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

M. Pitkänen[1], February 1, 2006

[1] Department of Physical Sciences, High Energy Physics Division,
PL 64, FIN-00014, University of Helsinki, Finland.
matpitka@rock.helsinki.fi, http://www.physics.helsinki.fi/∼matpitka/.
Recent address: Puutarhurinkatu 10,10960, Hanko, Finland.

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Abstract

The quantum view about metabolism has developed in two stages. First came the somewhat unbalanced vision about the connection of quantum metabolism and bound state formation. The second breakthrough was the discovery of dark matter hierarchy and associated hierarchy of generalized EEGs.

1. Quantum metabolism and bound state formation

Topological self-referentiality states that the topological field quanta of the classical fields associated with a material system provide a concrete representation for a theory about the material system. Actually this principle generalizes and implies an entire hierarchy of representations. An important outcome of the topological self-referentiality is that the 'buy-now' part of the buy now-pay later mechanism for energy production can be understood as a generation of bound states with binding energy liberated as a usable energy. 'Pay later' means that sooner or later thermal noise destroys the bound state.

This observation led 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: this implies a connection with the claimed over unity phenomena. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy. Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just challenging the basic assumptions of the Newtonian biology.

This vision can be criticized for over-emphasizing the formation of bound states: also the transitions to bound states with lower energy, say transitions between cyclotron states, can generate metabolic energy.

2. Dark matter hierarchy and quantum metabolism

The vision about a hierarchy of generalized EEGs associated with dark matter hierarchy a second decisive boost for 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.

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

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These ingredients allow to develop a general view about how the sensory representations and motor control are realized in terms of MEs. Time mirror mechanism and charge entanglement induced by W MEs are 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.

4. 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.

5. 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. 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.

1   Introduction

TGD inspired theory of consciousness and the ideas about quantum control allow already now a rather detailed view about conscious brain. There are general theories for qualia, sensory representations, and quantum control based on many-sheeted ionic flow equilibrium. p-Adic space-time sheets serve as correlates for cognitive representations and intentions and p-adic-to-real phase transitions provide the physical correlate for the transformation of intentions to actions.

The role of metabolism for quantum consciousness has however remained poorly understood hitherto. There are also other white regions in the map. How motor control is realized: directly from brain level or from magnetic body as the computer sitting at its own terminal metaphor would suggest? And what is the deeper quantum meaning of neurotransmitters and hormones, and so called information molecules in general? If they were only inhibitors, excitators, and modulators, the organisms would not bother to construct so many different information molecules.

Before continuing I wish to thank for many people for providing very important stimuli: in fact, the strange synchronies encourage me to think that we all might belong to a greater pattern gradually becoming self-conscious. I would like to mention Lian Sidoroff for turning my attention to remote mental actions and bio-photons and for very stimulating discussions and questions. Also the contact by finnish new energy enthusiasts Juha Hartikka, Jukka Kinnunen and Tapio Tammi, came just in right time to allow to realize the connection with some new physics phenomena suggested by new energy technologies. The material sent for year or two ago by Gene Johnson related to brain metabolism turned also to be very invaluable. I do not know who I should thank for the existence of web: without the availability of information about practically anything between Earth and Heaven this kind of convergence of ideas would be completely out of question.

1.1   Dark matter hierarchy, sensory representations, motor action, and metabolism

Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [M3] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in powers of $\lambda = 2^{11}$ in the first model [M3]. Later it became clear that much more general scalings are possible but this scaling law seems to favored as far as EEG is considered (see the appendix of [C8]. One reason might be that this number appears also as a fundamental constant in TGD Universe. Also the ratio of proton and electron masses appearing in the ratio of corresponding

cyclotron frequency scales is rather near to 2^{11}. For $k_{em} = 4$ the energies of EEG photons are above thermal threshold at room temperature for $f \geq 1$ Hz, and 5 Hz frequency corresponds to 86 meV energy.

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [M3], and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [M3].

The implication is that the transfer of energy between magnetic bodies and biological body could be major factor in metabolism. The question is whether the magnetic bodies provide metabolic energy for brain or utilize the metabolic energy provided by brain or both. Time mirror mechanism as a mechanism of intentional action would predict that magnetic body uses the metabolic resources of brain during intentional action. Together with the strange findings about ionic currents through cell membrane suggesting that ionic channels and pumps are actually ionic receptors and the ionic currents through them are only small samples about the net currents, this vision leads to a profoundly new view about brain metabolism.

The model for DNA as topological quantum computer led to a rather detailed view about magnetic body: in particular magnetic flux tubes connect bio-molecules and guarantee the spatial coherence of the biological body. One example of this coherence gel like behavior of the cell interior. The phase transitions changing Planck constant change the length of magnetic flux tubes and these phase transitions are excellent candidate for the basic mechanism of bio-catalysis. In longer scales this mechanism could provide the fundamental mechanism behind biological functions like locomotion. One could say that the motor actions of magnetic body realized as $\hbar$ changing phase transitions induces motor actions of biological body.

1.2   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.

1.2.1   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. The cyclotron frequency of O_2^- radical is 9.4 Hz in Earth's magnetic field: could it be that oxygen radicals provide the 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.

1.2.2 '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 and ZEG corresponding to $k_{em} = 1$ level of dark matter hierarchy. This kind of radio static has been indeed identified as I learned when building a model for taos hum [M5].

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 $k_{em} = 5$ level of dark hierarchy. This and the

fact that also short term memory corresponds to $k_{em} = 5$ encourages the interpretation that natural language and internal speech corresponds to signals communicated from $k_{em} = 5$ 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.

1.3 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 [M3]: 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.

To sum up, the flow diagram of this chapter is following.

1. The notion of topological self referentiality is introduced.

2. The model of bio-photons is proposed.

3. New view about metabolism and consciousness is developed.

4. A TGD based theory of molecular motors allowing to understand at deeper level the function of the membrane potential and the mechanisms generating nerve pulse and EEG waves, is constructed.

5. The basic philosophy about chemical communications as quantum counterpart of the email communications and about the quantum role of the neurotransmitters and information molecules as quantum links in a quantum web.

I have been forced to learn a lot of new things about the metabolism of brain and molecular motors during last months and weeks 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.

2 Background ideas

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. Reader can safely skip over this section at the first reading.

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

The attempt to understand homeopathy the framework provided by many-sheeted space-time [K5] 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 [K5]. 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 [K5]. 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 Z^0 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 [C8] as $\lambda = n$ where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C7]. 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. $n = 2^{11}$ obviously satisfies this condition. 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 $1/n_F$. There is a lot of evidence that the powers of $n = 2^{11}$ define preferred scalings of $\hbar$: n_F corresponds to $n_F = 2^{3 \times 11} \times 24$ which suggests that also the scale factors $n_F = 2^{k \times 11} \times 24$ could be favored. 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.

2.2 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.

2.3 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.

2.4 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. 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.

2.5   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.

2.6   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 guaranteing 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 metaphoral 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 [L5], which in turn inspired a model for protein folding [L7], 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.

2.7   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

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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.

3 General view about sensory representations, motor control, and brain metabolism

In this section the general after dark matter revolution vision about sensory representations, motor control, and brain metabolism is discussed.

3.1 General vision about living matter as a macroscopic quantum system

The following assumptions summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [63, 64] discussed in the article "Time, Space-time and Consciousness" in [17] and chapter [K1].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermionic ions in excited cyclotron states.

2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

   The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate

the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and memory differ only is that the time scale involved is different. Declarative memory corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

3.2 A general view about quantum control, coordination and communication inspired by dark matter hierarchy

The general vision about motor action is roughly the following. The dark matter hierarchy with levels labelled by the increasing values of Planck constant defines a hierarchy of intentional agents. Intentions are realized as p-adic space-time sheets transformed to real ones as intention is transformed to desire. Negative energy MEs serving as space-time correlates for dark photons and also dark variants weak bosons and gluons are good candidates for the representations of these desires. A natural guess is that the desires are communicated from given level of dark matter to the next level below it and ultimately the level of ordinary matter represented by the biological body is reached and the signal induces various neural and other activities realizing the desired motor actions. Each level has a lot of freedom to decide about the details of that part of motor action for which it is responsible.

Motor action is an iterative top-down process, a gradual build-up of a four-dimensional space-time statue representing the motor action starting from a rough sketch and adding gradually the details. This view is consistent with how we experience motor control: what happens is that we decide to move hand, rather than initiating consciously some complex neuronal activity in brain leading to the raising of the hand. We need not know how the motor action happens in order to initiate it.

The control signals from the magnetic body must enter to structures with high connectivity and very probably be very simple and symbolic. A reference wave generating complex hologram would be an over-simplified example about an initiator of a complex control action proceeding gradually to the lower levels of hierarchy by similar simple signals. Of course, some linguistic structure based on, say, amplitude modulation is required to avoid interference of the undesired signals with the bio-control. Various gap junction connected structures are

a good guess for the relay stations the control commands from the magnetic bodies. Thus gap junction connected neuron groups, astrocytes, and the walls of arteries and perhaps even capillaries are good candidates for receivers at the level of brain. At the level of body various organs, epithelial tissues, walls of arteries, and also skin could be the mediators of the generalized motor actions during sleep.

3.2.1 Dark matter hierarchy and motor control

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [M3], and from the implications of the model of DNA as topological quantum computer [L5, L7, L4]. Consider first general assumptions about how motor actions would be controlled from magnetic body.

1. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Neutral massless extremals could be responsible for signals related to control, coordination and communication. Also charged and colored MEs are predicted but their role has not yet been firmly established. Negative energy MEs would be related to motor control and positive energy MEs to communication of sensory data. Zero energy ontology, which has become the cornerstone of quantum TGD [C2, C3], justifies the notion of negative energy ME.

2. Magnetic body has an onion like hierarchical structure and its layers receive sensory information from biological body and perform motor control. The matter at the layers of magnetic body corresponds to the value of Planck constant which is so large that cyclotron energies are above thermal energy. A fractal hierarchy of analogs of EEG is involved with these communications. The frequencies involved correspond to harmonics of cyclotron frequencies for biologically important ions and to differences and sums of these with Josephson frequencies associated with Josephson junctions defined by the magnetic flux tubes carrying dark supra currents. Magnetic flux tube refers in the following to ordinary or "wormhole" magnetic flux tube since it is not yet clear which of them of these options if not both are realized [L5]. Flux tubes bind the biological molecules to a web-like structure and are responsible for the macroscopic quantum coherence of living matter.

3. Negative energy control signals from the magnetic body initiate topological quantum computation like processes whose outcome is expressed as four-dimensional self-organization patterns relying basically on gene transcription inducing motor responses in a very general sense. It is also possible that the outcome is expressed as an electromagnetic signal generated by intronic portion of the DNA representing a call of tqc subprogram. The experimental work of Peter Gariaev suggests that polarization coding of

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DNA sequences is involved with the sub-program calls and TGD provides a model for how this could take place [L5].

4. Harmonics of cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control. Differences and sums of harmonics of cyclotron frequencies and Josephson frequencies would be involved with communication of sensory data.

5. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures parallel to the cell membrane associated proteins serving as Josephson junctions. Also magnetic flux tubes parallel to axon serving as as templates for axons could define communication lines connecting cell membranes to the cellular magnetic body ($k_{em} = 2$ perhaps) Also synaptic contacts should involve similar magnetic flux quanta connecting them to neuronal magnetic body ($k_{em} = 3$ perhaps).

6. In DNA as topological quantum computer vision magnetic flux tubes as carriers of supra currents of dark variants of charged particles and connecting cell interior and exterior define braid strands. The quantum phase transitions changing the value of Planck constant and thus length of flux tubes would be fundamental building element bio-control in the scale of biological body and involved with both bio-catalysis and higher biological functions at nanoscale (molecular motors) and in the scale of cells and organs.

7. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism [M3]. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

There are also additional hypothesis which are natural in TGD framework but whose necessity is not yet clear.

1. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes in principle possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

2. Besides neutral massless extremals (MEs) TGD predicts also charged MEs obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). W ME would represent an exchange of virtual W boson giving rise to em current. Charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3]. The exchange of W bosons appears in an active role in TGD inspired model [F9] of cold fusion, biofusion [85], and plasma electrolysis [86]. The exchange of exotic W:s between nuclei would give rise to exotic nuclei. For instance, chemically equivalent bosonic counterparts of biological important fermionic ions such as Na^+, K^+, Cl^- could be generated and could form Bose-Einstein cyclotron condensates at magnetic flux tubes. Whether biologically important ions can have exotic nuclei having mass number differing from expected could be easily tested.

3. The second nonlocal quantum control mechanism relies on em charge entanglement. Charge entanglement could involve a superposition of pairs ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. The successful proposal for the protein folding code relying on the assumption that wobble base pairing corresponds to charge entanglement between quark and antiquark (superposition of uu_c and dd_c pairs forming a pion like state) at the ends of the magnetic flux tube connecting tRNA with $N - H$ group of amino-acid backbone [L7].

4. These nonlocal quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and in this manner make possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior and inducing voltage pulse generating DC supra current [M2]. Also remote mental interactions, in particular telekinesis, might rely on this mechanism. Of course, the interactions between magnetic body and biological body are essentially remote mental interactions.

3.2.2 What conditions the sensory projectors to the magnetic body must satisfy?

General constraints for a rather detailed and testable models for the hierarchy of sensory canvases (magnetic bodies) and for the system projecting sensory

data to it. An especially important new element is the model for the generation of ELF MEs acting as sensory projectors.

The projectors to the sensory canvas should satisfy several constraints.

1. Sensory projectors should correspond to magnetic flux quantum structures (tubes or sheets). The magnetic flux tube structures would be to those of Earth's magnetic field plus possibly those generated by the magnetic structures and would have fixed directions by anchoring to the large scale Earth's magnetic field.

2. Projectors must be able to bind neurally represented features to the point of the sensory canvas they project. Binding would be achieved the magnetic flux quanta traverse through synaptic contacts of a larger number of firing neurons.

3. There must exist a fixed frame of reference which does not rotate when head or body rotates or moves in the scale of magnetic body much larger than the corresponding body part. The directions of Earth's magnetic and gravitational fields fix naturally this kind of reference frame. Red blood cells and pyramidal cells are magnetic structures and define naturally compass needles allowing to construct sensory representation providing information about the orientation and configuration of the body with respect to this preferred coordinate frame.

4. The fundamental exterior-interior division of the sensory experience to the bodily sensations and percepts about external world or body as seen by external observer should correspond to fundamentally different sensory representations. Blood-brain barrier is an excellent candidate for the representation of this separation at the level of brain. Neuronal consciousness would represent outsider's cognitive view about the external world and body whereas blood consciousness would represent insider's view about body.

Astrocytes define the analog of a skeleton for neurons having endfeet to the synaptic contacts and might play key role in the binding. Hence astrocytes might act as higher level sensory organs integrating the sensory input of synchronously firing neuron groups. The myeliniation of axons by oligodendrites is usually regarded merely as an insulation allowing to achieve rapid neuronal communications through long distances. Myelin sheaths could also serve as sensory receptors scanning for nerve pulse activity along axon.

3.2.3 Communications and energy transfer at cellular level

The communication and energy transfer at cellular level could rely on Bose-Einstein condensed and coherent photons at the lowest level of dark matter hierarchy. MEs defining single sheeted covering of M^4 with lengths given by typical distance between red blood cells and ordinary cells would define the space-time correlates for these photons. The wavelength range involved would

cover visible wave lengths so that the identification as bio-photons [77, K4] might make sense.

At higher levels of the dark matter hierarchy MEs would have λ^k, $\lambda \simeq 2^{11}$ sheets, each of them carrying the energy $E = \hbar_0\omega$ of a visible photon, so that the relationships $E_k = \hbar(k)\omega = \lambda^k\hbar_0\omega$ would have a space-time correlate. Their decay to ordinary photons by de-coherence would produce λ^k ordinary photons. This would make possible coherent liberation of large amounts of energy and momentum.

Besides chemical signalling genuine quantum communication based on bound state entanglement between red blood cell colony and neurons can be considered. Charged entanglement induced by W MEs is one option and state function reduction of this entanglement inducing deviation from charge equilibrium could induce Ca^{++} waves just as it would induce nerve pulses. The blood cell colony, the activated synchronically firing group of neurons, and astrocytes could entangle to form single quantum system and communication would be a cellular variant of telepathy. The entanglement of the blood cells with the synchronically firing neuron groups could be crucial for the assignment of features represented by neuron groups to the points of the magnetic sensory canvases.

Charged entanglement between magnetic body of some gland and corresponding hormones carried by blood flow represents a possible example of quantum communications. Hormone would be like an old fashioned postman but the letters would contain quantum links to the quantum web. Nerve pulse transmission would be a more modern communication method involving electronic transfer along axons: postman mechanism would be realized only at synaptic contacts. Quantum links could ultimately refer to the primary sensory input at the level of sensory organs so that sensory input would be associated with cognitive mental images produced by the neural activity. Besides carrying the quantum links, neural transmitters would induce neuronal chemical qualia at the synapse.

3.2.4 Emergence of symbols at molecular level and new view about hydrogen bond, water, and bio-catalysts

The hierarchy of dark matter leads to novel ideas about what distinguishes living matter from ordinary matter. The emergence of symbols and symbolic dynamics and what might be called "molecular sex" could be a fundamental step in the process and I have considered two visions for how this would take place.

1. First vision

First vision is relies on the model of DNA as tqc based on braids and has quite close contact with empirical reality [L5, L4, J7]. In this case DNA nucleotides are analogous to colors of braid strands and base pairing corresponds to molecular sex for DNA molecules. The color of braid strand implies long ranged highly selective interactions between DNA and distant molecules, such as lipids of the lipid layer of cell membrane or amino-acids. Free amino-acids inherit the colors

of the first two nucleotides in the codon XYZ whereas the color of the third nucleotide corresponds to a quantum superposition of colors for codons coding for the amino-acid: this defines the quantum counterpart of wobble base pairing. Amino-acids can be divided into amino-acids and their conjugates analogous to opposite sexes and generalized base pairing determines the interactions of the amino-acids to a high degree. Hydrogen bond can be identified as a special case of flux tube. There are also flux tubes connecting acceptors of hydrogen bonds acting as plugs in the connection lines formed by the magnetic flux tubes and Y corresponds to this kind of plug at the level of amino-acids.

One of the implications is a code for protein folding [L7].

1. Hydrogen bonds play a key role in bio-catalysis but are not understood completely satisfactorily in the standard chemistry. Hence the basic question is whether hydrogen bonds can be regarded as or are accompanied by short (wormhole) magnetic flux tubes: note that the subject-object asymmetry of directed attention would correspond to donor-acceptor asymmetry of they hydrogen bond. If this is the case, the identification of the magnetic flux tube connection as a generalized hydrogen bond becomes natural. At least the atoms able to form hydrogen bonds could form flux tube contacts so that the model would be very predictive and would conform with the known important role of hydrogen bonds in bio-catalysis.

2. The fact that hydrogen bonds connect base pairs suggests a generalization of the notion of base pairing stating that under some conditions amino-acids coded by XYZ and UY_cV can behave like base pairs. These amino-acic pairs correspond to pairs of amino-acid residues which are hydrophilic *resp.* hydrophobic and hydrophobic residue do not form hydrogen bonds in general. These flux tubes would thus be more general and in general long. The model for DNA as topological quantum computer requires this kind of flux tubes and they would in general connect atoms or molecules which act as acceptors in hydrogen bonding: $O =$ atom in amino-acid and aromatic ring are basic examples.

3. If one assumes that both $N - H$ and $O =$ associated with the constant part of the amino-acid can act as flux tube terminals and represent Z and Y nucleotides of the codon XYZ coding for the amino-acid, one obtains $Y = Z$ pairing of $O = -O =$ flux tubes are allowed and $Y = Z_c$ pairing if only hydrogen bond like pairings are allowed. Direct check shows that $Y = Z$ pairing is surprisingly successful.

The phase transitions changing Planck constant change the length of flux tube and these phase transitions could be a main tool of bio-catalysis. The contraction of flux tubes connecting bio-molecules brings them near to each other and this explains why they are able to find each other in miraculous manner. Also a detailed understanding about DNA as topological quantum computer emerges [L5]: the acceptors of hydrogen bond (aromatic rings, $O =$ atoms, ...) serve as fundamental plugs at which flux tubes terminate and continue further.

Also a direct connection with the basic metabolic process $ATP \rightarrow ADP + P_i$ emerges: this process can be identified as temporary splitting of the flux tube implied by the reconnection process between the flux tube connection the $O =$ atoms of second and third phosphate of ATP and hydrogen bond connecting two water molecule. Flux tube connections would also provide an explanation for the properties of gel phase in cell interior and the phase transitions changing Planck constant would induce the phase transitions of gel phase (say gel-sol transition) [M2] suggested to be a basic mechanism behind various biological functions in molecular and cell scale [33].

2. Second vision

The mathematical realization for the hierarchy of Planck constants leads to a generalization of the notion of imbedding space and this leads to four kinds of phases resulting as combinations of phases with increased or reduced unit of spin and quantum numbers associated with CP_2 degrees of freedom. Each phase corresponds to its own Planck constant and is characterized by a discrete symmetry group.

Especially interesting are phases with a maximal value of Planck constant involving charge fractionization and increase of spin unit. The free electron pairs of aromatic cycle are reasonable candidates for dark electrons of this kind. This means that one can consider variants of hydrogen atom with a fractional electron charge and the obvious idea is that the values of fractional charge would define "names" and their "conjugate names". Thermal stability poses strong constraints since atomic and molecular energy scales are reduced as Planck constant increases.

