Are dark photons behind biophotons?

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February 2, 2024
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Contents

Abstract

TGD approach leads to a prediction that bio-photons result when dark photons with large value of effective Planck constant and large wavelength transform to ordinary photons with same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness served as a particular motivation for developing a more detailed view about bio-photons.

1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.

2. Also the abstraction and de-abstraction processes in various scales which are essential for neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different manners to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed n-particle states correspond to instances of the rule or association of n events. Schrödinger cat serves as an example: the superposition of living cat-closed bottle and dead-cat-open bottle gives a quantum representation for the rule that it is not good idea to open the bottle. Cat attending to/quantum entangling with the bottle is conscious about the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.

3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of subself corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus *change*, how is it possible to carry conscious information about *quantum state*? Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation.

   This memory reading mechanism can be formulated for both photons and phonons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination. The notion of bio-phonon could also make sense and even follow as a prediction. The identification of dark photons responsible for the reading of memories with EEG is suggested by the strong correlation of latter with the contents consciousness. This would also suggest a correlation of bio-photon emission with EEG for which there is a considerable evidence. The indications that bio-photons are associated only with the right hemisphere suggests that at least some parts of right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts the of left hemisphere at least might prefer dark photons in IR energy range transforming to ordinary phonons in ear or dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

4. After the writing of the original version of the chapter it turned out that there are good justifications for the proposal that the energy spectrum of dark photons might be universal and do not depend on the mass of the charged particle. This requires that h_{eff} is proportional to the mass of the charged particle. This conforms with the hypothesis that bio-photons result in the transformation of dark photons to ordinary photons and

the hypothesis cyclotron frequencies code serve as kind of passwords characterizing the ion. Dark ions could also affect ordinary matter by inducing molecular transitions in visible and UV ranbge by transforming first to bio-photons.

In the following I shall discuss bio-photons in TGD Universe as decay products of dark photons and propose among other things an explanation for the hyperbolic decay law in terms of quantum coherence and echo-like mechanism guaranteeing replication of memory representations. Applications to biology, neuroscience, and consciousness are discussed and also the possible role of bio-photons for remote mental interactions is considered. Also the phenomenon of Taos hum is discussed as a possible evidence for biophonons.

1 Introduction

I have written already earlier about bio-photons [K15] and proposed that bio-photons result when dark photons with large value $\hbar_{eff}$ of effective Planck constant and large wavelength transform to ordinary photons with the same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness [L3] [L3] served as a motivation for a complementary treatment from different perspective.

The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness [L3] [L3] served as an additional motivation for a complementary treatment.

1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.

2. Also the abstraction and de-abstraction processes in various scales which are essential for the neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different way to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed n-particle states correspond to instances of the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.

3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of sub-self corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus change, how it is possible to carry conscious information about quantum state? Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation.

   This memory reading mechanism can be formulated for both photons and photons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination and the notion bio-phonon could also make sense and even follow as a prediction.

The observation that bio-photons seem to be associated only with the right hemisphere [J17] [K4] suggests that at least some parts of the right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts ofthe left hemisphere at least might prefer dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

1.1   Basic Facts About Bio-Photons

Alexander Gurwitsch discovered bio-photons as early as 1923 and called the phenomenon "mitotic radiation". Fritz Popp is one of those who have continued the pioneering work with bio-photons [I13, I17]. Also Roeland van Wijk [J22] shoud be mentioned as one of the many people involved. Recently the possible fundamental role of bio-photons in neuroscience has been realized.

To get a first quantitative grasp of bio-photons one can look at `http://en.wikipedia.org/wiki/Biophotons` [I1]. Ultraweak emissions of visible and also UV light from living matter. Spectrum looks continuous. Intensity (power per unit area) is 10^{-13} to 10^{-10} W/m^2. The intensity of solar radiation is 1.361 kW/m^2 and stronger by 13-16 orders of magnitude. The intensity of bio-photons is however much above the intensity of thermal radiation at energies of visible and UV photons.

In order to obtain a more biological perspective one can look for the intensity in the natural length and time scales of neuron. 2 eV is the energy of red visible photon. Using the relationship $J = 6.4 \times 10^{28}$ eV one obtains that if all bio-photons were photons with energy of 2 eV, there would be about 3.2 bio-photons per area of μm^2 characterizing cell nucleus during period of 1 ms defining characteristic time scale of neuronal firing. This raises the question whether bio-photons might be relevant for neural firing.

Chemi-oxidation via oxidative stress by reactive oxygen species (ROS) and/or catalysis by enzymes (peroxidase, oxygenase) has been suggested as a source of bio-photons [I1, I10]. The excitation of biomolecule to triplet (spin 1) state would decay via the emission of bio-photons.

Evidence has been given that bio-photons represent coherent radiation [I12, I5]. For instance, the distribution for bio-photon number for given energy is nearer to Poissonian distribution characterizing coherent state of photons (technically a state, which is an eigenstate of annihilation operator for photon of given energy and quantum analog of classical state in which it makes sense to assign classical field to the state). The coherence time from photon counts is much longer than the estimate 10^{-13} seconds based on standard sources. Time scale of at least second is nearer to reality. Also delayed luminescence (see `http://tinyurl.com/ycl75l5g`) of bio-photons [I5] as a respose to a stimulation of system by visible photons reflects long range temporal correlations and not expected for incoherent radiation. Instead of exponential decay hyperbolic power low type decay takes place. The underlying reason is not well-understood.

The coherence is not easy to understand if chemi-oxidation is the source of bio-photons although it could quite well correlate with the production of bio-photons. The coherence and empirical findings made already by Gurwitsch have inspired the proposal that bio-photons could play an important role in control and communications in living matter. The attitudes of mainstream are very negative to proposals of this kind as the Wikipedia article (see `http://tinyurl.com/yaey7ovw`) [I1] illustrates. Recently the situation have been changing and reports supporting the existence of non-chemical communications (see `http://tinyurl.com/abk828g`) between cell cultures having no physical contact are emerging [I2].

One can raise a long list of questions about bio-photons.

1. What is the actual nature of bio-photons? If bio-photons are not primary entities (contrary to what is usually believed), what is behind bio-photons? Could bio-photons be decay products of something more fundamental and perhaps new from the perspective of recent day physics? If bio-photons are fundamental entities responsible for control and communication, the extreme weakness of their intensity becomes a problem. The idea about bio-photons as leakage of more fundamental entities could allow even metabolic role for the these entities.

2. How bio-photons are produced? The proposed mechanism based on oxidative stress does not explain coherence nor the reported communication and control function.

3. How do bio-photons or more fundamental entities relate to biology in general and specifically to metabolism, to neuroscience, to certain findings of Gariaev's group [I9], to Becker's DC currents [J3] and the related TGD inspired model discussed in [L1]? Could bio-photons relate to vision and imagination? Bischof [J30] and Bokkon *et al* [J4, J9, J26, J10, J25] have made several proposals in this respect. What is behind the correlation between EEG and bio-photons (for which multiple sources of evidence exist - [J8, J20, J17] - or that between the changes in bio-photon emission in meditative [J36] and qigong practices [J16, J12, J11, J15]? What about remote mental interactions, which are natural and ubiquitous if TGD-inspired biology is accepted: could bio-photons or more fundamental entities provide a control and communication tool?

The following considerations are inspired by a collection of mostly recent articles collected through Pubmed and the Qigong and Energy Medicine Database (see `http://tinyurl.com/ybyyns3k`) (`http://www.qigonginstitute.org/html/database.php`, [J2]). The purpose is to build a more detailed view about bio-photons relying on ideas represented already earlier [K10, K15].

The basic vision involves some new elements: bio-photons are decay results of dark photons, which are the fundamental objects. Dark photons play a key role in non-destructive reading of sensory/cognitive/memory representations by interaction free measurements. Besides dark photons and also dark phonons could be involved in interaction free meaurements and could be behind imagination resp. internal speech. Hence the notion of biophonons deserves a serious consideration. Dark photons and maybe also dark phonons would be generated by the memory reading mechanism automatically as a kind of echo and could yield virtual sensory input allowing to test whether sensory representation is realistic. Also copies of memories would be produced automatically by the echo mechanism: this could explain after-images and serve as a basic mechanism of learning. Dark photons could also serve communication and control purposes and define metabolic energy, making possible remote metabolism by what I have called quantum credit card mechanism. The energy range of biophotons corresponds to visible and UV range so that they are optimal for biochemical control by inducing molecular transitions.

1.2 Basic Ideas Of TGD Based Model Of Bio-Photons

The following list summarizes the key TGD inspired ideas about bio-photons.

1. *Identification of elementary particles microscopically.*

   Quantum antenna hypothesis suggests that bio-photons are associated with topological light rays - "massless extremals" (MEs, topological light rays [K14]). Biophotons - in fact, all elementary particles - are identified as pairs of wormhole contacts with wormhole contacts connecting two space-time sheets in CP_2 directions. The two space-time sheets would be most naturally ME and magnetic flux quantum (tube or sheet). These details do not matter much for applications.

2. *Identification of bio-photons as decay products of dark photons.*

   In TGD Universe bio-photons would be ordinary photons resulting from the transformation of dark large $\hbar_{eff} = n \times \hbar$ low frequency (f_l) photons to ordinary photons with high frequency (f_h). In the original form I proposed (f_l, f_h) pairing as what I called scaling law of homeopathy [K8], and later realized the connection with the hypothesis about hierarchy of Planck constants. This transition would transform low frequency dark photons with E= $h_{eff} \times f_l$ to ordinary photons with E= $h \times f_h$ ("l" is for "low" and "h" is for "high"). The outcome could be observed as bio-photons.

   Any system having field body with parts having large $\hbar_{eff}$ can generate dark photons in turn decaying to bio-photons or dark photons with smaller value of $\hbar_{eff}$. Decay cascade decreasing $\hbar_{eff}$ down to $\hbar$ is the most general option and the integers n in $\hbar_{eff}(k)/\hbar = n(k)$ are factors of $n(1)$. This is a strong number theoretical prediction. The longest possible decay sequence to ordinary photons would factorize the integer $n = \hbar_{eff}/\hbar$ so that this kind of process might also have number theoretical meaning.

The low intensity of bio-photons suggests that the rate for the transformation of ordinary to dark is very low and/or that the density of charged particles (say ions of cyclotron BE condensate) generating dark photons is very low. Given a quantitative model for the mechanism one could estimate the rate for the transformation of ordinary photons to bio-photons. Gariaev's experiment [I9] yielding radio wave photons (interpreted as dark photons) from incoming laser light beam irradiating DNA sample could help to estimate the transformation rates as function of h: the most naive guess inspired by scaling argument is $1/h_{eff}$ dependence for given photon energy. DNA would induce energy conserving transformation of ordinary laser photons to long wave length dark photons with the same energy. A possible mechanism is modulation of the beam by radio wave frequency.

The crucial parameter is the magnitude for the $f_l \to f_h$ transition amplitude. Dimensional analysis suggests that the rate $\Gamma(f_l \to f_h)$ is proportional to f_l. This would give very slow rate for ELF frequencies so that the intensity of bio-photons would be very low l for a given intensity of dark photons.

The intensity of dark photons could be rather high. Gariaev reported the transformation of laser light to radio waves in scattering from DNA in rather wide range of frequencies [I9]. These photons had biological effects on remote target (stimulation of growth of potatoes). If radio frequency photons are dark photons with visible energies they could have provided metabolic energy for high enough intensity. The role of controller is also possible. Dark photons could be also used to read memory representation in non-destructive way by interaction free measurements so that dark photons would be fundamental from the point of view of cognition.

The value of not only h_{gr} but also that of h_{eff} at magnetic flux tubes could be proportional to the mass of charged particle populating the flux tube in question. Flux tubes would distill the molecules to separate flux tubes. Cyclotron energy scale would be universal and does not depend on the mass of charged particle: therefore bio-photons would have universal energy spectrum in the range of molecular excitation energies.

3. *Possible connection with negentropic entanglement.*

   The connection of dark photons with negentropic entanglement is not well understood but highly suggestive. One can imagine at least three reasons for the connection, which are not necessarily exclusive.

   (a) If the braiding (geometric entanglement!) of magnetic flux tubes carrying dark matter and dark photons (!) serves as a correlate for negentropic entanglement, braided collections of flux tubes define negentropically entangled systems serving as negentropy sources. This fits nicely with DNA as topological quantum computer vision [K1] and with the vision about various representations (sensory, motor, memory,..) [L3]).

   (b) Dark photon with $\hbar_{eff} = n \times \hbar$ with frequency f_l can be said to contain n ordinary photons with frequency f_l. Could these analogs of ordinary photons be negentropically entangled?

   (c) An alternative view is that dark photons are necessary for generating quantum coherence and negentropic entanglement in long length scales. This option is consistent with the first two options.

   Note: Topologically dark photons correspond to the n sheets of n-fold covering of space-time sheet assignable to n-furcation reflecting the failure of the strict determinism of Kähler action for preferred extremals. One might even ask whether dark photon with energy E could be seen as space-time correlate of Bose-Einstein condensate of photons with energy E/n!

4. *Some signatures of bio-photons in TGD Universe.*

   The simultaneous presence of frequencies f_h and f_l is the basic signature of the proposed mechanism. Cyril Smith [J6] has done a lot of work with this kind of connection and claims that $f_l \leftrightarrow f_h$ transformations (interpreted as transformations between dark and bio-photons in TGD framework) occur in living matter. His interpretation is completely different. Smith mentions the frequency ratio $f_h/f_l = 2 \times 10^{11}$ as very special one. For $\hbar_{eff}/hbar = 2 \times 10^{11}$

radiation with $l_l = 2.56$ kHz would correspond visible photon with $\lambda = .6$ μm at the red end of the spectrum.

Assuming that bio-photons indeed appear in TGD Universe, the first predicted signature is a correlation between fluctuations in EEG power and the ultraweak emission of visible photons from brain identified as particular kind of bio-photons. This kind of correlation has been observed [J8] but visible photons emerge from right hemisphere [J17].

(a) Could this mean that right brain and left hemisphere emit dark photons in different energy ranges: one possibility is that left hemisphere emits infrared photons above the thermal energy. The photons would have energies above the Josephson energy $E_J = 2eV_{rest} = .12$ eV in case of Cooper pairs of electrons. Here $V_{rest} \simeq .06$ V denotes the membrane resting potential are possible infrared analogs of bio-photons.

(b) The idea that dark photons correspond to imagination and dark phonons to internal speech in turn would suggest that left brain as brain hemisphere responsible for internal speech operates with dark phonons rather than dark photons. Right hemisphere being specialized to spatial thinking would favor dark photons.

Second signature are long range temporal correlations reflecting the origin of bio-photons. These correlations are observed for bio-photons as delayed luminescence [I5] and the sequel presents a model for the correlations based on dark photons explaining hyperbolic decay law and suggesting a totally unexpected connection with zeros of Riemann zeta.

1.3 Are Biophonons Also Predicted?

It came as a surprise that a general model for the non-destructive reading of memory mental images and their time reversals (interpreted as predictions of the future based on interaction free measurement) in principle allows the use of not only dark photons, but also *dark phonons* in the reading process. The mechanisms of imagination and internal speech could emerge from the general structure of quantum jump and model for self representation based on negentropic entanglement.

The identification of bio-photons as decay products of dark photons suggests strongly that bio-phonons also result as decay products of dark phonons. Internal speech could be one manifestation of the transformation of dark phonons to ordinary ones. This transformation could also appear as a dissipative leakage phenomenon.

As a pleasant surprise came the realization that there is a poorly understood phenomenon of this kind known as Taos hum [I19]. The patient suffering from it hears an unpleasant humming sound reflecting the properties of the acoustic environment but which does not generate any response in microphones. Nevertheless neurophysiological correlates for hearing the Taos hum are observed.

