable i and expected to reduce to cusp catastrophe in the range of control variables studied in the experiments.

From the behavior of V as a function of A one can deduce the following.

(a) If d would appear as an argument of I_D asymptotics would not be the same for $d = d_1$ and $d = d_2$ unless one has $I_D(d_1) \simeq I_D(d_2)$ for large values of A. Hence it seems that I_D does not depend on d. The dependence of $I_A(A, i, ..)$ on i is reflected in the difference of the graphs of $V = f_{A_i}(A)$, $i = 1, 2$ as function of attenuation.

(b) I_A must be negligible at the limit $A \to 0$ of high attenuation since the asymptotic value of V does not depend on whether A_1 or A_2 is attenuated. Too strong an attenuation would mean that the attenuator is not anymore able to emit appreciably negative energy photons. $I_A \propto A(1-A)$ is the first guess for I_A. For 30 dB attenuation one would have $A = 10^{-3}$ so that I_A would be indeed small.

In principle the model based on the emission of negative energy photons is able to reproduce the observed behavior for V. $I_B \propto A$ decreases as the attenuation increases whereas the current I_A induced by the generation of negative energy photons from the attenuator increases when the attenuation parameter increases since the probability for generation of negative energy photons is expected to grow with the size of attenuator and thus with $1 - A$. Thus the observed change of sign of V for A_1 attenuation can occur for

$$\begin{aligned} I_D(A,..) &< I_A(A, i = 1, ...) \ , \\ I_B(A) &< I_A(A, i = 1) \ . \end{aligned} \tag{6.17}$$

The condition

$$I_A(A,1) > I_A(A,2) \tag{6.18}$$

must be satisfied and could relate to the branching of the primary beam and less probably with the value of the parameter d. This condition is not consistent with the expectation that $I_A(A,1)$ is a fraction of $I_A(A,2)$. Branching should induce an amplification of the negative energy signal. This would suggest that the branching corresponds to a "time refraction" in which the refracted part of the signal corresponds to positive energy photons.

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