The notion of fractional electron inspires the notion of "half" hydrogen bond for which electron has a fractionized fermion number. The full hydrogen bond would be formed in the fusion of half hydrogen bonds and give rise to a structure analogous to a full electron shell expected to be especially stable. Catalyst sites might correspond to half hydrogen bonds and the basic recognition mechanism could be the fusion of half bond and its conjugate to form a full hydrogen bond. One could speak about "molecular sex". The sequences of half bonds would represent words so that molecules would have names. Also interpretation as quantum computer codes might make sense.

The problem of this vision is the lack of direct contact with experimental facts and for this reason it will not be discussed in the sequel.

3.3 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.

3.3.1 Time mirror mechanism

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. 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.

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.

3.3.2   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 mechanism [K4]. 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 [82] 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 [K5]? 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. Besides electromagnetic plasma wave patters also classical Z^0 plasma waves are possible. What is intriguing that Z^0 plasma frequency of water corresponds to the basic metabolic energy quantum of .5 eV. 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.

3.3.3 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 [G2], 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 [26] 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:

$$B = H + M \quad , \quad D = E + P \quad , $$
$$H = \mu B \quad , \qquad D = \epsilon(E + P_0) \quad , \quad P = (\epsilon - 1)E + \epsilon P_0 \quad . \tag{1}$$

D clearly vanishes for the ground state.

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

$$M = M_0 + m(t) \quad , \qquad H = H_0 + h(t) \quad , $$
$$E = P_0 + e(t) \quad , \qquad D = \epsilon e(t) \quad , \qquad P = P_0 + p(t) = \epsilon P_0 + (\epsilon - 1)e(t) \quad . $$

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

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

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

$$e \;=\; -\frac{k}{\omega} \times b \quad , \tag{3}$$

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

$$
\begin{aligned}
i\omega m &= \gamma \left[M_0 \times h - H_0 \times m - \epsilon P_0 cos(\theta)b \right] \\
&= \frac{\gamma e}{M} \left[(M_0 - \epsilon P_0 cos(\theta))h - (H_0 + \epsilon P_0 cos(\theta))m \right] \quad .
\end{aligned}
\tag{4}
$$

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:

$$
\begin{aligned}
M_0 &\rightarrow M_0 - \epsilon P_0 cos(\theta) \quad , \\
H_0 &\rightarrow H_0 + \epsilon P_0 cos(\theta) \quad .
\end{aligned}
\tag{5}
$$

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

$$
\begin{pmatrix} m^x \\ m^y \end{pmatrix} = \begin{pmatrix} \chi & -i\kappa \\ i\kappa & \chi \end{pmatrix} \quad ,
$$
$$
\chi = \frac{\omega_0 \omega_1}{\omega_0^2 - \omega^2} \quad , \quad \kappa = \frac{\omega \omega_1}{\omega_0^2 - \omega^2} \quad .
\tag{6}
$$

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

$$
\begin{aligned}
\omega_0 &\rightarrow \gamma(H_0 + \epsilon P_0 cos(\theta)) \quad , \\
\omega_1 &\rightarrow \gamma(M_0 - \epsilon P_0 cos(\theta)) \quad .
\end{aligned}
\tag{7}
$$

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

$$
\mu = \begin{pmatrix} 1 + \chi & -i\kappa & 0 \\ i\kappa & 1 + \chi & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad ,
\tag{8}
$$

gives

$$
(1 + \chi)(\partial_x^2 + \partial_y^2)\Psi + \partial_z^2\Psi = 0 \quad .
\tag{9}
$$

For plane waves one obtains the dispersion relation

$$\chi sin^2(\theta) = -1 \ . \tag{10}$$

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

$$\omega^2 \ = \ \omega_0(\omega_0 + \omega_1 sin^2(\theta)) \ . \tag{11}$$

2. Dispersion relation for a pure electret

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

$$\omega \ = \ \frac{eg}{2M}P_0 cos^2(\theta) = \omega_L \frac{\epsilon P_0}{B} cos^2(\theta) \ . \tag{12}$$

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

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

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

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

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 [38] 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.

3.4 Some mechanisms liberating metabolic energy and connection with free energy phenomena

In this section possible mechanism liberating metabolic energy are discussed. All these mechanisms can be combined with time mirror mechanism.

3.4.1 Some mechanisms liberating metabolic energy

Several mechanisms liberating metabolic energy are possible and very probably many of them are important.

1. The dropping of ions from space-time sheet to a larger one liberates energy. The liberated energy is essentially the difference of the zero point kinetic energies associated with the space-time sheets. Zero point kinetic energy derives from Uncertainty Principle: the smaller the box where particle is forced to move, the higher the momentum uncertainty and the larger the zero point kinetic energy.

2. The ion dropped to a magnetic flux tube can have very high cyclotron energy gradually dissipated as ELF MEs when the ion drops from the cyclotron state with magnetic quantum number $n \simeq f_h/f_{ELF} >> 1$ by a stepwise process $n \to n-1 \to n-2...$ to the ground state. The energy liberated in this process can be utilized by magnetic bodies at various levels of dark matter hierarchy. The mechanism is emission of negative energy dark photons inducing a coherent dropping of ions to lower cyclotron states. Magnetic bodies could share a considerable portion of metabolic energy used in brain.

3. A variant of this mechanism involves dropping of a photon BE condensed at ME parallel to a linear structure and having a frequency frequency which is multiple of f_h to a magnetic flux tube transversal to the linear structure and its absorption by a super-conducting ion. Also this mechanism generates ELF MEs with a fixed f_h/f_{ELF} ratio for a given ion at the super-conducting magnetic flux tube.

3.4.2 Liberation of metabolic energy via the formation of bound states

The formation of bound states liberates also energy. At the level of conscious experience the formation of bound states corresponds to a fusion of mental images to higher level mental images and a loss of consciousness at the level of fusing selves. Sharing of mental images corresponds to fusion of sub-selves of two unentangled selves to single sub-self. The sharing of mental images is allowed only by the TGD based definition of subsystem relying on the notion of length scale resolution. For instance, the fusion of left and right visual fields to single visual field would give rise to stereo vision in this manner.

Binding energy could be liberated as coherent photons at some level of the dark matter hierarchy and utilized for metabolic purposes. The beautiful aspect of this mechanism is that the liberation of metabolic energy is accompanied by the generation of higher level mental images, and the higher the amount of energy liberated, the longer lasting the mental image is. The value of Planck constant is even more important since the de-coherence time is expected to be proportional to $\hbar$.

1. Gravitational binding energies for blocks of water in the biologically most interesting length scale range $L(151) = 10$ nm–$L(167) = 2.5$ μm correspond to frequencies in ELF range. The immense spin glass degeneracy implied by space-time surfaces differing only by classical gravitational energy encourages to think that the generation of gravitationally bound states generates ELF MEs. The objection is that the energy of one ELF ME is quite too low and that one needs large number of ELF MEs to achieve statistical reliability for the sensory representations.

2. The role of the metabolism in the generation of the bound state entanglement suggests that the natural energy scale is in the range of molecular and atomic binding energies. Bound state energies are typically measured in electron volts from the bond energy of hydrogen bond. At DNA level the generation of hydrogen bonds correlate gives rise to generation of projector MEs. If so, hydrogen bonds connecting blood and cellular liquid to cluster would be responsible for the generation of the hydrogen bonds. This is consistent with the idea that water liquid crystals amplify and represent. There is however no obvious mechanism for the generation of ELF MEs.

3. The formation of water clusters is also a good candidate for the mechanism generating bound states and could play crucial role in the metabolism. The binding energy .485 eV of hydrogen bond which is very near to the energy associated with the p-adic length scale $L(163)$ is expected to define the length of ME generated in this process. This process could be especially important at DNA level.

3.4.3 Liberation of zero point kinetic energy in dropping of ions to larger space-time sheets as a source of metabolic energy

In TGD the simplest manner to liberate usable energy is the dropping of ions from the atomic space-time sheets to super conducting space-time sheets. Since the difference of the zero point kinetic energies is inversely proportional to the mass of the ion, proton is optimal in this respect. The energy liberated when the proton drops from the atomic space-time sheet to much larger space-time sheet is about $3\pi^2/2m_p a^2 \simeq .4932$ eV for $a = L(137) = L(151)/128 = .78$ Angstrom and very near to the metabolic energy liberated when single ATP molecule is utilized. This energy is also amazingly near to the energy $E = 2\pi/L(163) = .4921$ eV defined by the p-adic length scale $L(163)$ defining one of the miracle length scales associated with Gaussian Mersennes. With the scaling $L(151) = 10$ nm $\rightarrow xL(151)$, $x = 1.002$, allowed by experimental uncertainties these energies are identical.

The dropping of the protons from the atomic to the super-conducting space-time sheets explains also the strange findings of Irving Langmuir [88] and the the over unity energy production in water hydrolysis (also involved with the utilization of ATP!). In the generation of single ATP molecule 3 protons are accelerated in the electric field generated by the liberation of the metabolic

energy. These observations do not leave much freedom of choice: the flow of protons between super-conducting and atomic space-time sheets is the basic mechanism of the energy economy in the living matter: energy is liberated when the proton drops to the atomic space-time sheet and the charging of the energy batteries means that the protons are kicked back to the atomic space-time sheets.

Fractality suggests that also other ionic flows define similar cycles in smaller energy scales and ATP cycle takes only care of the most roughest energy metabolism. For instance, the dropping of Ca^{++} ion would give rise to energy of in various biologically important ions would liberate energy of about .01 eV if proton liberates energy of .5 eV. The corresponding photon wave length is about 100 microns. The excitation of high n cyclotron states is possible also now and the generation of ELF MEs at multiples of cyclotron frequencies could give rise to sensory representations and contribute to EEG.

3.4.4 Connection with free energy anomalies

1. Anomalies discovered by Langmuir

The first class of anomalies is known more than a century and were discovered by the nobel chemist Irving Langmuir [88] while developing the first electric lamps based on electrode consisting of tungsten wires. Langmuir made three discoveries which have been forgotten since then, perhaps because they are very difficult to understand in the framework of existing chemistry.

1. The first observation was that the heating of tungsten wire in vacuum to get rid of the gas inside it liberated practically unlimited amount of gas. Langmuir stopped the process when an amount of gas equivalent with 7000 volumes of tungsten wire had been evaporated. The question Langmuir posed himself was 'Where this gas comes'. I do not know whether Langmuir found any satisfactory answer but a very attractive possibility is that the heating allows the transfer of gas ions from super-conducting magnetic flux tubes to the atomic space-time sheets. This would indeed imply that the tungsten wire could act as effectively endless source of gas.

2. The second observation of Langmuir was that the energy liberated in the electrolysis of water to hydrogen and oxygen in presence of electric current in electric voltage in Volt range liberated energy which was by a factor of order 10^3 higher than the energy deduced from the binding energy of the hydrogen molecule. This suggests strongly that the electrolysis somehow generated bound states and that binding energy was liberated. The simplest explanation would be the dropping of ions to the magnetic flux tubes by a process in which they emit the difference of zero point kinetic energies for initial space-time sheet and magnetic flux tube as the kinetic energy as a photon emitted in the process. The energy could also be liberated when the magnetic field penetrates to matter, say metal, implying that the hydrogen atoms collide with the atoms of the metal. The

basic function of the electric voltage and electron current in this process would be the splitting of the bonds binding hydrogen to the water.