Taos hum is experienced only after and before sunset. The electric "static" (electrical noise in shortwave radio receivers) beginning after sunset and believed to have a biological origin has been proposed to at least correlate with this phenomenon. A natural interpretation would be that when vision is not a possible communication tool anymore, dark photons or dark phonons propagating along ME-flux tube pairs are used for communications. Since living matter is full of electrets dark photons or phonons can give rise to the static.

Several options can be considered: dark signal could propagate from the source to receiver as dark photons or phonons along ME-magnetic flux tube pair, continue by travelling along ME-flux tube pair parallel to the auditory pathway down to the ear as dark photons or phonons and transform then to ordinary phonons generating the experience. The most conservative option consistent with the earlier proposal that the distinction between right and left hemispheres relates to the wave length range of dark photons (bio-photons in left hemisphere would be in infrared) [K4].

It seems that Taos hum is experienced in a pathological situation: a possible interpretation is that the leakage of dark phonons to bio-phonons is too strong and leads to the experience. Also the electromagnetic component of the patient's immune system could fail and negative energy dark photon signals could suck metabolic energy from the patient.

I will consider a slightly modified briefer version of a model that I developed for Taos hum for more than a decade ago as evidence for the notion of magnetic body [K10] (sensory magnetic canvas was the term that I used at that time). In this model Taos hum was interpreted as a

phenomenon analogous to microwave hearing. At the end I will consider variants of the model involving dark photons and/or dark photons.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L4].

2 Bio-Photons In TGD Universe

I have discussed already earlier the identification of bio-photons in TGD framework [K3, K15].

2.1 The Origin Of Bio-Photons In Standard Physics Framework

The are several proposals for the source of bio-photons: for instance cell membrane [I8], DNA [I12], mitochondria [I15], linear molecules [I22], microtubules are proposed as sources of bio-photons. The existence of several sources conforms with the universality of production mechanism.

1. Biophotons seem to be emitted under stress [I21]. It has been proposed that bio-photons arise as a product of redox reactions of free radicals [I1, I10]. The hypothesis is motivated by the correlation between bio-photon counts and doses of reactive oxygen and nitrogen species but does not explain in any obvious manner the coherence of bio-photons. The proposed production mechanism is that a biomolecule is excited to a triplet state (spin 1) and releases photon as it returns to the ground state. Laser like behavior would be required in order to achieve the coherence. The correlation of bio-photon production with ROS can however have alternative explanations.

2. A model for bio-photon production based on non-linear polarizable double layers obeying Maxwell's ED: cell membrane is proposed [J25]. Destructive interference between incoming and reflected wave leaving a wave confined inside double layered structure.

2.2 The Origin Of Bio-Photons In TGD Universe

Dark photons decaying to bio-photons could be produced by many systems - even non-living systems. Therefore the production mechanism of bio-photons would be universal and there would be several dominating production mechanisms for bio-photons. One test for this is to check whether water and quartz crystals produce bio-photons (the claimed health effects of quartz crystal might be real and relate to dark photons).

In the framework of standard biology one would try to identify biochemical mechanisms for the production of bio-photons. The coherence of bio-photons however suggests that something totally new is involved. Just the assumption that something genuinely new is involved of course sounds rather outlandish unless one has a concrete proposal for what this new is and unless this something new is able to solve other puzzles.

2.2.1 Do dark photons give rise to biophotons?

The basic philosophy in what follows will be as following. In computer world decomposition to hardware and software is very useful. In biology this division could mean that biochemistry describes dynamical hardware and also the mechanisms modifying it. Electromagnetic fields in TGD sense, dark photons, magnetic body, topological quantum computation, communications and control by dark photons would correspond to software. If this division is real, one might have rather satisfactory description of the software without even mentioning biochemistry. "Biology is governed by symbolic dynamics" is other manner to state the idea: to predict the behavior of priest all that one needs to know that he/she is a priest. One could never predict the behavior of priest from biochemistry and Newton's laws but single word "priest" associated with his person allows this. The basic justification for this separation between software and hardware (biochemistry) would come from the identification in terms of dark matter having now direct interactions with ordinary matter (in the sense that particles with different value of $\hbar_{eff}$ cannot appear in interaction vertices.

1. In TGD framework the counterpart of confinement inside double layered structure in polarizable media proposed as a model for bio-photons [J25] is confinement of photons inside topological light rays (MEs) acting like wave guides. Mechanism can be said to be gravitational since MEs are not only extremely non-linear structure but as space-time quanta also gravitationally non-trivial. The deviations of TGD from Maxwell's electrodynamics (MED) are important and come from induced field concept implying also topological field quantization. For instance, MEs are analogous to wave guides and have no counterpart in MED. MEs can carry non-vanishing light-like currents not possible in MED. MEs mediate precisely targeted signals propagating with light velocity without changes in their shape, to only single direction. Therefore MEs are ideal for communication and control. Topological field quantization makes space-time topology in various scales a key player also in biology. This leads to the notion of magnetic body and also the notion of electric flux quanta such as cell membrane.

2. In TGD Universe the large value of $\hbar_{eff}$ provides a general explanation for macroscopic quantum coherence. This allows several sources of bio-photons resulting when dark photon transforms to ordinary photon of same energy.

   - Dark photons could be absorbed and emitted in cyclotron transitions at magnetic flux tubes. Dark photons could be Josephson photons from a Josephson junction formed by the lipid layers of cell membrane. The minimal energy for the Josephson photon assignable to electronic Cooper pair is $E = 2eV_{rest} = .12$ eV for electronic Cooper pair and $V_{rest} = .06$ eV and is above thermal threshold. More generally, the spectrum of dark photons would be a combination of cyclotron spectrum and Josephson spectrum assignable to cell membrane [K6]. Frequencies would come as sums of harmonics of cyclotron frequency for a given bosonic ion or Cooper pair of fermionic ions and harmonics Josephson frequency.

   - The variation of the membrane potential induces a modulation of Josephson photon frequencies $f_J = ZeV$. This suggests that frequency modulation defines the fundamental information representation. This brings in mind whale's song - maybe mathematically very similar to human speech (as hearing in as slowed down version reveals) - in various time scales!

   - Huping Hu has observed that dipole magnetic interaction between protons with distance of 10 nm corresponds to energy scale in EEG frequency scale [J24] [K4]. Large $\hbar_{eff}$ could raise the energy to visible range. The cyclotron transitions assignable to the pairs of dark protons forming analogs of Cooper pairs could generate dark photons with EEG frequency and cytochrome oxidase could catalyse the energy metabolism providing them energy.

One can raise several questions about dark photons and bio-photons.

1. How are dark photons generated? Gariaev's experiments [I9] suggest that at least DNA induces transformation of ordinary photons to dark photons with much lower frequency. Could amplitude modulation of f_h signal by f_l signal provide a mechanism producing $\hbar_{eff} = f_h/f_l$ dark photons decaying to bunches of ordinary f_l photons or to ordinary f_h photons? Resonance condition requires integer valued frequency ratio and in principle this could serve as a test. In many experiments, say the pioneering experiments of Blackman and others (see for instance [J7]), this kind of modulation is involved. If this mechanism really works it provides a tool for producing dark photons: this has an obvious technological potential.

2. How would reactive oxygen species induce $\hbar_{eff} \to \hbar$ transitions inducing a loss of coherence? The process should be the inverse for the generation of dark photons. Analog of induced emission: presence of ordinary photons of same energy in state would increase the rate for the transition $\hbar_{eff} \to \hbar$. What is the reverse of amplitude modulation? Small ripples in a slowly varying wave. Amplitude modulation with frequency much higher than modulated frequency. Are these two descriptions equivalent?

3. What is the connection with quantum antenna hypothesis [K14] ? Pairs of MEs and magnetic flux tubes giving rise to structures parallel to linear structures populating biosystems (axons, microtubules, DNA, linear molecules, etc) could be involved. Larger space-time sheet would induce a modulation by lower frequency defined by its scale. A hierarchy of amplitude modulations would be the outcome.

2.2.2 Has the decay of dark photons to visible photons observed in astrophysical scales?

There is an interesting news providing new light to the puzzles of dark matter in New Scientist (see http://tinyurl.com/y9r65xnh). It has been found that Universe is too bright. There are too many high energy UV photons in the spectrum. The model calculations suggest also that this too high brightness has emerged lately, and was not present in the early universe. The intergalactic space contains more neutral hydrogen and thus also more ionized hydrogen as thought previously and it was hoped that the ionized hydrogen could explain the too high brightness. It is now however clear that 5 times more ionized hydrogen would be required than theory allows accepting the experimental data.

The question is whether dark matter could explain the anomaly.

1. The usual dark matter candidates have by definition extremely weak interactions - not only with ordinary matter and also with dark matter. Therefore it is not easy to explain the finding in terms of ordinary dark matter. The idea about dark matter as remnant from the early cosmology does not fit naturally with the finding that the surplus UV radiation does not seem to be present in the early Universe.

2. In TGD dark matter is ordinary matter with large $h_{eff} = n \times h$ and has just the ordinary interactions with itself but no direct interactions with visible matter. Thus these interactions produce dark radiation with visible and UV energies but with probably much lower frequencies (from $E = h_{eff}f$). The energy preserving transformations of dark photons to ordinary ones are an obvious candidate for explaining the surprlus UV light.

3. These transitions are fundamental in TGD inspired model of quantum biology. Biophotons are in visible and UV range and identified as decay products of dark photons in living matter. The fact that the surplus has appeared recently would conform with the idea that higher levels of dark matter hierarchy have also appeared lately. Could the appearance of UV photons relate to the generation of dark matter responsible for the evolution of life? And could the surplus ionization of hydrogen also relate to this? Ionization is indeed one of the basic characteristics of living matter and makes possible charge separation [I3], which is also a crucial element of TGD inspired quantum biology [K16]

2.3 Biophotons, Dissipation, And De-Coherence

1. By above proposal the yield of bio-photons would be a leakage process. The transformation of dark photons to ordinary or dark photons with smaller $\hbar_{eff}$ means reduction of coherence length of order wave length by the ratio of final and initial effective Planck constants. The process leading to visible photons leads to a coherence length which is fraction of micron. Therefore also dissipative effect is in question. The ordered energy of dark photon BE condensate transforms to less ordered energy of ordinary photons.

   The process is expected to reflect the long scale coherence of dark photons. This could resolve the basic objection against the observation of delayed luminescence for which time scale should be of order 10^{-13} seconds for standard value of $\hbar$. Scaling of $\hbar$ to $\hbar_{eff}$ can increase this time scale even to seconds if not longer time scales.

   In the simplest mode the intensity of bio-photons is proportional to the intensity of dark photons proportional to the modulus squared for dark photon complex order parameter assignable to a coherent state of dark photons. Also other than coherent states are possible: for instance, Popp *et al* have suggested so called squeezed states (see http://tinyurl.com/y9qbh6nr) [I14].

2. Cancer could be understood as a disorder in which $\hbar_{eff}$ of part of magnetic body is reduced to smaller value and eventually to its ordinary value of $\hbar$ so that long range coherence is lost. If dark photons have energy of visible photons, basic coherent units have size of cell and one obtains "selfish cells" [I18].

3. Redox reactions, ROS and RNS induce loss of coherence by inducing process reducing $\hbar_{eff}$ and production of bio-photons: perhaps by the inverse of amplitude modulation which might generate dark photons. These reactions could have also a useful role in hardware development. Kind of etching of 4-D brain as a representation of self (modification of synaptic connections for instance) might be the basic function and necessarily involves dissipation.

2.4   What Is The Origin Of The Hyperbolic Decay Law?

The basic question concerns the origin of the hyperbolic decay law. It is not actually clear whether this law as anything to do with genuine decay or whether it reflects the behavior of complex order parameter of dark photons as a function of time. The latter interpretation is supported by the following argument.

The intensity decays slowly being in the first approximation of form $I(t) = I(0)/(1 + \lambda t)$: also hyperbolic waves of form $I_0 sin(log(1 + (t/t_0)))$ have been reported. The most general form for the intensity is

$$I(t) \;\; = \;\; I(0) \times exp(\lambda u) \;\; , \tag{2.1}$$

where $\lambda 1 + iy$ is complex parameter and $u = log(1 + \lambda t)$ is the analog of time coordinate defined as logarithm of the shifted and normalized dimensionless time coordinate $T = (t + t_0)/t_0$. Fractal power law $I \propto T^\alpha$ approaching for large values of t to $I(t) = t^\alpha$ would be in question.

In zero energy ontology (ZEO) this kind of behavior can be related to Lorentz invariance.

1. The boundary of CD corresponds to light-cone boundary with light-like coordinate. For irreducible representations of Lorentz group the wave functions at light-cone boundary $t = r$ ($c = 1$ in the units used) behave as r^α. The appearance of this coordinate might be due to the fact that dark photons travelling with light-velocity are involved.

2. For hyperboloids $t^2 - r^2 = a_0^2$ one would have wave functions behaving as

$$A_y(t) \;\; = \;\; A_0 \times u^s \;\; , \;\; s = -1/2 + iy \;\; , \;\; u = (\frac{t^2 - a_0^2}{a_0^2})^{1/2} \;\; . \tag{2.2}$$

   The intensity would be of the form

$$I_y \;\; = \;\; \frac{A_0^2}{u} \tag{2.3}$$

   approaching the hyperbolic form for $t \gg a_0$. For $a_0 = 0$ one obtains exact power law behavior $I \propto t^{-1}$.

3. Oscillatory behavior is obtained if one has superposition of two waves of this kind with different values of y:

$$A \;\; = \;\; cos(\phi)A_{y_1} + sin(\phi)A_{y_2} \tag{2.4}$$

   giving

$$I \;\; = \;\; \frac{1 + sin(\phi_1 + \phi_2) \times cos[(y_1 - y_2)log(u)]}{u} \tag{2.5}$$

   approaching hyperbolic decay law for $t \gg a_0$ and diverging for $t = a_0$. Linear combinations $\sum a_n A_{y_n}$ are also possible.

What is intriguing that the form of the complex parameter s is same as for the zeros of Riemann zeta.

1. There are several reasons to believe that the zeros of Riemann zeta might play fundamental role as "scaling momenta" in TGD framework [K18]. For instance, if the spectrum of wave vectors associated with the zeros of zeta is discrete and consists of logarithms of integers so that the zeros of Zeta define quasilattice, Riemann hypothesis holds true [K18]. Furthermore, discrete spectrum for the zeros is strongly favored by number theoretical considerations since it gives hopes about p-adic algebraic continuation of the integral by reducing it to sum for both zeros of zeta and for the Fourier transform.

2. The quantization of spectrum for the distribution defined by zeros of Zeta means that the spectrum of "momenta" is integer valued in suitable units. In the recent case the momenta correspond to values of the radial coordinate r so that only the integer values $r = nr_0$ are possible. The interpretation would be in terms of discretization of the radial coordinate r and also of time. This is just what number theoretic vision suggests and the notion of p-adic manifold (see appendix of the book) requires both at real and p-adic side.

3. This argument would suggest that hyperbolic scaling law at light-cone boundary actually corresponds to a distribution

$$A(u) = \sum_y A_y(u) \ , \ \ u = \frac{t}{t_0} \ \ .$$

localized to the values $u = t/t_0 = r/r_0 = n$. This implies automatically infinite number of intereference terms in the intensity $I(u) = |A(u)|^2$ and the comparison of $I(t/t_0)$ with the experimentally determined intensity of bio-photons serves as a killer test for the proposal since only one parameter - t_0 determining the scale - appears in the model.

3 Do Dark Photons Transform To Bio-Photons?

The following text is based on comments about the article *Quantum and Holistic Response of Human Skin to H_2O_2 Stimulation* by R. P. Bajpai, A. Rastrog and A. Popp to be published in Journal of Nonlocality (JNL).

The notion of bio-photon is now well-established and there is a lot of activity in this field. It is becoming clear that bio-photons might be highly relevant for brain functions as the correlations between fluctuations associated bio-photon emission and fluctuations of EEG. Some examples of experimental work relevant to what follows are bio-photon emission from hand [I28], the effect of hydrogen peroxide H_2O_2 on bio-photon emission from radish root cells [I27], and delayed luminescence of leaves [I29].