One can consider also the possibility that the binding of the hydrogen atoms to hydrogen molecules did not occur as two-particle process but involved the formation of water clusters and the liberation the binding energy.

Similar process might be involved with the generation of ATP which involves acceleration of hydrogen ions in membrane potential. Therefore the energy liberated in generation of ATP would be many orders of magnitude higher than expected and could give rise to generation of bound states as well as generation of MEs projecting to the sensory magnetic canvas.

3. The third strange observation of Langmuir was that the heat conductivity of the hydrogen gas created in the lamp was anomalously high. This could be understood if the hydrogen atoms or ion propagating along magnetic flux tubes during the conduction of the gas hydrogen ions liberated their energy when the magnetic field penetrated to a target material forcing hydrogen atoms to collide with the atoms of the material.

2. Strange properties of Brown's gas

There is also a connection with the strange properties of the so called Brown's gas discovered by Prof. Yul Brown [89]. Brown's gas results in the electrolysis of water using electric current running between oppositely charged plates in a voltage which is below 1.7 V. What is believed to occur is the electrolysis of water to oxygen and hydrogen atoms. The flame of hydrogen resulting in the electrolysis appears to have low temperature. When the flame is directed to a metal, it melts and one of the applications is welding of metals. The temperature of the metal remains the melting temperature during the melting. The process involves a liberation of energies which are several times higher than expected on basic of the binding energy of hydrogen atoms to oxygen and the electric power fed to the system.

The TGD based explanation would be that hydrogen atoms and/or ions drop at larger space-time sheets such as magnetic flux tubes of Earth and get additional kinetic energy as the increment of the zero point kinetic energy resulting from the localization inside space-time sheet. The estimates for the molecular weight of Brown's gas are consistent with the molecular weight of H_2O but also with the atomic weight of oxygen in a good approximation. If Earth's magnetic field penetrates to the atomic space-time sheets of the metal, then the hydrogen atoms flowing along magnetic flux tubes enter to the atomic space-time sheet of metal and collisions with the atoms of metal lattice occur and heat it and induce a phase transition leading to the melting of the metal. The liberation of the zero point kinetic energy means effective over-unity energy production in case that the ions at the magnetic flux tubes interact with a matter with the binding energy being liberated. If this interpretation is correct, living matter

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would construct the sensory representations using the same mechanism that explains the strange properties of Brown's gas.

3. Biefeld-Brown effect

Also Biefeld-Brown effect allows explanation as a recoil effect in many-sheeted space-time. For long time ago T. T. Brown observed [90, 91, 92] that when capacitor plates are loaded with opposite charges by coupling the capacitor to a voltage source, it jumps to the direction of the second plate. The magnitude of the effect depends on the voltage and begins to decrease above some critical voltage and eventually changes its sign. What is strange is that neither energy nor momentum conservation do not seem to hold true if one assumes that only electric energy is liberated: momentum and energy simply seem to appear from nowhere.

The explanation is in terms of a recoil effect in many-sheeted space-time. When the voltage is coupled on, the ions with opposite charges rush to the capacitor plates. By their inertia some of them leak to larger space-time sheets (the mechanism of auroras and breakdown of super-conductivity is essentially the same [J3]). The difference of the binding energies is liberated as additional kinetic energy and momentum of the dropped ion and the recoil momentum is obtained from the elementary text book formulas $E_f = E_i + \Delta E$, $E = p^2/2m$ as

$$\Delta p = -p_i \left(\sqrt{1 + \frac{\Delta E}{E_i}} - 1 \right) \ ,$$

where ΔE denotes the difference in zero point kinetic energies for a charged particle of mass m and subscripts i and f refer to initial and final states of the charged particle. These recoil momenta are absorbed by the entire system and give rise to a recoil effect if the recoil momenta from the plates do not exactly compensate each other. This is not expected to happen since the positive and negative charge carriers have widely different momenta due to the widely different masses and different velocities.

For definiteness assume that there are only electrons and ions of single type; that they drop to single space-time sheet only; and that capacitor plates have opposite charges during loading so that ionic and electronic currents are of opposite sign at the capacitor plates during loading. Under these assumptions the ratio of the momenta is

$$\frac{p_i(e)}{p_i(I)} = \frac{m_e n_I}{m_I n_e} \ ,$$

where $n(e)$ $(n(I))$ refers to the density of the electrons (ions). Combining this with the previous equation, one has

$$\frac{\Delta p(e)}{\Delta p(I)} = -\frac{m_e n_I}{m_I n_e} \frac{\left(\sqrt{1 + \frac{\Delta E(e)}{E_i(e)}} - 1 \right)}{\left(\sqrt{1 + \frac{\Delta E(I)}{E_i(I)}} - 1 \right)} \ .$$

When several ions are present, one must construct a more elaborate model. Also an effect tending to change the mutual distance of the plates is predicted.

The effect is proportional to the charge of the capacitor plate and thus to the voltage but depends on voltage in nonlinear manner. since the recoil momenta due to electrons and ions depend on non-linear manner on voltage. The change of the sign of the effect when voltage increases should be due to the fact that the velocities gained by ions and electrons depend on the voltage in different manners. The electronic band structure of the conductor could play an important role in the effect.

This mechanism is obviously ideal mechanism of locomotion in living matter and it would be surprising if bio-systems would not have invented it.

3.5 ATP and TGD

Adenosine-tri-phosphate (ATP) is usually seen as a universal energy currency molecule of cell (for excellent popular article see [46]). ATP is critical for all forms of life. ATP is involved with transport work (e.g. the transport of molecules along micro-tubuli) and mechanical work (muscle contraction and movement of flagellae and chromosomes). The major role of ATP is however related to chemical work. ATP serves also as a switch: by bonding to a protein and receiving or giving phosphate to a protein ATP molecule can induce a conformational change of protein leading to its activation or inactivation.

The basic processes involved are charging and discharging of the ADP molecule by phosphorylation and its reverse process (according to standard view: TGD view is somewhat different). Many aspects of the ATP functioning are far from being completely understood and there are real mysteries, if not paradoxes, involved. One of them is how the process inducing ATP mediated energy transfer is accompanied by momentum transfer giving rise to a coherent locomotion. TGD based view about bio-control as an ionic flow equilibrium in many-sheeted space-time suggests a new ideas about the basic mechanisms of the energy and momentum transfer and ionic super-conductivity allows to understand the mystery of coherent locomotion.

3.5.1 The structure of ATP

ATP contains the purine base adenine, which is one of the DNA nucleotides, and the sugar ribose which together form the nucleoside adenosine. ATP consists of carbon, hydrogen, nitrogen, oxygen and phosophorus assembled to a complex with an atomic weight about 500. One phosphate esther bond and two phosphate anhydrite bonds hold the three phosphate groups (PO_4) together whereas b-N glucocide bond binds the ribose and adenine together. Phosphates are called high-energy molecules which means that the transfer of the phosphate group is believed to be accompanied by a large energy transfer. The energy transferred is the typical energy used in biological reactions so that very little energy is wasted.

The energy liberated in the dephosphorylation of the client molecule receiving the ATP energy must be small and the un-stability of ATP means that the same must be the case for ATP. If this picture is correct, the phosphate bond could thus be visualized as a potential well whose bottom is at the the zero level of the potential outside the well: jail rather than well would be in question. ATP is fabricated and used only when it is needed. This means that ATP is coupled to an ATPase enzyme complex usually catalyzing also the chemical reaction using the energy of ATP. The phosphate group is transferred by hydrolysis to another compound in this process.

ATP has also variants in which adenine is replaced by some DNA nucleotide (thymine, guanine, uracil, cytocine). These energized forms of DNA nucleotides are however produced from ATP by transferring the phosphate group to the appropriate nucleotide.

3.5.2 ATP as a universal energy currency

All biological energy is utilized with the mediation of ATP believed to serve as a universal 'energy currency'. For instance, the ATP produced in plants by photosynthesis is transformed to carbohydrates taking care of long term energy storage and animals transform the carbohydrates back to ATP by oxidizing it in the respiration process. The reader might recall from her school days that the first process uses CO_2 and water whereas the latter produces CO_2 and water besides ATP.

The charging of ADP (adenosine-di-phosphate) to ATP battery is achieved by phosphorylation, that is the addition of a phosphate molecule to ADP. This can proceed by several mechanisms: by photo –, oxidative –, and substrate level phosphorylation. In prokaryotes phosphorylation occurs either at the cell membrane or in the cytosol. In prekaryotes phosphorylation occurs in chloroplasts (plants) or in mitochondria (plants and animals). Viruses are not able to manufacture their ATP themselves.

Chemi-osmotic phosphorylation in the mitochondria or chloroplast membrane and also the phosphorylation in bacteria at cell membrane involves generation of electronic charge in region between membranes followed the acceleration of the hydrogen ions in the electric field associated with an appropriate membrane structure, and is followed by the transfer of the protonic energy to enzyme ATPase, a molecular analog of a rotating water wheel in which phosphate groups are added to ADP [47]. About 3 hydrogen ions provide their energy to the build-up of the ATP molecule [48]. This wheel (or perhaps Karma's wheel might be a better metaphor!) has three active sites to which phosphate groups can bind. Under optimal conditions the wheel rotates 200 cycles per second so that 600 ATP molecules result. The protonic current from membrane is thought to keep this wheel rotating.

The dis-charging of ATP means the transformation of ATP back to ADP by giving one phosphate to the substrate molecule receiving the energy. When power consumption is exceptionally high, ATP can give off two phosphate groups and thus end up to AMP (adenosin-monophosphate).

To get a quantitative grasp about what is involved, it is useful to have some numbers. Each of the about hundred trillion human cells contains about billion ATP molecules (the total number of ATP in the body is about 50 grams) and for each ATP the terminal phosphate is added and removed 3 times each minute [49]. If this basic process stops for only few minutes, death follows. The energy transferred by single ATP is about $E = .49$ eV and corresponds with one per cent accuracy to the energy of photon with wave length equal to $L(167)$, one of the four miraculous biologically important p-adic length scales associated with the Gaussian Mersennes.

3.5.3 The hard problems of the existing scenario

Despite its unique role in biology the understanding of the functioning of ATP is not yet completely understood.

1. Challenging the notion of phosphate bond

Personally I find the identification of the high energy phosphate bond as energy battery as confusing. I am not the only one who finds the existing theoretical picture in-convincing: the very notion of the higher energy phosphate bond has been questioned on empirical grounds [50, 53, 54].

2. How coherent locomotion is possible?

The understanding of how the momentum is transferred coherently so that all parts of an entire macro-molecular structure, organelle or organ move in the same direction is perhaps the hardest one of the problems involved. To realize how hard this problem actually is, it is enough to recall that we have hundred trillion cells and each cell contains about billion ATP molecules. Hundreds of billions chemi-osmotic phosphorylation process generating momentum with *same* direction must occur simultaneously. It is hardly an exaggeration to say that the occurrence of this kind of process in the framework of the standard chemistry looks highly improbable and it is strange that there are still those who quite seriously claim that macroscopic quantum coherence is not needed to understand the functioning of the living systems.

3.5.4 Hydrolysis of ATP in TGD universe

The generation of phosphate polymers and polymers in general occurs by de-hydration which quite generally seems to involve dropping of a proton to larger space-time sheet and liberation of metabolic energy quantum. It is interesting to find how one could understand these processes in TGD framework. Since the notion of wormhole magnetic flux tube playing a central role in the model of DNA as topological quantum computer and in the model of bio-catalysis, it is natural to look whether the basic steps of these processes could be understood in this conceptual framework.

1. ATP→ ADP process

AMP, ADP, ATP are phosphorylated RNA nucleosides [46] and the hydrolysis of ATP to ADP [28] plays a key role in the metabolism. Obviously also

the molecules XMP, X=U,C,G are important biologically. Each PO_3 in ATP corresponds to one unit of negative charge except for the last one which carries two units of negative charge. According to the standard chemistry ATP$\leftrightarrow$ ADP corresponds to the hydrolysis

$$ATP^{4-} + H_2O \leftrightarrow ADP^{2-} + P_i$$
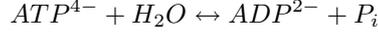
where P_i denotes orthophosphate HPO_4^{-2}. In ADP the last phosphate group is $HO - PO_2^{-2}$ rather than $O = PO_2^{-2}$ as in case of ATP.

The actual process is however much more complex than this.

1. The process involves several steps such that energy is liberated in two steps in which the change of Gibbs free energy is $\Delta G = .42$ eV and $\Delta G = .31$ eV making altogether .73 eV, which should closely relate to the liberated metabolic energy.

2. Three protons are accelerated in electric field during the generation of ATP. The interpretation would be in terms of driving of electrons from larger space-time sheet to $k = 137$ atomic space-time sheet. If the larger space-time sheet corresponds to $k = 139$, the increment of the zero point kinetic energy of proton is $(1-1/4) \times \times E_0(137) = .375$ eV for $E_0(137) = .5$ eV of metabolic energy quantum. Three protons would give net zero point kinetic energy increment of 1.125 eV which is higher than $\Delta G_{tot} = .73$ eV. The explanation of the discrepancy should relate to Coulombic binding energy of protons with ATP and F_1. This interpretation conforms with the observation that the liberated energy is higher for the third proton. It must be emphasized that one can imagine several alternative explanations.

Consider now a more detailed model for the process. The binding of ATP to the catalytic site involves several steps.

Step 1: The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves liberation of Gibbs free energy about $\Delta G_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [45].

Step 2 Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Step 3: Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Step 4: ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

This picture suggests that the notion of the high energy phosphate bond is not quite correct as suggested also by some empirical findings [50, 53, 54]. The metabolic energy would be stored as the zero point kinetic energy of protons rather than in phosphate bonds. Perhaps the fundamental function of phosphates would be to make DNA and RNA polymers charged in turn making possible the formation of wormhole magnetic flux tubes and braiding making possible a wide repertoire of catalytic actions.

2. Model of $ATP \rightarrow ADP$ based on wormhole magnetic flux tubes

Consider first the basic philosophy behind model.

1. In the model of DNA as topological quantum computer XMPs, $X = A, T, C, G$ can be connected to oxygen atoms by wormhole magnetic flux tubes having quark and antiquark at opposite throats of wormhole contact and charge conjugated quark-anti-quark pairs at the ends of the flux tubes. Dark u quark and its charge conjugate code for A, T and d quark and its conjugate for G, C so that the conjugation for nucleotides corresponds to charge conjugation for quarks and $A - G$ and $T - C$ symmetries of the third nucleotide of the codon to isospin symmetry.

2. Basic bio-catalytic processes are identified as a reconnection of the wormhole magnetic flux tubes and change of the length of the flux tube induced by the change of the value of Planck constant associated with it. It would not be too surprising if this kind of mechanism were involved also in $ATP \rightarrow ADP + P_i$. The reason for the special role of ATP among XTP might be that the positive charge $q(u) = 2/3$ of u-quark maximizes the attractive interaction between u quark and phosphate.

3. Flux tubes connect to oxygen atoms in the proposed model of bio-catalysis and protein folding [L7] . The model is relies on ideas inspired by the model of DNA as topological quantum computer [L5]. In this model hydrogen bonds are assumed to correspond or to be accompanied by (wormhole) magnetic flux tubes. Also flux tubes connecting acceptor atoms or molecules of hydrogen bonds are assumed to be connected long flux tubes and represent genuinely new physics. Examples of acceptors are $O =$ atoms in phosphates and amino-acids and aromatic rings in DNA and also in some amino-acids. The model for protein folding has tight connections with existing chemistry and leads to a very simple and successful criterion for the formation of hydrogen bond between $N - H$ and $O =$ in the constant part of amino-acid and to a successful proposal for the folding code.

4. DNA as tqc model gives further constraints. The structure of the phospholipids suggest that in the case DNA nucleotides long flux tubes connect the aromatic ring of the nucleotide to the $O =$ atom at the hydrophilic end of the lipid acting as a standard plug which in turn can be connected to another acceptor and eventually terminates to a donor of hydrogen bond.

The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide. Not surprisingly, phosphorylation would be absolutely essential for the operation of DNA as topological quantum computer. $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer.

A possible model (perhaps the simplest one found hitherto) for the reaction ATP$\rightarrow$ ADP+P_i is based on the assumption that it splits a flux tube connection defining strand of a braid defining topological quantum computation. A change of the hardware of topological quantum computer would be therefore in question.

1. Suppose that ATP defines a standard plug in flux tube connections. This would mean that aromatic ring and the oxygen atoms $O =_1$, $O =_2$, and $O =_3$ of the phosphates are connected by magnetic flux tubes to a string and $O =_3$ in turn is connected to some (hydrogen bond) acceptor elsewhere, say $O =$ or aromatic ring. These flux tubes represent genuinely new physics in accordance with the fact that "high energy phosphate bonds" are not really understood in the standard chemistry.

2. The reconnection of $(O =_2) - (O =_3)$ flux tube with the hydrogen bond connecting two water molecules leads to the splitting of the flux tube so that the incoming and outgoing the flux tubes are shortcut by $(O =_2) - -H - (OH)$ *resp.* $(O =_3) - -H - (OH)$ hydrogen bonds (connection to ground is the analog in circuit theory). This corresponds in the usual terminology the liberation of the third phosphate: ATP$\rightarrow$ ADP+P_i. P_i however remains at the end of flux tube to be attached later to another ADP.

3. The process involves also hydration. $(OH)^-$ ion joins to the third P to give P_i^{-3} and H^+ to $O - P$ in second P to give $H^+ - O$ in ADP^{-1}. The exchange of electron would lead to the final state $ADP^{-2} + P_i^{-2}$.

A possible model for the dropping of protons would be following.

1. It is absolutely essential to realize that F_1 is an open system and that naive thermodynamic considerations can lead to misunderstandings. In particular, the notion of high energy phosphate bond does not make sense. The source of metabolic energy is chemical energy used to drive protons to the atomic space-time sheets of F_1. The function of the large negative charge of ATP is to increase the rate for the binding of ATP^{-4} to F_1. In the classical picture the binding to F_1 is followed by the dropping of two protons to larger space-time sheet. The value of the metabolic quantum could be

reduced from .5 eV to about .21 eV by the Coulombic interaction energy of proton with PO^{4-}. The Coulombic binding energy of the remaining protons at F_1 with $ADP + P_i$ is smaller and the dropped proton liberates larger energy about .31 eV. In quantum picture the division of the process to this kind of sequence might not be a good approximation.

2. One function of the ATP $\rightarrow$ ADP would be to induce the dropping of the third proton from F_1 space-time sheet. Metabolic energy should make possible information processing. Second function might indeed relate to the topological quantum computation like process since the decay would correspond to a splitting of a braid strand coming to the aromatic ring of A and proceeding along string defined by the ring and three O =:s of phosphates and continuing further. This would make possible tqc as a braiding for both halves of the split flux tubes. After the reconnection the total braid structure would be different.

3. The reason for why P_i leaves the catalyst site and proton is dropped (step 2) should be the in-stabilization of the bound state of positively charged proton with $ADP^{-2} + P_i^{-2}$ which does not have so strong Coulomb interaction energy with proton as ATP^{-4} As a consequence, proton can drop to the larger space-time sheet.

4. What remains open are the details of the transformation of the chemical energy to zero point kinetic energy of protons. Remote metabolism suggests that protons send negative energy phase conjugate photons to the direction of geometric past inducing a transition of an energy carrying molecule to a lower energy state. This would mean the failure of the standard description in terms of reaction kinetics. The catabolism of nutrients is the eventual provider of the metabolic energy and the coenzyme nicotinamid adenic dinucleotide NAD^+ [29] receives electron and the energy liberated in the catabolic reaction. In the proposed framework it is not an surprising that NAD^+ is analogous to RNA dinucleotide (perhaps as remnant from RNA era when dinucleotides defined the 2-codon code) and consists of two phosphates and adenine and nicotinamide nucleosides. The oxidation reaction $NADH \rightarrow NAD^+$ in turn liberates this energy. Protons could gain their energy by sending negative energy photons to $NADH$. Negative energy photons would propagate along "topological light rays" parallel to the flux tubes connecting the system in a precisely targeted manner to NADH aromatic rings. Alfwen waves propagating along magnetic field lines would be the standard electrodynamics counterpart for these topological light rays.

Many details of the process remain open but it would seem that the key ideas of TGD based quantum vision about living matter are fused together in rather detailed manner in this picture.

4 A model of metabolism and 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 nonlocal liberation of usable energy and represents a new kind of metabolism involving time mirror mechanism 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 [33]) 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 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 [66, 67]. 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 Z^0 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 the Z^0 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 About metabolism in general

I summarize the basic facts about blood circulation and red blood cells in the hope of helping the non-biologist reader to get overall view. I hope that the non-professional style of the representation and the unavoidable in-accuracies do not irritate biologists. I introduce also some strange findings and propose how quantum view could allow to understand them.

4.1.1 Cellular respiration

Mitochondria act as power plants of the animal cell. Mitochondria are coded by their own DNA and the DNA is inherited from mother and thus not copied in cloning. If mitochondria contribute to consciousness, as one might suspect, then clones do not experience the world in a similar manner.

ATP is the universal energy currency and TGD based model for ATP generation will be discussed later. Suffice it to say that the energy is transferred to ADP by phosphorylazing it in the presence of a suitable ATPase enzyme which usually also catalyzes the transfer of the phosphate molecule from ATP to the client molecule.