R. Bajpai has discussed a squeezed state description of spectral decompositions of a bio-photon signal [I30, I4]. This proposal is highly interesting from TGD point of view, which relies on the notion magnetic body carrying dark matter as large $h_{eff} = n \times h$ phases identified as dark matter. Magnetic body would control living matter by its "motor actions" such as changing the thickness of a flux tube carrying monopole flux so that the strength of magnetic field and therefore cyclotron frequency changes. Dark cyclotron photons could transform to ordinary photons with the same energy identified as bio-photons and bio-photons could be seen as a kind of leakage.

Squeezed photon emission relies on a modification of harmonic oscillator mass or frequency or both meaning that the original vacuum state becomes many-photon state. The fact that the cyclotron states of charged dark matter at magnetic flux quanta indeed are essentially harmonic oscillator states suggests that the "motor action" of the magnetic body consisting of the change of flux tube thickness induces the emission of squeezed dark photons with wavelengths scaled up by $h_{eff}/h = n$ in turn decaying to bio-photons with a universal energy spectrum if the conjecture equating h_{eff} with gravitational Planck constant $\hbar_{gr} = GMm/v_0$ introduced by Nottale: $h_{eff} = h_{gr}$ indeed implies that the dark photon cyclotron spectrum does not depend on the mass of the charged particle.

This model would explain the coherence of bio-photon emission in macroscopic and macro-temporal scales. Bio-photon emission would reflect the decay of dark photons to ordinary photons identified as bio-photons. Hyperbolic decay law corresponds to exponential decay law with respect to logarithmic of time variable bringing in mind renormalization group: this replacement could reflect the fact that a scaling of causal diamond (CD) is identifiable as the geometric counterpart of subjective time in TGD inspired theory of consciousness.

3.1 Basic Ideas

In the following I try to summarize what I have understood about bio-photon emission.

1. Bio-photon emission is induced by some external stimulus, which can be light or stress of some kind, say chemical stress such as hydrogen peroxide (H_2O_2) stimulation. The signal is ultra-weak and broadband so that spectroscopy is difficult. The signal is analyzed in time domain by dividing the time interval into pieces with duration say 3 minutes and deducing photon number distribution, average photon number, and variance for each interval. The variation of the interval length is used to deduce whether signal can be modelled semi-classically as being produced by independent transitions of molecules or whether "quantum entity" is responsible for the signal. The average signal strength is constant but there are fluctuations inside bins.

2. The interpretation proposed in the article is in terms of squeezed photons: this state has minimum quantum un-certainty - that is the product $\Delta x \Delta p$ for canonically conjugate variables associated with the signal has the smallest possible value consistent with Uncertainty Principle. I understand that there is a constant average signal plus a slowly decaying tail representing the reaction of "quantum entity". The temporal coherence in long time scales is one motivation for "quantum".

3. Bio-photon signal would be produced by a decaying squeezed state with long lifetime and with hyperbolic rather than exponential time dependence. Similar model applies also to bio-photon signal generated by a dose of light: according to the article these two signals have 3 identical squeezing parameters. A further parameter having interpretation as a strength of response is not universal. Also delayed luminescence gives rise to similar signal. The suggestion is that in all cases some "quantum entity" reacts to the stimulus: chemical stress in the case of H_2O_2 stimulation.

4. The alternative interpretation based on semiclassical model assuming that statistically independent molecular transitions produce the signal does not allow to understand the signal: for instance an exponential decay rate is predicted and the response should reflect the molecular transitions involved. Also constant value of average signal strength is difficult to understand semi-classically.

There is a nice article about squeezed light at `http://tinyurl.com/y97r7eda` [B2].

1. The mathematics behind the notion is that of harmonic oscillator with slowly varying mass and frequency parameters. The vacuum state of oscillator is one example of squeezed state with minimum momentum position uncertainty (for photons photon number-phase uncertainty). Coherent state of oscillator obtained by applying resonant driving force is second example of squeezed state.

2. A general squeezed state is characterized by complex squeezing parameter $R = e^r$, and phase angle ϕ mentioned also in the article. Besides this there is angle θ telling the rotation made for the counterpart of spatial coordinate before squeezing so that squeezing is maximal for θ. To my understanding θ and ϕ describe essentially the same thing but I am not sure.

3. For amplitude (phase) squeezed state the position (momentum) uncertainty is minimized below that for harmonic oscillator vacuum state but Uncertainty Principle forces the increase of width of the distribution for phase. Now these canonically conjugate variables correspond to photon number and phase angle analogous to the rotation angle of harmonic oscillator rotating in position-momentum plane.

4. There is also a parameter called displacement (α): this parameter characterizes the displacement of the position of harmonic oscillator vacuum occurring already for harmonic oscillator under resonant oscillator force for which potential is linear on position and momentum: the stronger the force, the larger the displacement. Unlike (r, θ, ϕ) α does not seem to be universal. The value of the displacement $|\alpha|$ would naturally characterize the strength of the stimulus modelled as a resonant oscillatory external force.

5. Squeezing can be described formally in terms of an exponential of a squeezing operator analogous to an oscillator Hamiltonian. Squeezed state is defined by its exponent giving rise to a formal time evolution to be not confused to real time evolution of squeezed state which can be created by a sudden scaling of the parameters of oscillator Hamiltonian preserving the area in position-momentum plane.

   The peculiar feature of squeezed light is that in frequency domain photons appear as pairs in the sense that the state is superposition of states with even photon number.

6. Time dependent parameters in oscillator Hamiltonian is one manner to produce squeezing (`http://tinyurl.com/y89mvsnu`. The vacuum state for harmonic oscillator becomes squeezed state when (say) the frequency of the oscillator becomes time dependent. In the simplest situation the oscillator frequency could suddenly change to some other value. I have an impression that this kind of sudden change of oscillator Hamiltonian induced by the external stimulus is assumed to make vacuum state a squeezed state.

   With respect to new oscillator Hamiltonian the vacuum state is squeezed state that is superposition of many-photon states with even photon number. Squeezing in the most general case is time-dependent symplectic transformation preserving the area in position-momentum plane and as a special case one can have time dependent modulation of harmonic oscillator mass and frequency, now photon frequency. The modulation would very slow as compared to photon frequency for ordinary value of Planck constant.

3.2 The Key Challenge

Introduction discusses also what authors of and also I see as a key problem.

1. Some mechanism must provide the energy for quantum entity so that it can generate bio-photon signal or something generating bio-photon signal. This is mentioned in introduction as the basic unsolved problem. It is not at all obvious how (and even whether!) universal energy quantum of about .5 eV and considerably below the bio-photon range beginning at about 1 eV (visible and UV).

2. Two mechanisms have been proposed: explicit and implicit. Explicit mechanism involves chains of chemical reactions of reactive oxygen species helping to gather metabolic energy to that of molecules (up conversion). The signal would reflect the chemical properties of bio-molecules in the chain involved. Implicit signal would be signal coming from quantum entity and depend on its states and evolution of the response of quantum entity to the stimulus.

3. The conclusion is that the explicit mechanism is not favored and that implicit mechanism produces squeezed state. The challenge is to identify the "quantum entity" and understand whether it provide the metabolic energy directly or helps to transform ordinary metabolic energy to that of bio-photons. Also one must understand how the "quantum entity" receives its energy - presumably from Sun too.

3.3 What I Did Not Understand

There were many things that I failed to understand, basically due to the lacking background knowledge about squeezing.

1. What the estimated values of r and ϕ (equivalent with θ?) are? It would be nice to have something about this in introduction. An illustration of time evolution of a squeezed state would help enormously. A brief summary of definitions of basic parameters as Appendix would help enormously non-specialist reader.

2. The oscillator Hamiltonian involves oscillator frequency. What is the value of this frequency now and how it relates to the photon frequency? Can it be equal to photon frequency for visible light or does it perhaps correspond to the time scale for oscillation in squeezing (phase rotation). Or can this frequency be interpreted in terms of amplitude modulation.

   I saw in Wikipedia an example in which the variation of phase uncertainty corresponds to a period of 10-100 ms. This is bio-logical time scale range. It would be nice to have a comment about the value and possible origin of the slow time scale associated with the squeezing since it would naturally relate to the time scale of macro-temporal quantum coherence.

3.4 TGD Inspired Comments

Some TGD inspired comments are in order since the squeezed light would be very naturally be induced by "motor actions" of magnetic body.

3.4.1 Do motor actions of the magnetic body induce squeezing?

1. TGD predicts a hierarchy of Planck constants $h_{eff} = n \times h$ and suggests that cyclotron frequency modulation is one of the key mechanisms in living matter. For instance, the variation of membrane potential would induce modulations of generalized Josephson frequency which is sum of difference of cyclotron frequencies and the ordinary Josephson frequency $f_J = 2eV/h_{eff}$. The modulation of the frequency and amplitude of harmonic oscillator to yield time dependent symplectic transformation is one mechanism producing slowly varying squeezing. Low frequency modulation of this kind could produce also dark photons which according to TGD inspired proposal would transform to ordinary photons with same energy identified as bio-photons.

2. In TGD framework the squeezed state would be that of dark photons with $h_{eff} = n \times h$ and much larger than ordinary Planck constant to guarantee that VLF or even ELF frequencies correspond to energies in the range of bio-photon energies ($E = h_{eff}f$). This must be taken into account when if one tries to model the situation. The large value of h_{eff} would explain the slow time scale of squeezing naturally. For the ordinary value of Planck constant the time scale of squeezing is gigantic as compared to the natural time scale assignable to visible photons (about ten femtoseconds).

3. An instantaneous change of the frequency of harmonic oscillator produces squeezed state. The change of the thickness of the magnetic flux tube would change the value of magnetic field strength (by flux conservation) and thus of cyclotron frequency $\omega = ZeB/m$. This would affect the oscillator frequency (cyclotron states can be regarded as harmonic oscillator states) so that the outcome would be squeezed state. Do "motor actions" of magnetic body induce squeezed photon states? Does magnetic body react to stimuli by changing the thickness of its flux tubes?

4. Could a phase transition changing the value of Planck constant induce a squeezed state? The answer is negative. If the scalings $x \to nx$ and $\omega \to \omega/n$ take place in the phase transition $h \to n \times h$ as has been assumed then $h \to n \times h$ respects the property of being energy eigenstate property and vacuum goes to vacuum.

The following comment is not directly related to squeezing but to possible interpretation of phase transitions changing Planck constants as singular symplectic transformations (symplectic group of $\delta M_+^4 \times CP_2$ is isometry group of "world of classical worlds" (WCW).

1. Magnetic flux is invariant under symplectic transformations defined by magnetic field for the surface over which it is taken. These symplectic transformations have nothing to do with those of phase space since they act at the level of space-time. One can still ask whether transformations analogous to basic squeezing could make sense.

2. A especially interesting choice of symplectic variables corresponds to the choice of cylindrical coordinates (ρ, ϕ). The symplectic transformation $(\rho, \phi) \to (\rho/a, a \times \phi)$ for $a = n$ would scale does the thickness of the flux tube by integer n and increase the angular range from 2π to

$n \times 2\pi$. A possible interpretation is that one obtains a multi-sheeted covering by allowing the original variable ϕ to have range $n \times 2\pi$.

3. What makes this interesting is that just this kind transformation is assumed to take place in the transition $h \to h_{eff} = n \times h$ and lead to n-fold singular covering of space-time surface. Could the phase transition increasing Planck constant correspond geometrically to a singular symplectic transformation leading to n-fold covering and radial scaling at the level of space-time?

3.4.2 What is behind the hyperbolic decay law of the squeezed state?

One should also understand the hyperbolic decay law of the squeezed state.

1. What causes the slow hyperbolic decay of the squeezed state? Hyperbolic decay corresponds to the exponential decay $dN/d\tau = -kN + R$ but with time variable u which is logarithm of ordinary time variable: $\tau = log(1 + t/t_0)$ (note the convention $u(t = 0) = 0$). This gives decay law

$$N(t) = N(0) \times \left[1 + \frac{t}{t_0}\right]^{-k} + \frac{R}{k} \quad .$$

For $k = 1$ one obtains $x \propto 1/t$ hyperbolic behavior for large values of t. Somehow the ordinary linear time is replaced by its logarithmic variant.

2. In TGD framework the decay would correspond to the gradual decay of dark photons to ordinary photons. The decay kinetics for dark photon number N_D and bio-photon number N_B would be described by two equations:

$$\frac{dN_D}{du} = -kN_D + R \quad , \quad dN_B = kN_D \quad , \quad u = log(\frac{t}{t_0} + 1) \quad .$$

The rate for emission of bio-photons would be now

$$\frac{dN_B}{dt} = kN_D(0)\left[1 + \frac{t}{t_0}\right]^{-k} + R \quad .$$

$k = 1$ gives hyperbolic decay law. Note that the rate approaches to the rage R of dark photon production: constant background intensity of bio-photons has been indeed observed.

3. What is the mechanism replacing the time coordinate with its logarithm in the decay law? The logarithmic behavior strongly suggests a connection with a renormalization group approach relying on scaling invariance: the extension of 2-D conformal invariance so that it makes sense in 4-D context is indeed the basic symmetry of quantum TGD. Time evolution would correspond to scaling. Scale invariance implies that the logarithm of the scale appears as an evolution parameter in renormalization group evolution. Zero energy ontology would suggest that time coordinate corresponds to the scale characterizing the size of causal diamond (CD) and that time evolution for the bio-photon emission corresponds to a quasi-continuous scaling of CD.

4. In TGD inspired theory of consciousness the correspondence between subjective time and geometric time reduces basically to the identification of time evolution as subsequent scalings of CD occurring in repeated state function reductions, which would in ordinary quantum measurement theory leave the state invariant.

3.4.3 Where do bio-photons get their energy?

The basic problem of bio-photon scenario is the mechanism providing the metabolic energy for bio-photons. Ordinary metabolic energy quantum is around .5 eV and below visible energies.

1. In TGD the quantum entity would be magnetic body with hierarchical onion-like structure with layers, whose sizes can be even larger than that of Earth. Cyclotron frequency defines time scale and for large $h_{eff} = n \times h$ the frequency of cyclotron photons can be even in ELF range (say in EEG range). h_{eff} would thus scale up the time scale of coherent and the values of h_{eff} deduced earlier are so large that it could be measured in time scales assigned to EEG.

2. In TGD framework one can consider the possibility that cell membrane as generalized Josephson junction and in microscopic description membrane proteins acting as generalized Josephson junctions generate dark photons in visible and UV range and these in turn transform partially to ordinary photons identifiable as bio-photons. Could ordinary metabolism excite the dark cyclotron Bose-Einstein condensed (like laser in population reversed state)?

3. Or could the magnetic body associated with the bio-systems receive this energy directly from Sun: as ordinary solar photons transform to dark photons at magnetic body. I have considered a mechanism for creating CDs (not causal diamonds now but coherence regions of water of size of order micrometer suggested by Vitiello and Del Giudice (`http://tinyurl.com/yagy3fcu`) [I7]). Inside CDs were water molecules would be excited to energies slightly below the bond energies in the exclusion zones (EZs): the difference would be just the metabolic energy quantum .5 eV.

   Metabolic energy quanta could generate EZs of size of large neuron by splitting O-H bonds and giving rise to $H_3/2O$ stoichiometry inside EZs. My own crazy proposal is that the UV energy about 12 eV comes directly from Sun as ordinary photons and travels as dark photons along flux tubes of magnetic body to the organism and partially transform to bio-photons. This model can be generalized to include dark photons covering entire spectrum of bio-photons (there is an argument predicting that the spectrum of dark photons is universal and that of bio-hotons). A precise model for energy balance might help to conclude that "quantum entity" providing additional metabolic energy must be there.