Cellular respiration is the basic metabolic process in animals whereas in plants photosynthesis replaces cellular respiration and allows plants to produce glucose used by animals for their metabolism. The basic formula for the respiration is familiar from school days: $C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ and tells that one glucose molecule is transformed into carbon-dioxide and water and gives in this process the energy stored in it in the photosynthesis. The actual process is however considerably more complex than this oversimplified representation suggests. There are several forms of cellular respiration. Glycolysis is anaerobic respiration mechanism and converts glucose to pyruvate (in particular in neurons and glia). 2 ATP molecules per one glucose molecule are produced and this is enough for the continuation of the glycolysis which itself requires some energy.

Aerobic respiration involves a further processing of pyruvate which is transported to the mitochondria where it is used in Krebbs cycle for synthethizing the high energy compounds whose oxidation leads to the generation of ATP. This process is possible only if cell receives oxygen from blood flow. 30-35 ATP molecules per one glucose molecule are produced in this process [72]. Also fats function as energy reserves: when oxidized they produce 9 times higher energy yield than pyruvate molecules but the rate of the process is slower by a factor of 1/8. Brain does not utilize fat as an energy reserve: rather, astrocytes store the energy reserves of glucose to glycogen which they both synthesize, store, and catabolize.

Lactace and alcohole fermentation represent further anaerobic respiration mechanisms. Lactace fermentation is utilize by muscle cells and after maximal exercise the overproduction of the lactate acid is responsible for the characteristic muscle pain. Some plants utilize alcohole fermentation.

4.1.2 Blood circulation

Blood circulation could be regarded as a logistics of the living system. Logistics involve the delivery of both energetic and structural components such as glucose molecules, oxygen, and proteins. Blood circulation supports a chemical signalling system based on hormones. Blood acts as a buffering system based on phosphates and proteins and has defensive functions similar to those of immune system. Blood serves also as a reservoir of body heat and blood flow can control the body temperature by convection and conduction mechanisms.

There is a strict separation of the oxygenated and de-oxygenated blood corresponding to pulmonary and systemic flows. The first type of blood vessels are arteries which have walls consisting of smooth muscles which can constrict and dilate and in this manner control the rate of the blood flow. The rate of blood flow depends also on its velocity controllable by the rate of the heart beat. Blood flow is known to be controlled both by hormonal and neural control mechanisms.

Besides arteries there are capillaries which have walls consisting of single layer of cells, endothelium. Capillaries lack the smooth muscle so that the flow to the capillaries must be regulated by precapillary spincters containing smooth

muscle and joining arteries to capillaries: their dilation or constriction controls the flow into the capillary. The basic mechanism for transferring molecules from capillaries to cells is diffusion. Lipid soluble molecules like oxygen and carbon monoxide diffuse through cell membranes automatically whereas water soluble molecules can diffuse only through pores. The size of the pores varies and in brain the pores are very small so that blood brain barrier results.

Oxygen is bound to hemoglobin which is a tetramer of four identical myoglobin proteins. Red blood cells transfer the hemoglobin near cell and oxygen diffuses through the wall of the capillary and through the cell membrane to neuron and eventually reaches the mitochondria. Glucose is the energy carrier molecule transferred by blood and glycolysis and aerobic cellular respiration transform the energy stored in the glucose to ATP.

4.1.3   Red blood cells

Red blood cells, being carriers of oxygen, are expected to be especially important for consciousness. Being not a professional biologist I freely use the popular article [35] in which besides standard facts also the importance of red blood cells and astrocytes for consciousness is also advocated.

Some poorly understood aspects of the blood flow support the idea that blood behaves like a coherent conscious unit under some conditions.

1. The first, already mentioned, mystery is that a heightened neuronal activity induces a rush of blood cells to the neurally active regions but is accompanied by a very low oxidative metabolism.

2. Second mystery is how the signal about the need for the increased blood flow is mediated to the pre-capillaries to relax smooth muscle when blood is needed. Signalling is up-stream and signalling mechanisms based on the diffusion of chemicals like NO, CO_2 and protons, extracellular K^+ and purines have been proposed but no consensus about the mechanism has been reached. An alternative mechanism is based on direct communication to an appropriate magnetic body which in turn would perform the needed motor action.

3. A further mystery is that red blood cells exhibit a coordinated group response to threats [37]. In light of this the observation that sea stars have a hemal system with no obvious function and, although possessing no brain, are capable of displaying rather refined intelligent behavior [35], is rather suggestive.

With these observations as a context, it is interesting to try to interpret basic facts about blood flow.

1. Red blood cells are distinguished by their unique role in the oxygen transport and by their anaerobic metabolism (it would not make sense for red blood cells to consume oxygen molecules!). Red blood cells exhibit many

characteristics of prekaryotes and might be called metakaryotes: indeed, at some stage of development mammalian red blood cells eject their nucleus and organelles. It has been found that neural cells can be trained to become red blood cells, which supports the view that the role of blood flow is more than mere logistics. Red blood cells are the only cells which are unable to divide and become cancerous.

If one takes seriously the proposal that magnetic bodies perform quantum control through magnetic flux sheets traversing genomes and receive sensory input via flux quanta associated with proteins traversing cell membranes, this means that red blood cells would communicate only somatosensory input to the respective magnetic body and magnetic and motor control performed through them would be very primitive: perhaps control of motion of blood cell.

Blood cells would correspond to $k_{em} = 1$ level of dark matter hierarchy assigned to prokaryotes. $k_{em} = 1$ and flux quantization for planar flux sheets of thickness $L(169) = 5$ μm, lower bound for the size of cell nucleus, would give length of $\lambda L(169) = 5$ cm for $\lambda \simeq 2000$. Blood cells could perhaps organize to thread like structures parallel to the blood veins.

2. Red blood cells and their hemolymphatic counterparts contain iron and are good candidates for magneto-receptors [69, 70]. The orientation of the magnetic structures with Earth's magnetic field and the fact that liquid codes the direction of the gravitational field to pressure gradient define a good candidate for a preferred coordinate system used already by honeybees containing magnetite and ferritin in their abdomens [32]. Red blood cells could serve as compasses and code for the orientation of the body with respect to the magnetic field and gravitational fields and a grid of blood cells could code for the local variations of the magnetic field making possible navigation using magnetic field. This information could be represented at the $k_{em} = 1$ somatosensory magnetic body assignable to the blood flow.

3. The velocity of the blood flow in capillaries is about mm/s so that scaling law gives $f = v/L = 1$ kHz, which happens to be the kHz frequency of neural synchrony.

4. Red blood cells exhibit a high capacity for chemiluminescence and it is possible to make red blood cells bioluminescent by genetic engineering. Red blood cells are known to absorb light through the skin and thus might serve as photo-receptors in dermal optics [71]. In [35] it is proposed that red blood cells give rise to primitive vision and be responsible for blind sight. Ocular blood vessels are indeed very near to the surface. DNA is believed to generate bio-photons whereas mammalian red blood cells which have no DNA are indeed known to not emit bio-photons [79]. Perhaps red blood cells 'see' the bio-photons generated by DNA: this would conform with the general idea that DNA generates 4-D templates consisting of coherent photons and guiding the biological self-organization.

The large number of mitochondria in the heart muscle, liver and red muscle cell give them their red color. Whether this color is always related to the color of haemoglobin is not clear to me. At least, the idea about a communication system between red blood cells and mitochondria based on red light is worth of demonstrating to be wrong. Unfortunately, I do not know how near the average wave length associated with this red color is to the 'miracle wave length' of 640 nm associated with the photons of photosynthesis.

4.2 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 nonlocal 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 [E9, M2].

4.2.1 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 [33].

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 [J3, M2].

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 postsynaptic 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 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.

4.2.2 The three metabolic pools in brain

Brain metabolism [72, 73, 74] 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 depolarization 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.

4.2.3 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 [72]. 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 [75]. 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.

4.2.4 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.

4.2.5 The metabolic energy needed to build magnetic bodies

It is interesting to find what the 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 $L(167) = 2.52$ μm with quantized magnetic flux has rest energy L/S and if the area is $S = L(167)^2$ 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 λ^k-fold coverings of ordinary flux tube and have $\lambda^{k_{em}}$-fold energy, $\lambda \simeq 2^{11}$. For instance, for $k_{em} = 5$ this would mean a factor $\sim 3 \times 10^{16}$ meaning that 10 ns would be scaled up to 10^8 seconds. This 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.

4.2.6 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 [25] 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.

Since red blood cells correspond to $k_{em} = 1$ level of dark matter hierarchy most naturally, the counterpart of EEG would correspond to EEG waves with 5 Hz frequency scaled up to 40 GHz for $\lambda \simeq 2^{11}$. Radio waves 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 [M5, 97] I learned that after sunset there appears a radio static which has a biological origin and correlates strongly with taos hum [97]. 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.

4.3 Astrocytes and quantum control of brain

4.3.1 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 [67].

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 swell and and the 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 [67] 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 depolarization 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 [M3]. 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 [67] 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 [67] "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 [75]. 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 consis-

tent 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 [M3] and nerve pulse [M2], 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 [35]. 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 [66] 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 [M3], 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.

4.3.2   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.

4.3.3   Calcium waves as a tool of generalized motor control

The basic facts about Calcium waves are summarized in [40]. 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 microns 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.

4.3.4 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 [M2]. 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 [35], 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 [35]. 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.

4.3.5 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 $k_{em} > 4$ levels of dark matter hierarchy during sleep. $k_{em} = 5$ corresponds to the time scale of few minutes assignable to short term memory and to astrocyte-neuron interaction which is absent during deep sleep.

$k_{em} = 6$ would correspond to a Josephson period of 9 days (.2 seconds for ordinary EEG) and $k_{em} = 6$ level could quite well be involved with sleeping consciousness. Structures responsible for circadian rhythms should involve $k_{em} = 6$ level: the downwards scaling of 24 hour rhythm by λ^2. $\lambda \simeq 2^{11}$, would correspond to 48 Hz rhythm in ordinary EEG not too far from 40 Hz thalamocortical resonance frequency. 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 [68].

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.

4.4 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.

4.4.1 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 Z^0 MEs.

The size L of the excited part of the astrocyte syncitium, 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 syncitium 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.

4.4.2 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 [39] and thus piezoelectrics [25] and allow the transformation of 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 [66], 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.

4.4.3 Taos hum and endogenous sound waves

The victims of taos hum [97] 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.

4.4.4 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 [66] 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 $k_{em} = 5 \rightarrow 4$ 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.

4.4.5 '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 [41, 42, 43] 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 [81]) 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.

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 [81] 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 [45] 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 [K5]. 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 [81]. 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 $\sqrt{2m_p E}$ 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 [44] 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 join along boundaries bonds 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 [87] 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 [G2] would mean that the MEs generated in dielectric breakdown would act as switches inducing the JABs 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 join along boundaries bonds acting as Josephson junctions between magnetic flux tubes and atomic space-time sheets. The TGD based model for auroras [J3] 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/macromolecule 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 leakge 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 aminoacids 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 aminoacids 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 [33]. 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 [55]. With the advance of the experimental techniques molecular motors have become a hot research topic during last years [41, 42, 43].