   For year or two ago there was a discussion in Journal of Non-Locality about people claimed to be able to receive their metabolic energy from solar radiation and just for fun I considered a model based on dark photons and involving same mechanism as appears in metabolism. I also remember of having seen years ago a paper about problems in attempts to understand energy balance in brain but do not remember more about this.

3.4.4 Squeezing and entanglement

A very interesting variant of squeezed state mentioned in `http://tinyurl.com/y97r7eda` [B2] is two-photon squeezed state. In this state the amplitude to begin with is product of two vacua, which is unentangled state. The other vacuum is squeezed up in position by R and other one down by $1/R$. This produces entangled state, which is highly interesting bio-logically: could this entangle "quantum entity" and the receiver of the radiation? Is it possible to interpret the findings about bio-photons in terms of two-photon squeezing?

4 How Could Dark Photons And Phonons Relate To Consciousness?

One of the basic objections against the identification of moment of consciousness as quantum jump is that contents of consciousness corresponds always to change. How it is possible to code anything about the states of the world if this is the case? For instance, how conscious entity can construct a self model which by definition should correspond to something which is approximately invariant in quantum jump sequences? Negentropically entangled subsystems indeed can be parts of the

state approximately invariant under dynamics dictated by Negentropy Maximization Principle (NMP) [K12].

The manner to circumvent the objection comes from the notion of interaction free measurement: the conscious information about invariant part of system, say self model, could be obtained by interaction free measurement, which involves state function which leads the incoming photons to interaction free state. This information would be obtained as sequences of bits and might be correspond to declarative, verbal memories rather than direct sensory experiences.

4.1 What Does Bomb Testing Have To Do With Cognition And Consciousness?

Dark photons decaying to bio-photons could be involved with the basic cognitive processes like memory recall involving interaction free measurement. At the ideal limit the photon which interacts with a subsystem representingbit of memory mental image suffers state function reduction to a path at which it does not interact with the memory system in the usual sense. Hence memory mental image is not affected at all at this limit. The following model for memory recall is discussed in the article "A Vision about Quantum Jump as a Universal Cognitive Process" (see `http://tinyurl.com/yc46pq86`) [L2]

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement, see `http://tinyurl.com/kx2jsyu` [B1] for illustration of the system considered.

    The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

    The system involves four lenses and two detectors C and D. In the first lense the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

    (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lense). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lense and ends up to detector C or D through lense.

    (b) If the bomb is dud, photon travels through both paths and interference at the lense leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.

2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state function reduction is an interaction which can eliminates the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

This picture is only metaphorical representation of something much more general.

1. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.

2. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining

one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.

4.1.1   Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a bit can be considered. The model applies also to the reading of future plans (memories on reversed time direction).

1. Reading of a particular bit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit. Memory bit to be read would be mathematically analogous to bomb in the Elizur-Weizman bomb tester thought experiment in which one tries to determine whether bomb is active (bit 1) and can therefore explode or passive (bit 0) and cannot explode.

2. A possible problem is that the analogs of detectors C and D for a given qubit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?

3. ZEO means that zero energy states appear have both embedding space arrows of time and these arrows appear alternately during periods of repeated state functions having no effect at the other boundary of CD. This dichotomy would correspond to sensory representation-motor action dichotomy and would suggest that there is no fundamental difference between memory recall and future prediction by self model and they different only the direction of the signal.

4. Since photon absorption is the basic process, the conscious experience about the bit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.

Some comments are in order.

1. To avoid misunderstandings it should be emphasized that TGD based view about memory is not the same as the standard view. In ZEO brain is four-dimensional and in principle memories can be negentropically entanglement memories in geometric past. It is possible to build copies of memories by memory recall, and learning would correspond to a generation of large enough number of copies of the memory mental image. Memory recall could be seen as a negative energy signal inducing the interaction free measurement of memory qubits. Dark photons with EEG frequencies (say in theta band characterizing hippocompus) but having energies of visible photons could be involved with the memory recall. Correlation between EEG and bio-photons supports this view.

2. If the systems taking the role of the detectors C and D in interaction free measurement are analogous to population reversed lasers, their return to the ground state could automatically generate virtual sensory input propagating to the sensory organs and allowing to check

whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected however to be much shorter than that for a typical neuronal activity.

Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J14] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about .1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity. This mechanism could also explain generation of after images.

3. Photons can be replaced with phonons or quanta of any other wave motion with constant propagation velocity (no dispersion of signal) in a given reference frame. This suggests that imagination and internal speech correspond to the two reading mechanisms of memories.

4.2 Why Vision And Hearing Are So Fundamental For Cognition?

The interaction free measurement of bits of sensory and memory representations is formulated in terms of photons. It can be however formulated also for sound waves using phonon detectors and acoustic waves traversing through two different paths. Quantum coherence is required but the hierarchy of Planck constants makes sense also for phonons by the basic equation $E = hf$.

In TGD framework there are good reasons to believe that sound waves are not only something emerging at the level of condensed matter but correspond to oscillations of string like objects at 4-D space-time surface. These strings connect the wormhole contacts assignable to the light-like orbits of partonic 2-surfaces. Partonic 2-surfaces can be assigned with elementary particles but also to 2-surfaces with arbitrarily large size scale. The outer boundary of any physical object would correspond to a partonic 2-surface. String world sheets carry fermion fields localized at them (right-handed neutrino is an exception in that it is de-localized at entire space-time surface). The fact that strings always connect two partonic 2-surfaces corresponds to the fundamental two-particle character of sound waves. Sound would be as fundamental phenomenon as photons and other massless bosons.

This encourages to ask whether photon (more generally gauge boson: TGD suggests that scaled up copies of gluons and weak bosons behaving like massless particles even in cell length scale are possible) and photon absorption could define fundamental potentially representations of information in terms of bits realized in terms of interaction free measurements. Negentropic entanglement at the passive boundary of CD would define another representation, which is directly conscious. Negentropic entanglement is possible also at active boundary but is not absolutely stable.

Photons would correspond to "seeing" but at neuronal level rather than at the level of retina - and imagination. Phonons would correspond to hearing at neuronal level and internal speech which is also essential for cognition. Both internal speech and imagination could be understood at fundamental aspects of cognition. Dark photons with energies of visible photons (decaying to what is interpreted as bio-photons) and dark phonons would be behind imagination and internal speech. I have already earlier proposed that the lipid layers of neuronal membranes (and maybe also ordinary cell membranes) can be regarded as pixels of a sensory map representing neuronal qualia [K7]. These pixels could serve as the counterparts of the detectors C and D appearing in interaction free measurement.

The evidence for the importance of bio-photons (in TGD framework dark photons decay to bio-photons in energy conserving manner) in biology and neuroscience is emerging, see for instance the experiments of Persinger's group [J17, J18, J19]. I have discussed these findings from TGD point of view in [K4]. One can speculate about direct translation between the words of language and visual pre-images. Something like this one might expect.

Biophotons seem to be associated only with the right hemisphere [J17]. This suggests that right hemisphere or some parts of it prefer dark photons being thus specialized to visual imagination in accordance witht the fact that spatial relationships are the speciality of right hemisphere. Could

this mean that left hemisphere or some pats of it prefer dark phonons? Left hemisphere indeed is the verbal hemisphere specialized to linear linguistic cognition and produces also internal speech.

4.3   Dark Photons, After Images, And Mechanism Of Learning

After images are generated when one stares to bright light source for some time. Anyone can observe how the after images develop. After images drift gradually downwards suggesting that they are indeed generated at the retina and their source drifts downwards in gravitational field. After image also reappears periodically and can change their color in each re-appearance.

It has been suggested that bio-photons could be responsible for the generation of after images. In TGD framework the after images would be generated by dark photons decaying to bio-photons.

1. Delayed luminescence has been proposed as explanation. The light absorbed by retina from intense light-source emitted partially as bio-photons could define the secondary source. This is a possible mechanism since retina is sensitive to even single photon. One can however ask what is the real mechanism behind delayed luminescence.

2. Consciousness theoretic explanation based on the model fo sensory receptor as an analog of capacitor which suffers di-electric breakdown. There is some recovery time. Looking into bright light-source generates visual sensation but requires a long recovery time. The image is regenerated after the recovery. Visual mental images define conscious entities (selves) and just as we do they also would have sleep-awake cycle). Where the sensory input comes or do bio-photons resulting in the decay of dark photon BE condensates generate it. Why the periodic appearance and why the gradual change of color? Could it be that the photons rotate in a large loop identifiable as a closed magnetic flux tube? Does the time constant (length of loop) for a visual receptor depend on the peak frequency for which it is sensitive.

3. Or is a generation of copies of visual memory in question? Magnetic body or brain generates a virtual sensory input as dark photons transforming to bio-photons at retina. Internal speech involves similar echo like effect and also piece of music is recalled repeatedly. Could delayed luminescence provide a mechanism of memory storage: the repetition of the stimulus increases the probability of memory recall in TGD based model of long term memory as a communication with the geometric past?

   As a matter fact, delayed luminescence could be seen to reflect the presence of a deeper level cognitive mechanism rather than vice versa. The periodic appearance of after images could be a process in which retina receives periodically a virtual sensory input - perhaps from magnetic body via brain - and generates as a response nerve pulse pattern, and perhaps also dark photons generating a memory mental image which is negentropically entangled with the earlier memory representation.

   In this process memories representing the after image are read and the interaction free measurement involved with the process excites laser like systems which then generate radiative response defining the virtual sensory input, which then generates genuine sensory input. One could speak of a repeated echo. Why the color of the after image changes could be understood if the decay of the laser like states generates photons with several energies.

   Similar echo generating mechanism for dark phonons instead of photons could explain why during sleep and also during wake-up state some word of internal speech repeats itself.

4.4   Realization Of Memory Representations In Terms Of Braided Flux Tubes

The obvious question is how various representations (sensory -, memory -, ...) - "Akashic records" - are realized as negentropically entangled states?

Magnetic body should be the seat of memories in some sense.

1. I have already earlier proposed this kind of realization based on the observation that braiding in time direction generates space-like braiding [K1]. Dancers on the parquette with their feet connected to the wall by threads illustrates the idea. When dancers move at the parquette

their world lines define a time-like braiding in 3-dimensional space-time assignable to the floor. Also the threads connecting the dancers to the wall get braided - or entangled - as one might also say. There is clearly a duality between time-like and space-like braidings: the running topological quantum computer program coded by braiding in time direction is stored as space-like braiding defining memory representation of what happened. Note that same mechanism realizes also predictions and future plans as time reversed topological quantum computer programs in ZEO. CDs in various scales contain this kind of programs and their memory representations.

2. I have also proposed that the geometric entanglement - braiding - of flux tubes defines a space-time correlate for quantum entanglement. In the case of topological quantum computation it would be naturally described by probabilities, which are rational numbers (or perhaps even algebraic numbers in some algebraic extension of p-adic numbers characterizing together value of the p-adic prime the evolutionary level of the system). Hence the notion of number theoretic negentropy makes sense and one obtains a connection with topological quantum computation.

3. The representation of memories in terms of space-like braiding of magnetic flux tubes connecting various systems would be universal, and not restricted to DNA-cell membrane system in which the flux tubes would connect DNA nucleotides [K1, K19] or codons (this seems to be the more plausible option [K4]) with the lipids. One could indeed speak about Akashic records (`http://tinyurl.com/5hxjpr`).

4. The time reversals or these representations defined by the zero energy states of opposite arrow of the embedding space time would define a representation for future predictions/ plans in ZEO. For instance, the development of a seed to a full-grown organism could be coded in this manner in time scale where CD has time scale of order of the lifetime of the organism. Already Burr found evidence that the radiation field assignable to the seed has the same shape as the plant [I20, I23] or animal (salamander in his experiments). This energy field would naturally correspond to the magnetic body containing dark photon Bose-Einstein condensates. The Akashic records and their time reversal would naturally correspond to the morphic fields of Sheldrake [I25, I26]: memories and future plans in time scales longer than than duration of life cycle for an individual member of species would be possibles. Every scientist of course agrees that the societies are busily predicting and planning their futures but find very difficult to accept the idea that this could have some concrete quantum physical correlate.

4.5 How To Construct And Read Conscious Hologram?

There is also another question to be answered. How the vision about brain as a conscious hologram is realized in the proposed conceptual framework?

The idea about living system as a hologram has strong empirical basis. One of the most dramatic demonstrations of the hologram like character of brain was the discovery of Pietch [J31] that salamander's brain can be sliced to pieces and shuffled like a deck of cards and put together. When the resulting stuff is returned to the head of the salamander, it recovers! This extreme robustness is very strong support for the non-local hologram like storage of biological information. Ironically, Pietch tried to demonstrate that the theory of Karl Pribram [J28, J29] about brain as a hologram is wrong!

In TGD framework one can go even further and ask whether this robustness actually demonstrates that various representations (sensory - , cognitive -, memory -...) are realized at the long magnetic flux loops and sheets of the magnetic body rather than brain: one of the most disptable ideas of TGDi based quantum biology.

The notion of conscious hologram [K3] is one of the key ideas of TGD inspired theory of consciousness. Hitherto I have not been however able to find a really convincing concrete proposal for how brain could be a hologram in TGD Universe. The reading of memory - and other representations by interaction free measurement however leads to a natural proposal for what the hologram might be.

1. The formation of the hologram must closely relate to the vision about bit representations of memories possibly realized in terms of braided flux tubes and their non-destructive reading by interaction free measurement. Oversimplifying, tor a given bit of the representation the photons scattered without interaction would kick either of the two detectors C and D associated with it to an excited state (see `http://tinyurl.com/y86ysuyd`). This process is very much like absorption of photons by a photosensitive plate defining an ordinary hologram.

2. The lipids of the cell membrane are good candidates as something in 1-1 correspondence with the basic units of this hologram (note the analogy with computer screen - also a liquid crystal!). If one irradiates the laser like system formed by the detectors not only by the radiation scattered from the memory bits sbut by its superposition with the reference wave of same frequency, one obtains a good candidate for a hologram. It would be defined by the excited quantum state consisting of laser systems analogous to the detectors C and D. Any piece of the system should give and approximate representation of the memory and robustness of the representation is achieved.

3. In semiclassical treatment the probability that a given laser like detector is excited must be proportional to the modulus squared of the net field amplitude, which is a superposition of reference wave and scattered wave Also just. as in the case of ordinary holograms, the irradiation of the laser like system by the negative energy counterpart of the reference wave (its phase conjugate emitted in a state resulting in state function reduction to the opposite boundary of CD) effectively generates the conjugate of the scattered wave since only those parts of the system can return to the ground state with considerable probability for which the probability to go to excited state is high enough. Note that this implies that magnetic body contains geometric representations of the perceptive field as indeed assumed [K10, K11]. This is however not quite the classical hologram. Rather, the total number of absorbed negative energy phase conjugate photons for given pixel defines the "real" picture. A given point of the hologram corresponds to an ensemble of laser like detectors so that a statistically deterministic response is obtained as an ensemble average.

How to realize this concretely?

1. The lipids of cell membrane could serve as pixels of sensory representations [K7] defining conscious holograms. Each pixel should contain large number of laser like "detectors" so that statistical determinism would be achieved.

2. The basic structural element would be pair C and D of detectors such that either of them absorbs photon in an interaction free measurement so that a value of bit is defined. Universality serves as a strong constraint as one tries to guess what C and D could be.

   (a) The lipids at the two lipid layers of cell membrane could be in 1-1 correspondence with C and D. This option is not however universal.

   (b) It is however quite possible that the magnetic fields involved are what I have called wormhole magnetic fields [K20], which carry monopole fluxandinvolve two space-time sheets carrying opposite net fluxes. As a matter of fact, all elementary particles correspond to flux quanta of wormhole magnetic fields. In this case the two sheets would naturally correspond to detectors C and D and in the simplest situation they would have same Minkowski space projection. Universality of both detectors and holograms is achieved.

3. The cyclotron Bose-Einstein condensates for charged particles at magnetic flux tubes assignable to lipids are good candidates for the laser like systems if they contain cyclotron Bose-Einstein condensates. There are however several options since the magnetic flux tubes are closed and there are several ways to realize this.

   (a) DNA as topological quantum computer vision [K1] and the view about cell membrane as a sensory receptor communicating data to the magnetic body in turn sending control signals via DNA suggest the following. Magnetic flux loops have a part connecting DNA with nuclear or cell membrane (this would be the analog for the dipole of the dipole

magnetic field) and part which is long - even with size scale of Earth and corresponds to the magnetic field created by the DNA-cell membrane system. This picture applies both to the flux tubes of ordinary magnetic field and to the flux tubes of the wormhole magnetic field.

(b) An assumption in accordance with the general role of magnetic body is that Akashic records reside at the short portions of flux tubes connecting lipids with DNA codons: their braiding would define basic example about universal representations in living matter. The laser like detectors would reside at the long portions of the flux tubes connecting cell membrane and DNA. If wormhole magnetic fields are in question, the detectors C and D could correspond to the two parallel flux tubes carrying opposite monopole fluxes.

(c) Universality suggest that this picture allows many alternative realizations. In principle, the relative motion of any system (partonic 2-surfaces with light-like orbits) connected by flux tubes could give rise to Akashic records. The lipids of axonal membrane are excellent candidates for the pixels and the flux tubes connecting the lipids to microtubuli [J1] would also define Akashic records with long parts of the flux tubes serving as the laser like system. The maximization of the memory capacity would also explain why the neural pathways to brain tend to maximize their lengths by connecting right side of the body to left hemisphere and vice versa.

4. What remains still open is how to integrate the Josephson junctions defined by the lipid layers of the cell membrane to this picture.

4.6 Some Critical Questions

There are two basic objections against quantum theories of consciousness. How it is possible to have conscious information about invariant under quantum jumps if only change is experienced continuously? The outcome of state function reduction in standard quantum theory is random: how can one understand freedom of choice and intentional behaviour in terms of state function reduction? NMP and the possibility of negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) imply that TGD based quantum theory is not equivalent with the standard one, and this allows to circumvent the objections.

The experiments carried out to test whether 40 Hz thalamocortical resonance is correlate for conscious experience suggests that the resonance is present only when a new pattern is discovered, not when it has become a memory. The TGD inspired interpretation would be that the resonances accompanies negentropy gain and quantum jump is necessary for a conscious experience. However, the reports about higher states of consciousness suggest that the invariants can be experienced directly when all thoughts (interaction free measurements) are eliminated. This experience cannot be however communicated: one understands does not know what one understands. Therefore also the original vision that negentropic entanglement corresponds to a conscious experience - experience of pure understanding, which is not communicable - and in apparent contradiction with the basic hypothesis about quantum jump, would be correct after all! Only the identification of the hierarchy of quantum jumps as self hierarchy would be wrong.

5 Taos Hum As Evidence For Biophonons?

Taos hum is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [I19] a thorough review about nocturnal taos hum is given and the following representation relies on this article). Very concisely, taos hum seems is apparently a subjective experience without identifiable objective counterpart, and could therefore correspond to dark photons and/or phonons eventually transforming to ordinary sound and generating the experience. In the following basic facts about taos hum are summarized and some alternative TGD inspired explanations of taos hum are considered besides the original explanation as microwave hearing.

5.1   Basic Facts

Taos hum is perceived in and around Taos, New Mexico but similar phenomena are experienced also in Northern America and Northern Europe. The hum is mostly heard during night time. Most people experience the hum as irritating and it causes nocturnal disturbances. From the tests based on psychophysical matching the frequency range of the hum has been deduced to be 40-80 Hz and whereas amplitude is around 60 dB. The hum is a regional phenomenon. The hum does not usually appear between sunrise and sunset. The pitch and intensity of the hum varies inside house and finds the largest magnifications on lower floors. Rooms modify the hum by adding distinctive harmonics to it. The pitch of the hum changes when one moves from outer wall to the interior rooms. Hallways and small alcoves raise the pitch considerably. The wavelengths involved vary between 3.9-7.8 meters for 40-80 Hz frequency range which suggests that resonance effects could be involved. It has been however impossible to identify any acoustic origin for the phenomenon. The presence of effectively acoustic effects suggests that a gigantic amplification by the physical (and magnetic!) body of the patient is involved.

Hum can involve also an experience about whirling or roaring wind, kind of vortex although nothing moves around, and coming from all directions. Also a strange amplification of distant sounds can be experienced. White light in the horizon in the direction where hum comes from can be also perceived. Experiences analogous to hum have been reported also in past, even in antique ("Aeolian wind"), but nowadays the number of victims of the hum has increased, which suggests a connection with the emergence of electronics and computers. The direction which hum is experienced to come from seems to be random.

The hum can be accompanied by irritating tactile sensations and neuralgic pain. The unfortunate individual who suffers of extreme HUM disturbances, seems to be controlled by very fundamental and autonomic response-reflexes when in it grips. Such sufferers may behave in semi-conscious modes, modelling behavioral patterns seen only in animals. Typically the victim tends to get underground believing that this allows to get him rid of the hum. The victims of hum indeed tend to wake up with the realization that they have very strong and painful muscle tenure.

An important hint as regards to mechanism of hum is the fact that the temporal patterns of the shortwave radio static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the statics is present during night time.

All attempts to detect the hum instrumentally and to identify its source have failed. This has inspired various kinds of conspiracy theories about the nature of the phenomenon, for instance, the proposal the strong ELF power feed by submarine radars alone could explain the phenomenon.

5.2   Phenomena Possibly Related To Taos Hum

It is appropriate to discuss first some phenomena possibly related to the taos hum before considering the model for the phenomenon itself.

5.2.1   Microwave hearing

Microwave hearing [I11] is a phenomenon in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [I6] and that the sensation of hearing could result as back-projection from cortex to ears.

This, and the correlation with microwave static suggest that taos hum could be a particular case of microwave hearing. The model of sensory representations implies that brain acts as a sending microwave antenna: a natural implication is that brain can act also as a receiving microwave antenna. The size of the brain hemisphere corresponds to a microwave frequency of order 3 GHz and smaller structures inside brain correspond to higher radio frequencies.

If primary sensory organs are the seats of the sensory qualia and back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves - assuming that they underlie Taos hum - also must interact also with the sensory receptors at the skin.

Why taos hum? Could animals use microwaves for "seeing" in absence of sunlight? But for what purpose plants would use microwaves? Could organisms send negative energy $h_{eff} = n \times h$ [?] microwaves to environment and suck metabolic energy quanta with energy around .5 eV in this

manner? Remote metabolism! Or maybe time reversed photosynthesis in dark! Biophotons indeed have energy spectrum in visible and UV as also sunlight does. This would require non-standard value of Planck constant.

This hypothesis would explain why the microwaves causing taos hum not hum are not observed directly. And if something is sucking metabolic energy from you, it is would be rather natural to experience very unpleasant feelings and try to find a place to hide as many sufferers of taos hum try to do!

5.2.2 Physiophonic effect

Physiophonic effect is a phenomenon accidentally discovered by Antonio Meucci in 1842, in which vocal signals are electrically transmitted directly into the neurology of listeners [I19]. Physiophonic sound can be often amplified to an enormous volume. A possible interpretation is as externally stimulated internal sound but one can of course wonder whether the transduction to sound is necessary.

Since the body (especially collagen network) is liquid crystal allowing piezoelectric effect in which mechanical vibrations are transformed to electric signal, external sounds could be transformed to electric fields. On course, LC property implies that also genuine sound is generated so that both ELF em fields and ELF sounds can act as amplified signals. One can ask whether strong back-projection to the ears is generated so that sound percept results. This would imply oto-acoustic sounds directly detectable by microphones not found in the case of taos hum.

5.2.3 Microwave static and taos hum

It is known that the temporal patterns of the shortwave static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the fact that the static is present during night time would explain why hum is experienced at night time.

5.3 Possible Ingredients For The Model For Taos Hum

The facts about the role of the musculature, shortwave radio noise, and the role of acoustic environment combined with the model of microwave hearing based on the notion of dark photons [K9] pose strong constraints on the model of taos hum.

5.3.1 Taos hum as sensitivity to external biological control signals

Magnetic bodies control biological body by sending control commands to brain and body where they are transformed to nerve pulse patterns and various physiological waves. Also the lower levels of self hierarchy should control the respective levels of the hierarchy, in particular muscle cells, in a similar manner. In the case of hum patient the normal control signal could be replaced by a control signal from some external biological source, say plants, and would be responsible for the muscular vibrations amplified to the hum. In the worst situation the behavior of hum patients reduces to simple reflex actions: these reflex actions would be initiated by fake control signals.

The fact that the taos hum begins after the sunset would conform with the interpretation as sucking of metabolic energy with energy quanta in visible and UV range. The loss of metabolic energy could explain why the experiences of patients are so unpleasant. Since motor action is based on negative energy signals affecting directly neuronal membranes by the same mechanisms as ordinary motor actions the signals would also induce reflex actions.

The situation could be due to the failure of the em (or rather, electro-weak) immune system of the patient. In order to understand what is involved a brief discussion of model of motor control based on charge entanglement induced by W MEs is necessary: a detailed model is discussed in [K8, K9].

1. The exotic ionization of dark matter induced by W MEs generates dark plasma oscillations inducing electric fields which by many-sheeted variant of the Faraday law induce electric fields also at the space-time sheets where ordinary matter resides. Various ionic waves, in

particular Ca^{2+} waves and nerve pulse are examples of the physiological responses resulting in this manner.

2. Dark plasma frequency corresponds to a microwave photon with energy above the thermal threshold and the system must be able to provide dark photons with this energy to generate plasma oscillation patterns serving as control commands.

The electro-weak immune system could fail in the following manner.

1. In the healthy situation em immune system takes care that the body is tuned to the personal dark plasma frequencies and does not respond to control commands from alien magnetic bodies associated with, say, plants.

2. In an un-healthy situation persons plasma oscillation frequencies are tuned to some frequencies in the microwave static and microwave static provides the energy needed to generate plasma wave patterns and thus to realize control commands from the alien magnetic bodies. The plasmoids would induce microwave hearing and generalized motor actions at cellular level exhausting the personal metabolic sources and leading to the painful experiences and fatigue.

5.3.2   Taos hum and microwave hearing

The identification of the audible sensation associated with taos hum in terms of microwave hearing could explain the failure of the attempts to identify the source for taos hum. Amplitude modulation by ELF frequencies naturally associated with motor control would give rise to sensation of sound.

Concerning the model for microwave hearing, a good guideline is that the effect is expected to be possible as quantum effect only if the energies of the microwave photons are above the thermal threshold. This would require dark microwave photons for which 5 GHz photons have energy above thermal threshold (6 cm wavelength). Same applies to other effects caused by dark microwave photons.

Microwave hearing itself would rely on hearing of dark microwave photons at visible and UV frequencies. These dark microwave photons could accompany the microwave signal automatically or could be generated by cells via a phase transition increasing the value of Planck constant.

5.3.3   Taos hum and microwave seeing

The de-coherence of microwave photons to ordinary photons would produce the biological effects. This could explain also the reported perception of white light as resulting from the de-coherence of the microwave photons at the upper end of the spectrum: 1 mm microwave wavelength would correspond to 2.5 eV photon energy.

The de-coherence of dark microwave static to ordinary visible photons could make possible microwave vision during night time. This could explain why the static emerges after the sunset. Plants could also generate negative energy dark microwave photons with energies in the frequency bands of visible photons involved with photosynthesis to satisfy their metabolic needs when they do not receive sunlight. One can of course wonder whether the quartz in the rock heated during day-time could generate dark microwave photons during night-time serving as a metabolic source.

5.3.4   Taos hum as a failure of the electromagnetic immune system

Taos hum starts immediately after the sunrise and stops after the sunset and seems to have a biological origin. The magnetic bodies of (say) plant cells could send dark energy photons at microwave frequencies above 5 GHz: one reason is that they become visible in this manner.

Negative energy W MEs in the same frequency range and responsible for quantum bio-control in the time scale of microwaves could be involved. Due to the failure of the electro-weak immune system the surrounding biosphere could induce generalized motor actions and these would exhaust the metabolic energy resources of the victim. This would explain why the hum is intolerable and the extreme fatigue caused by it.

The radio noise generated by computers and other sources of radio waves should not cause troubles if these radio waves correspond to ordinary photons. If not, then the microwaves in question could provide the energy needed to realize alien control commands based on ELF modulation.

5.3.5   An explanation for 40-80 Hz modulation

The model of biological evolution and evolution of nervous system based on dark matter hierarchy [K6] leads to sa detailed identification of the values of Planck constant associated with EEG identified as of dark Josephson radiation with energies in visible and UV range and EEG frequencies. This level is involved with all life forms capable of genetic expression, in particular plants. Therefore the ELF modulation of microwave frequencies could be due to the control commands from the levels of the magnetic body normally meant to control the genetic expression of say plants. The modulation of the microwaves with EEG frequencies, in particular with the frequencies in the $37 - 44$ Hz thalamo-cortical resonance band, could force the patient to stay awake by not allowing the dominant EEG frequencies to drop down to theta and delta region of EEG as occurs during sleep.

5.3.6   Is stochastic resonance involved?

One could also ask whether the microwave static of victims of taos hum is anomalously amplified by some mechanism so that control commands from alien magnetic bodies can be realized. The transduction of weak microwave signals to mechanical oscillations by piezo-electric body liquid crystals, and the amplification of this signal in the presence of a metabolic energy feed to the musculature, could lead to this kind of situation.

Stochastic resonance with white noise generated by body provides one possible amplification mechanism. Micro-wave frequency would correspond to the amplified frequency. If so, one could perhaps understand why only some persons experience the hum and why the effect is strong at night time. White noise would be generated by body. White noise induces jumps between the states of the 2-state system with an average frequency f_K (Kramers frequency) which depends on the autocorrelation function of the white noise and the properties of the 2-state system [K17]. If the Kramers frequency satisfies $f_R = 2f$, where f is the frequency of the signal, a resonant amplification occurs. The dependence $f_K \propto exp(-\Delta V/D)$, where $\Delta V > 0$ is the height of the potential barrier separating the states of the 2-state system, implies and exponential sensitivity of f_K on $1/D$, where D is the intensity of the white noise. Hence the failure of the em immune system could be due to the too intense white noise produced by the body of the victim or due a too low height of the potential barrier.

5.3.7   Are electronic systems involved with the hum?

The fact that the number of victims of hum has rapidly increased during the era of radio communications and computers and suggests that both radio noise and computers might be actively involved with the hum. Also ELF noise from electronic systems might be important if these systems generate dark ELF photons.

Electronic instruments generate also frequencies in the range $40 - 80$ Hz, in particular the 50 Hz frequency associated with the household electricity. Also submarine radars generate very strong ELF signals. The liquid crystal character of human body implies that besides weak sound signals also these ELF signals can contribute to the signal amplified by musculature. If these signals correspond to the lowest level of dark matter hierarchy, they should not have biological effects but whether this is the case is not all clear.

The strong coupling between magnetic flux tube structures associated the with computer networks and sensory canvases might be created by the magnetic reconnection process during night time when the shape of the flux tube structures changes. Also whole-daily use of a computer could generate magnetic mirror bridges between the computer and user's musculature and allow computer to feed fake control signals to muscles.

5.4   How TGD Approach Could Explain Taos Hum?

The original explanation for taos hum was as analog of microwave hearing.

1. According to the original explanation, taos hum could be understood in terms of this kind of Josephson radiation or more general radiation at microwave and also higher frequencies generated by living matter during night-time and possibly providing some organisms with an

active "vision". The emission of negative energy dark photons could also make it possible for plants to suck metabolic energy from environment in the absence of solar radiation. This radiation would propagate along magnetic flux tube - ME pairs. Microwave hearing or its analog at higher frequencies would generate the experience of hearing. The question is what exactly happens in in microwave hearing or its analog.