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 [56]. 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 $ATP \rightarrow ADP + P_i$ 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 [44, 45].

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 [55].

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 modelable 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 [57]. 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 [59]. 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 [41, 42, 43]).

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 Feynmann 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 [57].

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 modeling of Brownian motors

Material about the mathematical modeling of Brownian motors can be found [41, 42, 43].

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 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 partipator: before a charged ion can bind to, say aminoacid, 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 parametrizations 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 modeling 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 modeling 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 modeling of the motion of motor enzymes along micro-tubule and actin filament [42]. 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 [59]. 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 [57]. 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 [42] 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 [61] 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 tunneling. 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 tunneling of the electron is what leads from potential well to another one. Since tunneling probability decreases rapidly when the tunneling length increases, the tunneling 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 [62]. 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 tunneling requires also that there is something which can tunnel. Thus a destructive interference can inhibit the tunneling 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 [65]?

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 [45].

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 [56] and challenging these notions [33] and somehow one might hope that the notion of many-sheeted space-time could resolve this apparent paradox. In [M2] 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 $ATP \rightarrow ADP + P_i$ 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 $ATP \rightarrow ADP + P_i$, and then energy storage system sends the negative energy photon back to the moving system inducing $ATP \rightarrow ADP + P_i$. At each step the moving system receives momentum $p = E/c$ but its net energy does not increase. This process could correspond to $ATP \rightarrow ADP \rightarrow ATP...$ 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

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

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 [J3].

$F_0 - F_1$ motor is certainly an extremely complex structure [44, 45] 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 [46, 55, 44, 45]. 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 [44, 45] 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 [45]. According to the analysis of [45] 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 [45] 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 [45] 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.

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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 $ATP \rightarrow ADP \rightarrow ATP...$ 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 tunneling 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 $ADP_2 + P_i \rightarrow ATP_1$ 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 $ATP_2+ \rightarrow ADP_2 + P_i$.

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 $ADP_1 + P_i \rightarrow ATP_1$. 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 [60], 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 [57]. 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 [94] in TGD framework [G3]. The mechanism might apply to both molecular and bacterial motors [76].

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 $sin(\int 2eV dt)$ 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 short-cut 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. $ATP \rightarrow ADP + P_i$ 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 $ATP \rightarrow ADP + P_i$. 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 $ATP \rightarrow ADP + P_i$ 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 [56]. 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 $ATP \rightarrow ADP + P_i$ splits the flux tube). It is found that alternating electric field induces pumping even without ATP [56].

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 Many-sheeted model for photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [27, 31] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting extremely simple model of photosynthesis is successful both at qualitative and quantitative level.

6.1 A rough overall view about photosynthesis

The photosynthesis in eukaryotes occurs in chloroplasts, which are the counterparts of mitochondria in animal cells and contain photosynthetic pigment-protein complexes [27, 31]. Prokaryotes do not possess chloroplasts and it is believed that chloroplasts are ancient prokaryotes captured by eukaryotic cells. In both cases the crucial structures are membranes.

There is an antenna system harvesting photon energy. Antennae are photosensitive pigments sensitive to visible light (400-700 nm). In some bacteria pigments are also sensitive to infrared light in the wave length range 700-1000 nm. The energy is transmitted in electromagnetic form to the so called reaction center. Antenna pigments as well as reaction center pigments are bound to proteins. After the light is transmitted to chlorophylls it excites electron pairs in turn transferred between pigments.

Oxygen producing plants have two photo-systems, photo-system I present also in plants not producing oxygen, and photo-system II [27, 31]. These photo-systems have several tasks to perform.

1. To store the energy of photons permanently to various energy carrying molecules, in particular glucose. Photo-system I takes care of this. Besides hydrogen carbon dioxide serves as the basic raw material of these molecules. The covalent double bonds between carbon and oxygen are reduced in the process. The photons excite in the reaction center of photo-system I electron pairs transferred to $NADP^+$ to give NADPH which

transfers electrons and metabolic energy to where they are needed. Photo-system II draws electron pairs from water and feeds them to the photo-system I to compensate the electrons lost in the generation of NADPH. As water molecules lose two electrons, oxidation happens which means the generation of O_2 molecules. The production of oxygen utilized also by plants themselves is a further basic function of plants.

2. To store photonic energy temporally by transforming ADP molecules to ATP molecules to be used for various purposes. In the photo-system I the electrons can also circulate energizing *one* ADP molecule to ATP per electron pair whereas photo-system II energizes *two* ADP molecules per electron pair to ATP molecule.
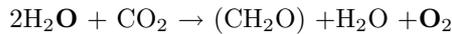
The overall reaction balance equations for photosynthesis deserve a consideration.

1. The overall reaction equation reads as

$nH_2O + nCO_2 \rightarrow (CH_2O)_n + nO_2$.
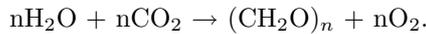
$n = 6$ corresponds to hexoses, in particular glucose, which are the basic products of molecular synthesis and carriers of the metabolic energy.

2. A more precise form of the reaction equation is

$2H_2\mathbf{O} + CO_2 \rightarrow (CH_2O) + H_2O + \mathbf{O}_2$

O means that free oxygen derives from water rather than from carbon monoxide which enters to the reaction much later than the oxidation of water. The oxidation of water

$H_2O \rightarrow 1/2\ O_2 + 2H^+ + 2e$
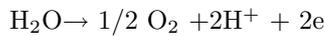
indeed happens in photo-system II and provides the electron pair to compensate the electron pair lost by the photo-system I.

3. Hill's equation

$2H_2\mathbf{O} + 2NADP^+ \rightarrow 2NADPH + 2H^+ + \mathbf{O}_2$
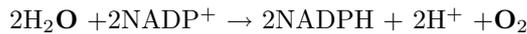
tells what happens in photo-system I before CO_2 enters the game. The equation tells that the oxidation of two water molecules providing two electrons and two hydrogen atoms for two $NADP^+$ ions happens first (for basic facts about NADP molecules see [30]). NADPH carries then the electrons and hydrogen atoms to the process leading to the formation of say glucose.

6.2 A general model for energy storage and energy utilization by remote metabolism

It is good to formulate first a general model for energy storage and utilization based on remote metabolism.

1. Metabolic energy can be stored as zero point kinetic energy to various space-time sheets. The storing particles form Bose-Einstein condensates so that the energy storage is analogous to a population inversion in laser. Bose-Einstein condensates of electronic Cooper pairs, H atoms, H_2 atoms and protonic Cooper pairs, O and O_2 atoms,... are possible. The dropping of a particle to a larger space-time sheet liberates a standardized energy quantum. Since Bose-Einstein condensate is in question, this process can occur coherently which allows high metabolic power. Electronic Cooper pairs kicked to $k = k_{ex} < 151$ space-time sheet from $k = 151$ cell membrane space-time sheets are involved with photosynthesis.

2. Remote metabolism provides and elegant manner to utilize the stored energy. The user must only send negative energy ME at energy sufficiently near to the energy currency. This implies a highly economical use of the metabolic energy. For instance, when an enzyme needs energy, it generates negative energy ME activating ADP to ATP by kicking proton to the atomic $k = 137$ space-time sheet. In this case .5 eV plus possibly an additional energy .34 eV to kick phosphate ion to $k = 131$ space-time sheet is needed. As already found, the model for the ATP$\rightarrow$ ADP transformation favors a situation in which space-time sheets involved are linear structures with thickness $L(137)$ and $L(139)$ predicting that the kicking of single proton gives rise to energy .25 eV.

3. "Seesaw" mechanism minimizes the waste of metabolic energy since the same energy can be used repeatedly [M2]. In the simplest situation two users send repeatedly negative energy MEs for each other and dissipative losses are minimized.

Energy and momentum conservation deserve separate comments.

1. Momentum conservation requires that the kicked particles interact with the Bose-Einstein condensate so that it can receive the momentum of ME. The resulting energy transfer to the condensate is very small, a fraction p/M about the energy of ME.

2. It is of paramount importance to realize that the particles of the Bose Einstein condensate cannot be free. This assumption would lead to contradictions since atomic binding energies are more than order of magnitude larger than metabolic energy quantum. This means that Cooper pairs must possess a binding energy not too far from that possessed the spin-paired valence electrons of water molecule.

   Hence the pairs of valence electrons form Bose-Einstein condensates at larger space-time sheets $k = k_{gr}$ are analogous to the delocalized valence electrons in metal. In the excitation of electrons $k_{gr}(i) \rightarrow k_{ex}(i)$, $i = I(, II)$ the binding energy of electron pair (electron) is not changed appreciably. Also electronic Cooper pairs have their binding energy with Opp system since the nuclear charge is still there, and are delocalized like

electrons in metal. Hence there are two separate delocalizations involved and naturally allowed by the many-sheeted space-time. The system is nearest to water if oxygen appears in atomic form.

6.3 The general model for photosynthesis

The model for the energy storage and utilization by remote metabolism in living matter is stupendously simple and equally simple is the many-sheeted model for photosynthesis resulting as a by-product.

6.3.1 A more detailed model for photosynthesis

The existing ideas about remote metabolism and p-adic length scale hypothesis provide useful hints concerning what happens in the process.

1. The appearance of electrons as pairs is a hint about the presence of electronic super-conductivity.

2. The basic constraint is that single electronic Cooper pair gives rise to single ATP in the case of photo-system I and 2 ATPs for photo-system II. Accepting the proposed model predicting that dropping $k = 137 \rightarrow 139$ of single proton liberates .25 eV and 3 protons drops in single ATP$\rightarrow$ ADP transition, one has that in photo-system I the increment of zero point energy for electronic Cooper pair should correspond to .75 eV at least and in photo-system II to 1.5 eV at least.

3. If the dropping of electron Cooper pairs is the mechanism liberating the zero point kinetic energy in both cases, this gives $k_{gr}(I) = k_{gr}(II) + 1$. Assuming $k_{ex}(i) = k_{gr}(i) - 2$ and the absence of energy losses the conditions $\Delta E_0(e, I) = 3\Delta E_0(p) = .75$ eV and $\Delta E_0(e, II) = 6\Delta E_0(p) = 1.5$ eV give

$$(k_{ex}, k_{gr})(I) = (147, 149) \quad , \quad (k_{ex}, k_{gr})(II) = (146, 148) \quad .$$

For larger values of $k_{gr}(I)$ the metabolic quanta approach to the limits 1 eV and 2 eV.

4. The objection against this model is that single Cooper pair cannot generate to ATP molecules in single stroke. This encourages to consider the option $(k_{ex}, k_{gr})(II)) = (148, 151)$ assuming that electron Cooper pairs decay at $k = 148$ space-time sheet and then drop to $k = 151$ space-time sheet. Because one has $\Delta E_0(e, 148) = \Delta E_0(2e, 147)$ and the electrons drop separately, the energy yield is twice that for a Cooper pair. The decay of the Cooper pair would be induced by the absorption of photon naturally since photon energy would be about two times higher than in the case of photo-system I.