2. The estimated wave length λ for sounds assignable to taos hum are in the range 4-8 meters: this estimate might comes from the correlation with the acoustic environment. Probably it comes simply from the formula $\lambda = c_s/f$, where $c_s = 3 \times 10^3$ m/s denotes sound velocity in air and f is the frequency 40-80 Hz assignable to the auditory experience on basis of neurophysiological correlates. This estimate must be taken with a big grain of salt.

   If the primary signal is dark photon signal $f_l = 40 - 80$ Hz and if one takes the wavelength estimate seriously, one obtains the estimate $f_h = c/\lambda \simeq .05 - .1$ GHz. Unfortunately this frequency range is below the microwave frequencies varying in the range .3-300 GHz but scaling down of wavelength estimate by less than an order of magnitude would improve the situation. Thermal energy at room temperature corresponds roughly to 2.5×10^3 GHz so that the energies would be below the thermal energy at physiological temperatures. This cannot be however used as a serious objection against interpretation as microwave hearing since the wavelength estimate is based on the effective assumption that signal corresponds to 40-80 Hz ordinary sound wave.

The TGD based model for EEG [K6] is based on dark Josephson radiation generated by cell membrane Josephson junctions in the energy range of visible and UV light and covering a wide frequency range. The model explains bio-photons and EEG as manifestations of one and same basic phenomenon: dark photons and the recent observations support this identification [J17]. This motivates a more radical explanation of taos hum.

1. The auditory information is presumably coded to modulations of carrier wave with frequency f_h by frequency $f_l = 40 - 80$ Hz, which is in EEG range and could be assigned with the magnetic interaction energy of dark protons assignable to the opposite sides the cell membrane [J24] [K4]. Dark photon wave length would be of the order of the radius of Earth and the only reasonable explanation for the claimed correlation with the acoustics of the environment is that magnetic body provides a representation of biological body and environment as indeed proposed (magnetic sensory canvas hypothesis [K10]).

2. Since Josephson frequency characterizes the cell membrane frequency scale, one might expect that the dark photons signal has the same frequency. In this case the wave length would be of the order $\lambda = c/f \sim .1$ mm, size scale of large neuron rather than the naïve estimate $\lambda = 4 - 8$ meters.

3. The dark photon signal would be generated by an amplitude modulation of a carrier wave at Josephson frequency $f_h = 2eV \sim 5 \times 10^{12}$ Hz (for electronic Cooper pairs) by frequency $f_l = 40 - 80$ Hz. According to the conjecture proposed earlier [K4], this would generate dark photons with $\hbar_{eff} = f_h/f_l \sim 1.2 \times 10^{11}$ near the thermal threshold. It is highly interesting, Cyril Smith reports that the frequency ratio $f_h/f_l = 2 \times 10^{11}$ is involved with the transformation of high frequency signal to low frequency signal [J6].

4. This picture would conform with the original idea that left brain utilizes frequencies not smaller than Josephson frequency assignable to cell membrane and right brain hemisphere visible and UV frequencies. In TGD framework this difference would be due the fact that cell membrane can appear in two ground states [K7]. The state realized in right hemisphere near to the vacuum extremal with Josephson frequencies in visible and UV range and the state realized in left hemisphere far from vacuum extremals and Josephson frequencies derivable from membrane potential.

One should also understand how dark photon signal transforms to dark phonon signals and how this signal transforms to ordinary sound generating the taos hum experience. Two options can be considered: for the first option only dark photons are involved, for the second option both dark photons and phonons are involved.

1. Living body - cell membrane is an electret - and thus transforms electric signals to sound waves and vice versa. The minimum option is that signal propagates as dark photons and transforms to dark phonons of same energy at cell membrane level. One can consider also second possibility: dark photons continue to propagate along ME-flux tube pair parallel to the axonal membrane.

2. Dark phonons in the high frequency optical branch of the spectrum (/photons) would propagate as oscillations assignable to axonal membrane (/ME - flux tube pair parallel to it) to ear. Dark phonons/photons would generate virtual auditory percept by transforming to ordinary phonons at ear.

3. Both the variants of the model could explain the basic findings about taos hum, in particular the fact that it creates a subjective experience without any objective counterpart.

One can ask why taos hum is not accompanied by its visual counterpart involving dark photons with visible photon energies. In fact, the persons suffering from taos hum occasionally report experiences of white light in the direction of sound. The mechanism could be essentially the same as for taos hum except that the right brain hemisphere is a better candidate for the receiver now if one takes TGD inspired view about cell membrane seriously.

6 Dark Photons In Biology And Neuroscience

In this section I want to add some details to the general vision about dark photons as deeper level behind bio-photons. What is certainly unusual that I will barely mention biochemistry. My knowledge about the complexities of biochemistry is not the reason for the neglect. The reason is that if hardware-software dichotomy in biology corresponds to the matter-dark matter dichotomy, the biochemistry separates neatly from the physics of dark matter for the software. It is a physical fact that dark matter dominates over ordinary matter in cosmic scales and is present everywhere so that it is not so surprising if dark matter would play a key role in biology. Recently the futile searches for WIMP (weakly interacting massive particle) with expected properties have forced particle physicists to ask whether dark matter could be much more than single WIMP, maybe a new phase of matter or even hierarchy phases as TGD suggests.

My basic defense for the notions of magnetic body and dark photons (also other dark particles) is that they follow from the basic TGD and allow to explain phenomena very difficult to understand in the standard biochemistry framework - consider only the correlation between EEG and bio-photons, coherence of bio-photons, and delayed luminescence.

6.1 General Vision

I have already explained the basic ideas about bio-photons as decay products of dark photons. In the following I try to develop a general vision about the role of dark photons in living matter.

1. Pulse patterns or temporal polarization patterns travelling along MEs are ideal for communications and control because of precise targeting, absence of dispersion and maximal possible signal velocity.

2. Resonance frequencies for dark photons could be an essential element in their interactions with biomatter. The most important of these interactions would be the generation of negentropic entanglement between new representations of mental images and already existing corresponding representations. For instance, for cyclotron Bose-Einstein condensates the magnetic fields at the ends of the sender and receiver must be equal in good accuracy. Password mechanism is suggestive: several resonance frequencies would define the letters of the password. Among other things this could lead to a selective remote activation of gene expression if dark photons represent codons of the genetic code [K21].

The vision of Hawkins about fundamental algorithm [L2] might find realization in TGD framework in terms of the basic anatomy of quantum jump in zero energy ontology (ZEO) [L3]. The basic idea is that conscious information processing consists of pairs formed by sensory perceptions

(involving the recognition of the objects of the perceptive field) and by motor action. Sensory perception and motor action are related by time reversal and correspond to state function reductions at opposite boundaries of CD. These processes can combine to complex program like structures via generalization of lock and key mechanism in which fitting of the key to lock corresponds to recognition.

Lock and key mechanism is a well-known mechanism of bio-catalysis, and allows a far reaching generalization. Dark photons could provide a very general non-local realization of this mechanism.

1. Lock and key mechanism allows to imagine biochemical programs consisting from reactions proceeding in fixed order. The idea is same as in a familiar game of children. At each step player gets a key of a room containing a new key and the task is to find the room. After visiting many rooms the successful player eventually has the key to the room containing the treasure. In computer languages like LISP the same idea is realized: program is represented as a collection memory location containing two addresses: the address of memory location and the address of the next memory location. Associative memory recall could rely on the same mechanism.

2. Lock and key mechanism can be realized in several ways. The most concrete manner is as a chemical reaction in which reactants have complementary surface geometries fitting like lock and key. Keys could be replaced with passwords. The password could be represented as a collection of resonance frequencies. Also a pulse sequence or a more general temporal field pattern such as a sequence of magnetic fields with discrete valued strength and duration (Persinger has found that this kind of sequences are "physiologically effective" [J17, J19]. Temporal polarization patterns are also possible and are suggested by Gariaev's group [I9].

   For frequency coding, a given step in the process would activate a collection of frequencies activating the next step of the program and magnetic flux tube connections along which signals propagate would allow to achieve highly selective activation.

3. The decomposition of quantum jump to state function reductions at opposite boundaries of CD explaining the sensory-motor dichotomy at the level of brain could be realized also at molecular level and define basically a pair of addresses/passwords. Sensory perception with recognition of the objects of the perceptive field would correspond to the fitting of the key to lock. The frequencies of future directed positive energy signals would serve as a password inducing a motor action generating a collection of frequencies of past directed negative energy signals serving as a password for the next step of reaction.

6.2 Dark Photons And Biology

A lot of experimental data about the role of bio-photons in biology exist [I13, I17, I24]. Coherence [I12] and closely related delayed luminescence [I5] are the basic poorly understood aspects of bio-photons. Already Gurwitsch demonstrated that mitogenetic radiation makes possible communication between cell cultures.

1. Passwords realized as frequency patterns could be at work also at the level of genome and rely on use of portions of DNA sequences as pairs of addresses. One could imagine a representation of DNA sequences in terms of frequency patterns of em fields.

2. Password mechanism realized in terms of frequencies for dark photons could allow interaction between remote genomes. One can imagine remote DNA replication, remote transcription and translation [K8]. If one accepts dark DNA [K13, K8] similar processes involving dark DNA and ordinary DNA can be imagined. I have discussed the role of dark DNA in making possible kind of R&D department allowing to test new variants of genes in the virtual world of dark DNA, RNA, tRNA and dark amino-acids. Peter Gariaev's findings suggest the possibility of remote DNA replication and remote activation of gene expression [K21].

3. The mechanism for the generation of sensory -, memory -, and cognitive representations as negentropically entangled zero energy states getting new tensor factors during quantum jump sequence is extremely general. Same can be said about the interaction free measurement as a

mechanism for nondestructive reading of these representations. This suggests that they are realized already at the biomolecular level so that also conscious intelligence is present already at nanolevel. What we call molecular machines would be conscious entities and swarm intelligence as a mechanistic algorithm would be replaced by self-organization of conscious entities able to co-operate thanks to the presence of collective levels of consciousness made possible by the magnetic bodies and flux tube reconnections generating larger quantum coherent structures.

4. One can imagine new mechanisms of metabolism based on dark photons. Dark photons could take the role of sunlight and provide energy for electrons in electron transport cycle appearing in both cell respiration and photosynthesis. The effect of visible laser light on skin might involve this kind of mechanism. Negative energy dark photons emitted by electrons would make possible remote metabolism (quantum credit card mechanism).

5. The possibility to transform ordinary photons to dark photons is what one should understand. The findings of Peter Gariaev [I9] can be explained in TGD framework if DNA transforms laser photons to dark photons with frequencies of radio waves extending at least to kHz. Somehow DNA is able to induce the phase transition changing the value of $\hbar_{eff}$: amplitude modulation by radiofrequencies is a good candidate for mechanism in the case that the frequency ratio equals to integer valued ratio $\hbar_{eff}/\hbar$.

6.3   Dark Photons And Brain

The role of dark photons in imagination and for memories has been already discussed. Dark photons could also have a role in vision.

1. In TGD inspired theory of consciousness sensory qualia are assigned with sensory receptor. These primary sensory mental images are negentropically entangled with the mental images at brain and magnetic body (decomposition of perceptive field to objects). Qualia would represent the colors of perceptive map. This assumption can be justified by very general arguments such as general coordinate invariance implying holography but is not absolutely necessary. Mental images at the magnetic body could be also involved with the entanglement sequence giving higher abstractions about the sensory input.

   The basic objection (phantom leg) can be circumvented if one accepts the vision about 4-D brain and TGD view about memory. Pain in phantom leg would be sensory memory of pain in the leg, which still existed. The memory feats of idiot savants and people with left brain damage would be most naturally also due to sensory (visual or auditory) memories. Also ordinary people can have sensory memories when neurons in temporal lobes are stimulated electrically. The pain could be also real but erroneously assigned with the non-existing leg.

2. The notion of sensory window is almost two decades old notion [K14]. In its recent version dark photons propagate along MEs associated with magnetic flux tubes parallel to neural pathways, perhaps both from and to sensory organs. Experimental evidence for the propagation of bio-photons signal between nerve ends [J32] provide support for this idea. Stimulation of other end by light induces bio-photon emission at the other end. What would happen that dark photons are generated a the first end and propagate to other end along MEs and decay to ordinary photons.

3. Seeing without the brain - or more precisely without neuronal connections to brain - is now known to be possible. Does this mean that dark photons mediate information to brain or that retina plus spine "see" and that the geometric aspects of vision are realized also at the level of retina?

4. Dark photons from magnetic body or brain or both to retina transforming there to ordinary photons could provide feedback allowing to transform visual input to stardardized visual mental images. The proposed mechanism would require that retina produces seeds for induced transformation to ordinary photons. This is a testable prediction: does retina generate light? Same mechanism could of course generate photons at the visual cortex so that visual

mental images could be generated also there. Dissipation would be also now unvoidable aspect of process and one of the basic functions of metabolism would be regeneration of dark photons.

There is a phenomenon called visual prosthesis referred also to as bionic eye (`http://tinyurl.com/9kasp3q`) providing support for the idea that also neurons can see. Bionic eye can provide the effect sense of vision in a situation when there is degenerative disease of photoreceptors and even for people born blind. Of course, the visual experience need not be same as for ordinary vision: it is possible to "see" geometric information about environment using only tactile sense. In any case, the sensation of vision is at neuronal level unless some functions of retina are still active: I do not know whether this must be the case or not.

The basic visual sensation is phosphene (`http://tinyurl.com/l8vpbu`), kind of diffuse light spot. If phosphenes are basic building bricks of also ordinary vision, the hypothesis that primary sensory organs are carriers of qualia can make sense only if prosthete vision is fundamentally different from ordinary vision. This is possible. Neurons can "see" in TGD framework (I have talked about neuronal windows): at this level vision relies on the reception biophotons travelling along magnetic flux tubes assignable to neuronal pathways. Retinal receptors would be specialised on vision and much more effective than neurons, which would detect just the presence of light.

5. This picture would make possible similar representations also for the other sensory modalities. For instance, people learn to "see" via tactile sensation and also by hearing.

6.3.1   Correlations between bio-photons, EEG, and neural activity

The recent experimental understanding about correlations between emission of bio-photons and neural activity of the brain is thoroughly discussed in [J20].

1. *In vivo* experiments of Kobayashi *et al* [J13] demonstrate that the spontaneous ultraweak photon emission from a rat brain correlates with cerebral energy metabolism, EEG activity, cerebral blood flow and oxidative stress. Van Wijk *et al* [J22] have demostrated significant correlations between fluctuations of alpha wave portion of EEG and bio-photon emission. It has been also demonstrated that neuronal axons can conduct photon signals [J32]. Thus there is a lot of evidence that bio-photons or something behind them are real and could serve communication purposes. Bischof has proposed that visual consciousness is a property of bio-photon field itself [J30]: this kind of conjecture is problematic philosophically and a weaker hypothesis about the correlation with visual consciousness and/or visual imagination looks more natural.

2. The article takes as granted that bio-photons are produced by biochemical processes related to reactive oxygen and nitrogen species (ROS and RNS). There is a strong correlation with oxidative metabolism of mitochondria. If f bio-photons are not fundamental entities, this correlation does not mean that these processes would directly produce bio-photons.

   One can however invent several objections against this mechanism.

   (a) Too short de-coherence time is the basic objection - Tegmark's estimate for the de-coherence time of bio-photons is $\tau \sim 10^{-13}$ seconds. The estimate is rough and gives coherence time increasing with temperature but certainly the lacking 10 orders of magnitude are a real problem and would require that generation of ROSs and RNSs is a highly coordinated mechanism. There are indeed indications that free radicals and their derivatives are necessary for synaptic processes and ordinary brain functions. If magnetic body controls metabolism the underlying quantum coherence could imply the required high spatial and temporal coordination.

   (b) Delayed luminescence is difficult to understand if only biochemistry is behind bio-photons.

   (c) A further problem is the extreme weakness of bio-photon flux - at least in the vicinity of organism where the measurements are made. The argument of authors is that the strong absorption of bio-photons in living matter is the reason for this.