5. The most natural p-adic space-time sheets carrying permanent Cooper pair condensates would be $k_{gr}(I) = 151$ giving $\Delta E_{2e}.86$ eV consistent with the upper bound .84 eV liberated as single ATP molecule is used. Same result is obtain in photosystem II. That ground state space-time sheets correspond to different p-adic primes would guarantee that photo-systems I and II are separate even when they have (apparent) spatial overlap.

The model for the effective axonal super-conductivity [J3] supports the view that the BE-condensate residing at $k = 151$ cell membrane space-time sheet is a fundamental electronic Cooper pair BE condensate since the p-adic prime characterizing the fundamental condensate is that for which thermal kicking of Cooper pairs to space-time sheets with smaller p-adic prime are not possible.

6.3.2 A model for the functioning of photo-systems

The previous considerations lead to the following model for the functioning of the photo-systems.

1. The function of the antenna system is to collect energy and store it to chlorophyll molecules by kicking electronic Cooper pairs from $k = k_{gr}(i)$ space-time sheet to $k = k_{ex}(i) < 1$, $i = I, II$ space-time sheets. Antenna pigments could generate MEs transferring the photonic energy to the reaction center as Bose-Einstein condensed photons.

2. Photo-systems II and I act in series. Photo-system II creates oxygen and generates 2 ATP molecules per electron pair whereas photo-system I is responsible for electron transfer and generates NADPH molecules. In the absence of photo-system II it generates only single ATP molecule per electron pair.

3. For both photo-systems chlorophyll acts as a population inverted many-sheeted laser receiving radiation, which inverts the electronic Cooper pair population. Energy storage reduces to the kicking of electrons to $k = k_{ex}(i)$, $i = I, II$, space-time sheet so that they get energy of 1 eV per electron.

4. The primary energy quanta absorbed from the solar radiation differ from the 2 eV and 1 eV energy currencies defined by Cooper pairs and electrons, and one can wonder how the transformation to standardized quanta occurs. Chlorofyll transition is certainly responsible for the absorption of quantum and the whole spectrum of visible light is involved. The question is how the absorbed energy of the chlorofyll is transformed to 2 eV or 1 eV quanta in the population inversion for electronic Cooper pairs. One could guess that the excited chlorophyll system generates ME bridges with energy 2 eV allowing the Cooper pairs to flow from $k = k_{gr}(i)$ to $k = k_{ex}(i)$ space-time sheet, $i = I, II$. In consistency with the seesaw mechanism, this emission would most naturally result from the dropping of electronic

Cooper pairs from $k = k_{ex}(i)$ to $k = k_{gr}(i)$ space-time sheets induced by the absorption of photonic energy by chlorophyll.

6.3.3 What happens in the oxidation of the water molecules?

The oxidation of water is perhaps the most mysterious aspect of photosynthesis. The equation $H_2O \rightarrow 1/2\ O_2 + 2p + 2e$ serves only book-keeping purposes and serious consideration of what might happen generates doubts about whether standard chemistry allows to understand what is involved. Since it is O_2 molecules which are produced, at least two water molecules are needed for the equation to make sense.

This observation suggests that collective effects are of importance, and one is almost unavoidably led to ask whether Bose-Einstein condensates of H, protonic and electronic Cooper pairs, H_2, O, and O_2 at larger space-time sheets might be involved. If the Bose-Einstein condensates of O_2 and electronic Cooper pairs are involved, situation simplifies dramatically. The model for sol-gel phase transition already led to the tentative idea that Bose-Einstein condensates of hydrogen atoms could be present in the cellular water. Only a small fraction of O_2, H_2, H, 2p and 2e would reside at larger space-time sheets. O-, O_2- and protonic Bose-Einstein condensates might perhaps make water some kind of liquid crystal structure for which electronic Cooper pairs are delocalized like electrons in metal and thus experience the Coulombic force. Also H atoms forming local bound states with O atoms could be delocalized just like valence electrons in the metal lattice.

In this framework oxygen production in photosynthesis could be seen as automatic side product due to the leakage of the O_2 molecules from the system. The sucking of electronic Cooper pairs from the Bose-Einstein condensate associated with water perturbs the critical system and O_2 molecules can be evaporated unless they are utilized by the system itself. The evaporation of O_2 molecules would correspond to the dropping of O_2 molecules to some larger space-time sheet giving at the same time a recoil momentum for the electronic Cooper pair so that it can enter to the reaction center to compensate the excited Cooper pair. The energy in question would be about .0039 eV.

6.4 Applying the general model of energy storage and utilization to ionic pumps

The general model allows also to understand the value of the cell membrane resting potential.

1. The $k = 139$ Bose-Einstein condensate of hydrogen atoms would be responsible for .125 eV energy quantum crucial for sol-gel phase transitions controlled by micro- wave MEs. Also electronic Cooper pairs at $k = 147 = 3 \times 49$ space-time sheet liberate same energy when dropping to larger space-time sheets.

2. H_2 and/or Cooper pairs of protons correspond to energy of .0625 eV (recall that there is small numerical uncertainty involved). Also electrons dropping from $k = 149$ lipid layer space-time sheet liberate this energy. Since the resting potential is .065 eV, this energy is very near to the energy needed/gained by singly charged particle when it traverses cell membrane. The zero point kinetic energy .125 eV of H atoms in turn correspond to the energy needed to carry doubly charged ion such as Mg^{2+} or Ca^{++} through the cell membrane. This leads to the hypothesis that the TGD counterparts of ionic pumps are based on remote metabolism, that is sending of negative energy MEs inducing the dropping of H, H_2 and possibly 2p from $k = 169$ space-time sheet or dropping of electronic Cooper pair from $k = 149$ and electron from $k = 151$ space-time sheet.

7 Explanation of super-luminal velocities in terms of remote metabolism

After the pioneering experiments of Nimtz and his collaborators 1992 [18] a lot of evidence for effective super-luminal signal velocities has been accumulating [19, 20]. 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.

7.1 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.

7.1.1 The explanation of super-luminality in terms of photon tunneling

The explanation of Nimtz [19, 20] 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 tunneling. 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 tunneling. The prediction is consistent with experiments [18, 19, 20] 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 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) [19, 21] 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 [21]. The phenomenological notion of hollow wave might allow precise formulation using the notion of many-sheeted space-time.

7.1.2 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 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 [21]. 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 [G2] 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 [19] 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.

7.2 Experiments involving super-luminal velocities

The pioneering experiments on super-luminal velocities were done by Nimtz and collaborators in Cologne 1992 [18] 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 tunneling time is asymptotically equal to $\tau \simeq 1/f$, where f is the frequency of the microwave. More generally, photon tunneling 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 [20].

7.2.1 Standard theoretical description of the findings

The interpretation proposed by Nimtz for super-luminal propagation is in terms evanescent waves representing semiclassically photon tunneling. The quantum tunneling of photons was first discussed by Wigner and later by Hartman who deduced the independence of the tunneling time on barrier thickness [22]. The article of Collins [23] 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

tunneling 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 tunneling 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 tunneling 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 tunneling 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 [18]. Second scale corresponds to an energy threshold of $E_{0,e.m.} = 4.5$ μV representing the difference of voltages induced in photodiodes in two experiments in which tunneling occurs/does not occur. In [21] the threshold is interpreted as an energy threshold for the breaking of local Lorentz invariance.

7.2.2 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 [18] 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 nega-

tive 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 [19] 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

$$\Delta\tau(\omega) \;\; = \;\; \tau_R - \tau = \frac{L}{c} - \frac{2\pi}{\omega} \tag{13}$$

of the real time τ_R taken to propagate through the barrier and of the semiclassical tunneling 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 [21] 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.

7.2.3 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 tunneling.

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 tunneling interpretation of the evanescent waves. Of course, TGD description remains a bundle of ideas and precise quantitative model is not yet possible.

7.2.4 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.

7.3 Experiments believed to involve anomalous interference

The experiments of Cardone and coworkers [21] 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.

7.3.1 The experimental arrangement

The experimental arrangement discussed in more detail [21] (see Fig. 7.3.1) 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.
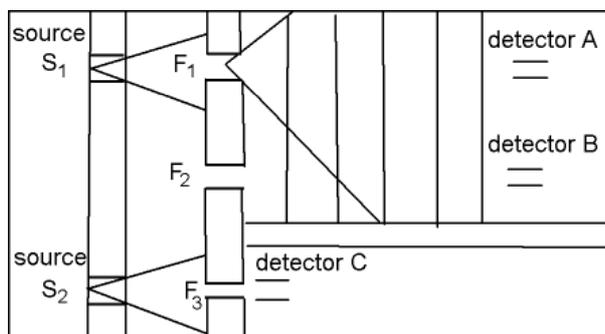

Figure 1: Schematic representation of the experimental arrangement of Cardone and collaborators.

7.3.2 Findings

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 $\Delta_A(1-3) = 2.3$ μV 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.

7.3.3 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 [21], 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 (cathode) 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.

7.4 The experiments involving crossed photon beams

In [21] the privately communicated preliminary experimental results of Ranfagni and coworkers are analyzed. The experimental arrangement is illustrated in figure 7.4. 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.
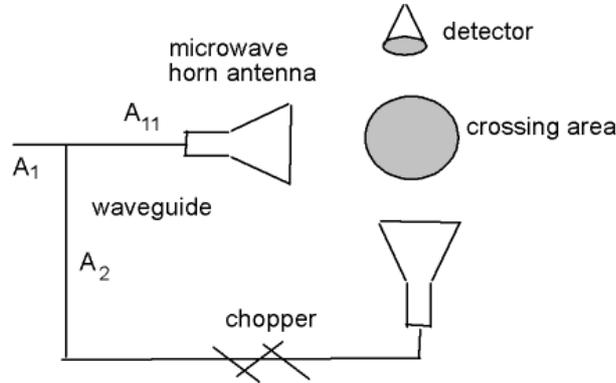

Figure 2: Schematic representation of the experimental arrangement of Ranfagni and collaborators discussed in [21].

7.4.1 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 [21] 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.

7.4.2 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 $5 \ \mu V$ 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.

7.4.3 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 [21] 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.

   i) 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.

   ii) 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.

   iii) 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.

7.4.4 A more detailed specification of the catastrophe theoretic model

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

$$\begin{aligned}\frac{dQ}{dt} & = C(V)\frac{dV}{dt} \\ & = I_B(A) + I_D(V, A, L, \lambda) - I_A(A, i, L, \lambda) \equiv F(V, A, L, i, \lambda) \ . \ \ (14)\end{aligned}$$

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

$$\frac{dQ}{dt} = F(V) = 0 \ . \tag{15}$$

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:

$$F(V) = \frac{d\Phi}{dV} \ , \tag{16}$$

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.

1. 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.

2. 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

$$
\begin{aligned}
I_D(A, ..) &< I_A(A, i = 1, ...) \ , \\
I_B(A) &< I_A(A, i = 1) \ .
\end{aligned}
\tag{17}
$$

The condition

$$
I_A(A, 1) > I_A(A, 2)
\tag{18}
$$

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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