Despite these difficulties the authors suggest that bio-photons define a new kind of fast signalling accompanying electric signalling (nerve pulses and waves propagating along axonal membranes) and consider a quantum model for the interaction of bio-photons with microtubules. As a matter of fact, the idea about microtubules as quantum antennae represents one of the first applications of the notion of "massless extremal" (ME) to biology in [K14].

I have already described the basic deviations of TGD based model from this picture. Dark photons relevant to biology make themselves visible by transforming to bio-photons by energy conserving manner: this gives rise to frequency pairs (f_h, f_l) with $f_h/f_l = \hbar_{eff}/\hbar = n$. The other member of the pair would reveal itself classically as low frequency classical radiation and second pair as higher frequency photon. The pairing of EEG with bio-photons could be understood in terms of this pairing. The findings of Cyril Smith [J6] would have interpretation of this pairing allowing also other than EEG frequencies as dark photon frequencies. Also the findings of Peter Gariaev [I9] suggest that also radio wave frequencies can appear as dark photon frequencies.

According to [J20] the evidence for the correlation between neural electrical activity of neurons and bio-photon emissions is however poor. Situation might improve in future but one can ask whether it could be possible to understand the poor correlation.

1. If the transformation of dark photons at EEG frequencies to ordinary photons gives rise to bio-photons, it might be possible to understand the poor correlation. Neuronal activity would modulate membrane potential and the therefore the frequency $f_J = eV/h_{eff}$ of Josephson radiation but not Josephson current determining its magnitude. Note that f_J can be also outside the EEG range and TGD suggests a hierarchy of scaled up variants of EEG.

2. Neural events would have time scale of order milliseconds much shorter than the time scale of EEG so that the frequency modulation caused by them would not be visible in the time scale T_{EEG} of EEG frequencies considered. Only the slow modulations of membrane potential in time scales longer than T_{EEG} would be visible as a slow variation of corresponding bio-photon energy. The testable prediction is that the time variation of the frequency spectrum of bio-photons directly reflects that of EEG spectrum.

6.3.2   Biophotons and vision

Bischof [J30] was probably the first one to propose that bio-photons might relate directly to vision. The following list of articles by Bokkon *et al* illustrates the development of ideas about the connection between bio-photons and vision. I have included a comparison with TGD based views, which have developed during last two decades and are discussed in chapters of various online books [K14, K10, K15].

- *Phosphene phenomenon: a new concept* [J25].

  It is proposed that the visual sensation of phosphenes (induced by mechanical, electrical, magnetic situli, ionizing radiation, etc..) is due to bio-photon emission inside neurons. Also an interference model concerning the mechanism of interaction between living organisms and electromagnetic fields is proposed. Authors suggests that the biological nonlinearly polarizable double layer allows destructive interference of incoming and reflected waves outside the double layer. As a consequence, in the inside constructive interference would take place at the same time. The proposal is that the interference patterns may play an important role in biological self organization and in biological functions.

  The authors investigate the boundary conditions necessary for explaining these non-linear optical effects in terms of the phase conjugation, and claim that there are solutions of the Maxwell equations which satisfy destructive interference of bio-photons. Necessary provisions are nonlinearly polarizable optically active double layers of distances which are small compared to the wavelength of light. In addition, they have to be able to move into the nodal planes of the impinging waves within a small time interval compared to the coherence time. The claim is that the conditions are likely fulfilled in the optically dense, but ordered and optically excited, highly polarizable living matter.

  In TGD framework phosphenes could result via a transformation of dark photons to bio-photons. The propose interference model is needed to channel the electromagnetic fields

inside cells and axons. In TGD framework the nonlinear modification of Maxwell's equations resulting from the fact that gauge potentials as primary dynamical variables are replaced with embedding space coordinates, implies topological field quantization manifesting structures like massless extremals (MEs), magnetic flux quanta (sheets and tubes) and electric flux quanta realized as space-time quanta. Hence precisely targeted beams of dark photons become possible.

- *Picture representation during REM dreams: a redox molecular hypothesis* [J4].

  The proposal is that the visible photons in retina are converted to neural signals, which in V1 are are converted into synchronized bio-photon signals inside the neutrons by neurocellular radical reactions in retinotopically organized V1 mitochondrial CCO-rich (CCO is a shorthand for cytochrome oxidase) visual areas.

  The TGD counterpart for this would be the conversion of the neural signals to dark photon signals to the magnetic body with ROS and RNS reactions inducing a small leakage to bio-photons. One can also imagine that dark photons are generated at regina and travel along visual pathway so that the communications to magnetic body would be much faster. The feedback as dark photons from magnetic body to brain to retina would generate virtual visual input which in wake-up state would be compared with the actual input. During REM dreams only the virtual sensory input would be present. In retina dark photon input would generate bio-photon emission and this kind of emission is observed [J21]. One can wonder whether the dark photon emission from retina reflected from target could give rise to a "lamp" making possible "active" seeing under some circumstances.

  Cytochrome oxidase (CCO) enzyme (see `http://tinyurl.com/6ep3ob`) is integral membrane protein permanently associated with the cell membrane and coded by mitochondrial DNA, and thus directly related to energy metabolism catalysing the reduction of oxygen to water in respiration and therefore something very primordial biologically. In TGD inspired model CCO would be needed for generating metabolic energy needed to generate dark photons. This would suggest that CCO rich regions are present also in other sensory areas. An interesting question is whether CCO rich regions are present both in left and right hemisphere. There is evidence that bio-photons are emitted considerably only in right hemisphere [J17]. Could this mean that the energy range for dark photons from left hemisphere is different or that dark phonons/biophonons effectively replace dark photons/bio-photons?

- *Visual perception and imagery: a new molecular hypothesis* [J9].

  The authors describe the basic hypothesis that neural signals from retina generate synchronized bio-photon signals by radical and non-radical processes in retinotopically organized visual areas and that these bio-photon signals provide intrinsic pictures in retinotopically organized mitochondria-rich visual areas.

  It is also proposed that long term visual memory corresponds to epigenetic information regulated by free radicals and redox processes. There is indeed evidence that reactive oxygen species and related haem pathway components as possible epigenetic modifiers in neurobehavioural pathology [J23].

  The TGD counterpart of this hypothesis is that dark photons generate representations of visual field at brain and possibly also at various layers of magnetic body with different degrees of abstraction. For dark EEG photons the layers would have size of order Earth radius suggesting a connection with Schumann resonance and magnetosphere as a higher level in the predicted self hierarchy.

  Epigenetic modifications and changes of synaptic connections would correspond in TGD framework to behavioral changes, not genuine conscious memories. The idea that ROS and RNS could perform this "carving" process analogous to the modification of computer hardware (now represented by biochemistry), is attractive. In TGD Universe genuine declarative memories would be however realized in terms of representations based on bit representations (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book).

- *Estimation of the number of bio-photons involved in the visual perception of a single-object image: bio-photon intensity can be considerably higher inside cells than outside* [J9].

  Authors consider two objections against biological role of bio-photons. First, bio-photons are a mere byproduct of cellular metabolism. Secondly, the extreme weakness of bio-photon flux does not support the idea that they might have biological significance. Authors however argue that bio-photon production is a controlled process and among other things gives rise to the above mentioned synaptic and epigenetic modifications. Authors also argue that the density of bio-photons inside cells is considerably higher than outside and consider a mechanism in which em fields are confined inside bilayered structures.

  In TGD framework bio-photons are replaced by dark photons propagating along MEs. Their intensity can be much higher and bio-photons would represent a small leakage resulting from the transformation of dark photons to bio-photons. Unfortunately one cannot say much about the rate of this process: p-adic length scale hypothesis however probably fixes it to be inversely proportional to the secondary p-adic time scale (.1 seconds for M_{127} characterising electron) and hierarchy of Planck constants suggests that the rate behaves like $\hbar/\hbar_{eff}$. The strong correlation with metabolism can be understood since the generation of dark photons requires metabolic energy. An interesting question is what happens at other sensory areas: are CCO rich regions present also there?

- *Visible light induced ocular delayed bioluminescence as a possible origin of negative after image* [J10].

  The motivation of the article is the experimental proof of the existence of spontaneous ultra-weak photon emission and visible light induced delayed ultraweak photon emission from in vitro freshly isolated rat's whole eye, lens, vitreous humor and retina [J21]. Authors propose that the photobiophysical source of negative afterimage can also occur within the eye by delayed bioluminescent photons. When one stares at a colored (or white) image for few seconds, external photons can induce excited electronic states within different parts of the eye that is followed by a delayed re-emission of absorbed photons for several seconds. Finally, these reemitted photons can be absorbed by non-bleached photoreceptors that produce a negative after image.

  In TGD framework one could understand the emission of bio-photons from retina as a leakage phenomenon. After images and delayed luminescence in general could be seen as a kind of echo resulting when dark photons travel to brain, maybe also magnetic body and return back after exciting laser like system which returns to it ground state by secondary emission. After images perhaps assignable to dark photons could give build up copies of memory representations. This could also apply to dark phonons: examples about this would be a repetition of single world or simple piece of music occurring during wake-up state and in sleep mentation.

  A virtual sensory input propagating to the sensory organs would allow to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected to be much shorter than that for a typical neuronal activity.

  Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J14] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity.

  As special case this mechanism would explain after images. After images would be sensory echoes resulting when the sensory signal travels to magnetic body and back to sensory organs, maybe several times. The time scale for negative after images is seconds and in principle this allows to get some idea about the slow time scales involved with the process and maybe also about the size scales of largest layers of the magnetic body involved.

6.3.3 Biophotons and intelligence

It is gradually becoming clear that bio-photons have a role in brain function. An interesting claim is that the biophoton spectrum is shifted towards infrared as the intelligence of the species develops [I16](see http://tinyurl.com/ycor8hs3). The idea is that biophotons are involved with the communications between parts of brain and biophotons with lower frequencies are favored: one reason could be metabolic economy since biophotons have energies in visible and UV range mostly and in humans the extends to near infrared. The observation is that glutamate-induced biophotonic activities and transmission in brain slices represent a spectral redshift feature from animals to humans.

Could TGD based model for biophotons as decay products of dark cyclotron photons help to understand this? In TGD framework dark photons would be involved with communications of biological body with personal magnetic body (MB) [K4, K2]. Bio-photons would result from dark cyclotron photons in energy conserving transformation to ordinary photons reducing the value of Planck constant $h_{eff} = n \times h$ to its ordinary value h. Dark matter as phase of ordinary matter with non-standard value of Planck constant

$$h_{eff} = n \times h = h_{gr} = \frac{GMm}{2\pi v_0}$$

proposed to be generated at quantum criticality [?]. Gravitational Planck constant h_{gr} was originally introduced by Nottale [?]. In this formula M is some mass, say that of black hole or astrophysical object, m is much smaller mass, say that of elementary particle, and v_0 is velocity parameter, which is assumed to be in constant ratio to the spinning velocity of M in the model for quantum biology explaining biophotons as decay products of dark cyclotron photons.

Both dark cyclotron photons from MB to brain and analogs of Josephson photons from cell membranes to MB would be involved in biology. When dark photons transform to ordinary photons they can induce molecular transitions. MB would control biomatter by inducing these molecular transitions. This explains the range of biophoton energies. Also EEG would consist of dark photons in this energy range but frequencies in EEG range and wavelengths of astrophysical size (7.8 Hz corresponds to circumference of Earth).

Dark cyclotron photons have cyclotron energy

$$h_{eff} \times \frac{eB_{end}}{m} = \frac{GM}{v_0} \times eB_{end}$$

independent of the mass of charged particle mass, which is essential for the universality of bio-photon spectrum. The value B_{end} of the "endogenous" magnetic field introduced by Blackman should vary by say two orders of magnitude to explain the range of biophoton energies. The value of h_{eff} should be rather high.

The redshift of biophoton energy spectrum for humans as compared to lower animals could mean that the spectrum for the values of B_{end} extends to lower values. Cyclotron periods would be also longer at lower end for the spectrum. Could the higher intelligence could be achieved by better metabolic energy economy? Or could the presence of flux tubes with lower value of B_{end} extend the spectrum of biophoton energies and bring in molecules with lower transitions energies (down to near infrared)? It should be possible to identify the molecules in question. They should be involved with the "glutamate-induced biophotonic activities". The communications between brain slices could be also indirect: first sensory signal to MB is sent and response comes as control signal to other part of brain.

The value of B_{end} in Blackman's experiments (I have identified it as lower end for the spectrum of the values of B_{end}) for vertebrates was 2/5 of Earth's magnetic field B_E with nominal value of .5 Gauss. Why 2/5 rather than 1? Could this reflect that gradual reduction of B_{end} from B_E during evolution? Should one repeat the experiments of Blackman and other pioneers for non-vertebrates to find whether B_E is higher for them?

6.4 Dark Photons, Meditative States, And Qigong Practices

Various experiments demonstrate that meditation tends to reduce bio-photon emission [J36, J5]. The interpretation would be that for some reason meditation reduces the leakage of large $\hbar$ photons to ordinary ones. How meditation could help to achieve this reduction?

If the generation of ROS generates bio-photons by the proposed mechanism with the ordinary photon generated in ROS serving as a seed inducing the transformation of dark photons of same energy to bio-photons then reduction ROS would explain the correlation. The life style of meditator might explain why the generation of ROS is reduced. If dark photons are involved with non-destructive reading of memories and future plans (time reversed memories), and if the absorption of dark photons by laser like systems followed by a return to ground state leads to an emission of also ordinary photons then cognitive processes would generate bio-photons. In meditative practices the basic goal is to calm mind by getting rid of thoughts so that this mechanism would not produce photons anymore.

The effects of Qigong practices on bio-photon emission has been also studied. Examples are changes of bio-photon emission and temperature of human hand during Qigong [J16], the effects of mental concentration on bio-photon emission [J12], temperature and bio-photon changes of the middle finger during Qigong and light imagery tasks [J11], and comparison of bioenergy and physiological markers in qigong and acupuncture research has been carried out [J15].

Quite generally, the hands of qi healer are expected to emit bio-photons. If Qi healer generates a flux of dark photons, some fraction of them dissipates to bio-photons, so that an increase of bio-photons could be the outcome.

7 Dark Photons And Remote Mental Interactions

Remote mental interactions are the same interactions that relate magnetic body and biological body. Now biological body is not the "personal one" but that of target and can be also inanimate in which case the presence of codes are not expected.

1. Flux tubes serve as correlates of attention. Attention would therefore be always involved with remote mental interactions - also those between various layers magnetic body and parts of biological body manifesting themselves in the biology of TGD Universe. Dark photons propagating along ME-flux tube pair serve as correlates of communication and control. "Motor actions" of magnetic body serve as tools of bio-control too. Also the reading of memory representations would involved dark photons and could therefore be involved with telepathy as mind reading.

2. Dark photons would accompany various remote mental interactions and the unavoidable leakage as bio-photons could be a signature of these interactions. For instance, healer generates low frequency dark photons along flux tubes creating the connection to the patient and part of these photons leak out in the process. Dark photons are expected to leak from the hands of healer as bio-photons.

3. Could simultaneous changes in bio-photon emissions from healer and healee take place and be also detected? Identical values of f_l and f_h for healer and healee would serve as as a signature. In principle testable aspect of darkness is the integer aluedness of $\hbar_{eff}/\hbar = f_h/f_l$. From quantum coherence criterion the distance roughly $L \leq c/f_l$ allows to guess upper bound for the value of f_l. The additional signature would be the identical temporal patterns of dark photons correlation functions at both ends. This would be the analog of long range temporal correlations in delayed luminescence.

4. Dark photons could be seen as universal mechanism of remote viewing. Do various sensory modalities involve separate frequency bands f_h or is the frequency band determined solely by distance? This question relevant also for brain. Second relevant question is the role of magnetic bodies. The model for the findings of Willian Tiller about intentional imprinting of electric devices [J35, J33, J34] requires that magnetic bodies serve as relay stations in this process. Both healers and healee's magnetic bodies and even those assignable to levels of collective consciousness could be involved (healing by prayer).

REFERENCES

Theoretical Physics

[B1] Elitzur–Vaidman bomb-testing problem. Available at: `https://en.wikipedia.org/wiki/Elitzur\OT1\textendashVaidman_bomb-testing_problem`.

[B2] Lvovsky AI. Squeezed light, 2014. Available at:`https://arxiv.org/pdf/1401.4118v1.pdf`.

Biology

[I1] Biophotons. Available at: `https://en.wikipedia.org/wiki/Biophotons`.

[I2] 'Psychic cells': Scientists discover cells can communicate through physical barriers. Available at: `https://newsroom.ucla.edu/portal/ucla/ucla-drew-scientists-undercover-243053.aspx`.

[I3] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: `https://www.youtube.com/watch?v=i-T7tCMUDXU`.

[I4] Sivadasan VA Bajpai RP, Kumar S. Biophoton emission on the evolution of squeezed state of frequency stable damped oscillator. *Appl Math & Comput*, 93:277–288, 1998.

[I5] Bajpai BP. Coherent nature of the radiation emitted in delayed luminescence of leaves. *J Theor Biol*, 1999.

[I6] Ingalls CE. Sensation of Hearing in Electromagnetic Fields, 2002. Available at: `https://www.angelfire.com/or/mctrl/ingalls.htm`.

[I7] Tedeschi Alberto Emilio Del Giudice, Paola Rosa Spinetti. Article: Water Dynamics at the Root of Metamorphosis in Living Organisms. *Water*, 2:566–586, 2010. Available at: `https://www.mdpi.com/journal/water`.

[I8] Dotta BT et al. Biophoton emissions from cell cultures: biochemical evidence for the plasma membrane as the primary source. *Gen Physiol Biophys*, 30(3):301–309, 2011.

[I9] Gariaev PP et al. The spectroscopy of bio-photons in non-local genetic regulation. *J Non-Locality and Remote Mental Interactions*, (3), 2002. Available at: `https://www.emergentmind.org/gariaevI3.htm`.

[I10] Kataoka Y et al. Activity-Dependent Neural Tissue Oxidation Emits Intrinsic Ultraweak Photons. *Biochem & Biophys Res Comm*, 285(4):1007–1011, 2001.

[I11] Lin JC et al. The Micro-wave Auditive phenomenon. *Proceedings of the IEEE*, 68, 1980.

[I12] Popp et al. Biophoton emission. New evidence for coherence and DNA as source. *Biophys*, 6(1):33–52, 1984.

[I13] Popp F-A et al. Physical aspects of biophotons. *Experientia*, 44(7):576–585, 1988.

[I14] Popp F-A et al. Evidence of non-classical (squeezed) light in biological systems. *Phys Lett A*, 293(4):98–102, 2002.

[I15] Rahnama M et al. Emission of mitochondrial biophotons and their effect on electrical activity of membrane via microtubules. *J Integr NeuroSci* . Available at: `https://arxiv.org/pdf/1012.3371.pdf`, 1:65–88, 2009.

[I16] Wang Z et al. Human high intelligence is involved in spectral redshift of biophotonic activities in the brain. *Proc Nat Acad Sci of USA*, 2016. Available at: `https://tinyurl.com/j5vusyy`.

[I17] Popp F-A. Properties of biophotons and their theoretical implications. *Indian J Exp Biol*, 41(5):391–402, 2003.

[I18] Popp FA. Cancer growth and its inhibition in terms of coherence. *Electromagn Biol Med*, 28(1):53–60, 2009.

[I19] Vassilatos G. Nocturnal Disturbances and the Infrasonic "HUM", 2001. Available at: `https://www.borderlands.com/journal/nux.htm`.

[I20] Burr H. *The fields of life*. New York: Ballantine, 1972.

[I21] Slavinski J. Biophotons from stressed and dying organisms: toxicological aspects. *Indian J Exp Biol*, 41(5):483–493, 2003.

[I22] Brizhik L. Nonlinear mechanism for weak photon emission from biosystems. *Indian J Exp Biol*, 46(5):353–357, 2008.

[I23] McTaggart L. *The Field*. HarperCollinsPublishers Ltd. Available at: `https:/www.torsioelement.com.`, 2001.

[I24] Volodyaev Ilya Mayburov SN. Photons Production and Communications in Biological Systems. *Progress In Electromagnetics Research Symposium Abstracts*, 2009.

[I25] Sheldrake R. *A New Science of Life: The Hypothesis of Formative Causation*. Inner Traditions Intl Ltd., 1995.

[I26] Sheldrake R. *The Presence of Past: Morphic Resonance and the Habits of Nature* . Icon Books Ltd, 2011.

[I27] Pospisil P Rastogi A. Effect of exogenous hydrogen peroxide on biophoton emission from radish root cells. *Plant Physiol & Biochem*, 48:117–123, 2010.

[I28] Pospisil P Rastogi A. Ultra-weak photon emission as a non-invasive tool for monitoring of oxidative processes in the epidermal cells of human skin: comparative study on the dorsal and palm side of the hand. *Skin Res & Tech*, 16:365–370, 2010.

[I29] Bajpai RP. Coherent Nature of the Radiation Emitted ion Delayed Luminescence of Leaves. *J. Theor. Biol.*, 93:287–299, 1999.

[I30] Bajpai RP. Squeezed state description of spectral decompositions of a biophoton signal. *Phys Lett*, A 337:265–273, 2005.

Neuroscience and Consciousness

[J1] Microtubules. Available at: `https://en.wikipedia.org/wiki/Microtubules`.

[J2] Qigong and Energy Medicine Database. Available at: `https://www.qigonginstitute.org/html/database.php`.

[J3] Selden G Becker RO. *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York, 1990.

[J4] Antal I Bokkon I, Dai J. Picture representation during REM dreams: a redox molecular hypothesis. *Biosystems*, 100(2):79–86, 2010.

[J5] Mahagita C. Roles of meditation on alleviation of oxidative stress and improvement of antioxidant system. *J Med Assoc Thai*, 93 Suppl 6:S242–54, 2010.

[J6] Smith C. Learning From Water , A Possible Quantum Computing Medium. In *CASYS'2001, 5th international conference on Computing Anticipating Systems held in Liege, Belgium, August 13-18. Abstract book*. CHAOS, 2001.

[J7] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J8] Persinger MA Dotta BT, Saroka KS. Increased photon emission from the head while imagining light in the dark is correlated with changes in electroencephalographic power: support for B kkon's biophoton hypothesis. *Neurosci Lett*, 513(2):151–154, 2012.

[J9] Bokkon I et al. Estimation of the number of biophotons involved in the visual perception of a single-object image: biophoton intensity can be considerably higher inside cells than outside. *J Photochem Photobiol B*, 2010.

[J10] Bokkon I et al. Visible light induced ocular delayed bioluminescence as a possible origin of negative afterimage. *J Photochem Photobiol B*, 103(2):192–119, 2011.

[J11] Chen W et al. Temperature and Biophoton Changes of the Middle Finger during Qigong and Light Imagery Tasks. *J Intl Soc Life Info Sci*, 2002.

[J12] Haraguchi S et al. Biophoton Change by Mental Concentration. *J Intl Soc Life Info Sci*, 2001.

[J13] Kobayashi M et al. In vivo imaging of spontaneousultraweak photon emission from a rat s brain correlated with cerebral energy metabolism and oxidative stress. *Neurosci Res*, 34:103–113, 1999.

[J14] Libet B et al. Subjective referral of the timing for a conscious sensory experience. *Brain*, 102, 1979.

[J15] Lin S et al. Comparison of bioenergy and physiological markers in qigong and acupuncture research. *National meeting of the Soc for Acupuncture Research*, 2004.

[J16] Nakamura H et al. Biophoton and Temperature Changes of Human Hand during Qigong. *J Intl Soc Life Info Sci*, 2000.

[J17] Persinger M et al. Congruence of Energies for Cerebral Photon Emissions, Quantitative EEG Activities and 5 nT Changes in the Proximal Geomagnetic Field Support Spin-based Hypothesis of Consciousness. *J Consc Expl & Res*, 2013. Available at: `https://jcer.com/index.php/jcj/article/view/277`.

[J18] Persinger M et al. Demonstration of Entanglement of Pure Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness. *J Consc Expl & Res*, 2013. Available at: `https://jcer.com/index.php/jcj/article/view/278`.

[J19] Persinger M et al. Experimental Demonstration of Potential Entanglement of Brain Activity Over 300 Km for Pairs of Subjects Sharing the Same Circular Rotating, Angular Accelerating Magnetic Fields: Verification by s_LORETA, QEEG Measurements. *J Consc Expl & Res*, 2013. Available at: `https://jcer.com/index.php/jcj/article/view/279`.

[J20] Rahnama M et al. Emission of Biophotons and Neural Activity of the Brain , 2010. Available at: `https://www.scribd.com/doc/45664376/Bio-Photons`.

[J21] Wang CH et al. Spontaneous and visible light-induced ultraweak photon emission from rat eyes. *Brain Res*, 1639:1–9, 2011.

[J22] Wijk Van R et al. Ultra-weak Photon Emission and EEG Alpha Rhythm. *NeuroQuantology*, 16:452–463, 2008.

[J23] Gericke GS. Reactive oxygen species and related haem pathway components as possible epigenetic modifiers in neurobehavioural pathology. *Med Hypotheses*, 66(1):92–99, 2006.

[J24] Wu M Hu H. Action Potential Modulation of Neural Spin Networks Suggests Possible Role of Spin. *NeuroQuantology*, 4:309–317, 2004. Available at: `https://cogprints.org/3458/1/SpinRole.pdf`.

[J25] Bokkon I. Phosphene phenomenon: a new concept. *Biosystems*, 92(2):168–174, 2008.

[J26] Bokkon I. Visual perception and imagery: a new molecular hypothesis. *Biosystems*, 96(2):178–184, 2009.

[J27] Hawkins J. *On Intelligence.* St. Martin's Griffin, New York, 2004.

[J28] Pribram KH. The Neurophysiology of Remembering. *Sci Am*, 1969.

[J29] Pribram KH. *Brain and Perception; Holonomy and Structure in Figural Processing.* Lawrence Eribaum Associates, 1991.

[J30] Bischof M. Biophotons-The light in our cells. *J Optometric Phototherapy*, pages 1–5, 2005.

[J31] Pietch P. Shuffle Brain: the The Quest for Hologramic Mind, 1972. Available at: `https://www.indiana.edu/~pietsch/shufflebrain-book00.html`.

[J32] Dai J Sun Y, Wang C. Biophotons as neural communication signals demonstrated by in situ biophoton autography. *Photochem Photobiol Sci*, 9:315–322, 2010.

[J33] Dibble WEJr Tiller WA. New experimental data revealing an unexpected dimension to materials science and engineering. *Mat Res Innovat*, 5:21–34, 2001.

[J34] Dibble WEJr Tiller WA. Anomalous Temperature Oscillation Behavior Near a Source in a "Conditioned" Space: part I, The Spatial Variation, 2002. Available at: `https://tillerfoundation.com/newpapers.htm`.

[J35] Tiller WA. Towards a Quantitative Science and Technology that Includes Human Consciousness. *Vision-In-Action*, 4, 2003. Available at: `https://www.via-visioninaction.org`.

[J36] Wijk Van R Wijk Van EP, Ackerman J. Effect of meditation on ultraweak photon emission from hands and forehead. *Res complementary & natural classical medicine*, 12(2):107–112, 2005.

Books related to TGD

[K1] Pitkänen M. DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe.* *https://tgdtheory.fi/tgdhtml/Btgdcomp.html*. Available at: `https://tgdtheory.fi/pdfpool/dnatqc.pdf`, 2015.

[K2] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I.* *https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: `https://tgdtheory.fi/pdfpool/biophotonslian.pdf`, 2023.

[K3] Pitkänen M. Bio-Systems as Conscious Holograms. In *TGD Universe as a Conscious Hologram.* *https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: `https://tgdtheory.fi/pdfpool/hologram.pdf`, 2023.

[K4] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. In *TGD and EEG: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: `https://tgdtheory.fi/pdfpool/persconsc.pdf`, 2023.

[K5] Pitkänen M. Comparison of TGD inspired theory of consciousness with some other theories of consciousness. In *TGD Inspired Theory of Consciousness: Part II.* *https://tgdtheory.fi/tgdhtml/Btgdconsc2.html*. Available at: `https://tgdtheory.fi/pdfpool/consccomparison.pdf`, 2023.

[K6] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: `https://tgdtheory.fi/pdfpool/eegdark.pdf`, 2023.

[K7] Pitkänen M. General Theory of Qualia. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: `https://tgdtheory. fi/pdfpool/qualia.pdf`, 2023.

[K8] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *TGD Universe as a Conscious Hologram. https: // tgdtheory. fi/ tgdhtml/ Bholography. html* . Available at: `https:// tgdtheory.fi/pdfpool/homeoc.pdf`, 2023.

[K9] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I. In *TGD Universe as a Conscious Hologram. https: // tgdtheory. fi/ tgdhtml/ Bholography. html* . Available at: `https://tgdtheory.fi/pdfpool/metab. pdf`, 2023.

[K10] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: `https://tgdtheory.fi/ pdfpool/mec.pdf`, 2023.

[K11] Pitkänen M. *Magnetospheric Consciousness.* Online book. Available at: `https://www. tgdtheory.fi/tgdhtml/magnconsc.html.`, 2023.

[K12] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: `https: //tgdtheory.fi/pdfpool/nmpc.pdf`, 2023.

[K13] Pitkänen M. Nuclear String Hypothesis. In *TGD and Nuclear Physics. https: // tgdtheory. fi/ tgdhtml/ Bnucl. html* . Available at: `https://tgdtheory.fi/pdfpool/ nuclstring.pdf`, 2023.

[K14] Pitkänen M. Quantum Antenna Hypothesis. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: `https:// tgdtheory.fi/pdfpool/tubuc.pdf`, 2023.

[K15] Pitkänen M. Quantum Mind and Neuroscience. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: `https://tgdtheory.fi/pdfpool/ lianPN.pdf`, 2023.

[K16] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: `https: //tgdtheory.fi/pdfpool/biosupercondII.pdf`, 2023.

[K17] Pitkänen M. Quantum Model of EEG. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: `https://tgdtheory.fi/pdfpool/eegII.pdf`, 2023.

[K18] Pitkänen M. Riemann Hypothesis and Physics. In *TGD as a Generalized Number Theory: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html* . Available at: `https:// tgdtheory.fi/pdfpool/riema.pdf`, 2023.

[K19] Pitkänen M. Three new physics realizations of the genetic code and the role of dark matter in bio-systems. In *Genes and Memes: Part II. https: // tgdtheory. fi/ tgdhtml/ Bgenememe2. html* . Available at: `https://tgdtheory.fi/pdfpool/dnatqccodes.pdf`, 2023.

[K20] Pitkänen M. Wormhole Magnetic Fields. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: `https://tgdtheory. fi/pdfpool/wormc.pdf`, 2023.

[K21] Gariaev P Pitkänen M. Quantum Model for Remote Replication. In *Genes and Memes: Part I. https: // tgdtheory. fi/ tgdhtml/ Bgenememe1. html* . Available at: `https:// tgdtheory.fi/pdfpool/remotereplication.pdf`, 2023.

Articles about TGD

[L1] Pitkänen M. Quantum Model for the Direct Currents of Becker. Available at: `https://tgdtheory.fi/public_html/articles/DCbio.pdf`., 2012.

[L2] Pitkänen M. A Vision about Quantum Jump as a Universal Cognitive Proces. Available at: `https://tgdtheory.fi/public_html/articles/hawkins.pdf`., 2013.

[L3] Pitkänen M. Comparison of TGD inspired theory of consciousness with some other theories of consciousness, 2013.

[L4] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: `https://www.tgdtheory.fi/tgdglossary.pdf`., 2014.