Do bio-photons originate from the decay of squeezed dark photons?

M. Pitkänen
Email: matpitka6@gmail.com.
http://tgdtheory.com/.

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1 Introduction

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 (see for instance [J1] and [K3]). Some examples of experimental work relevant to what follows are bio-photon emission from hand [I5], the effect of hydrogen peroxide H_2O_2 on bio-photon emission from radish root cells [I4], and delayed luminescence of leaves [I6].

R. Bajpai has discussed a squeezed state description of spectral decompositions of a bio-photon signal [I7, I1]. This proposal is highly interesting from TGD point

of view, which relies on the notion magnetic body [K2, K1] 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 so that bio-photon emission could be seen as a kind of leakage.

Squeezed photon emission relies on a modification of harmonic oscillator mass or frequency or both so that the original vacuum state looks like many-photon state from the point of view of new Hamiltonian. 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: $h_{eff} = h_{gr}$ [K4] indeed implies that the dark photon cyclotron spectrum does not depend on the mass of the charged particle and is therefore universal: gravitational Compton and de Broglie wavelengths are universal for the same reason.

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 the 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.

2 Summary about the article

2.1 Basic observations and interpretation in terms of squeezed states

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

1. Enhanced 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 (see for instance [I5, I4]).

   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: as if time would have been replaced with its logarithm in kinetic equations. 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. Also delayed luminescence of plant leaves [I6] generates similar signal. A further parameter having interpretation as a strength of response is not universal. The guess is that in all cases some "quantum entity" reacts to the stimulus: chemical stress in the case of H_2O_2 stimulation. Quite generally, oxidative stress would generate bio-photons.

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.

2.2 About squeezed states

There is a nice article about squeezed light at `http://arxiv.org/pdf/1401.4118v1.pdf` [B1]. Also Bajpai has published articles about application of squeezed states to the description of biophotons [I7, I1].

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 reduced below that for harmonic oscillator vacuum state but Uncertainty Principle: this 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://www.myoops.org/cocw/mit/NR/rdonlyres/Physics/8-514Fall2003/34A31831-1BF8-4D1B-8807-5767B40C90D1/0/lec2.pdf`. 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 the 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.

2.3 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 can provide the metabolic energy directly or helps to transform ordinary metabolic energy to that of bio-photons. Also one must understand where the "quantum entity" gets its energy - from Sun perhaps?

3 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.

3.1 Do motor actions of the magnetic body induce squeezing?

The change of thickness for a flux tube of magnetic body [K2] is natural candidate for the "motor action" of the magnetic body generating squeezed light.

1. TGD predicts a hierarchy $h_{eff} = n \times h$ of Planck constants 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. In the case of cell membrane (or rather membrane proteins) this variation would yield emission of squeezed dark photons communicating the sensory data to the magnetic body. Dark photons would transform to ordinary photons with same energy and 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.

3.2 A little sidetrack: could h_{eff} changing phase transitions correspond to singular symplectic and conformal transformations?

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 of course 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? This idea is not at all so far-fetched as it might look since the symplectic transformations (or contact transformations) of $\delta M^4_+ \times CP_2$ are isometries of "world of classical worlds" (WCW).

   I have proposed analogous idea in the context of conformal symmetries of TGD as a mechanism of conformal symmetry breaking: the the conformal algebra would be replaced with sub-algebra for which conformal weights are divisible by $n = h_{eff}/h$. The conformal generators lacking from the sub-algebra would

correspond to singular conformal transformations. As a matter fact, symplectic transformations have structure of conformal algebra with radial light-like coordinate of δM_+^4 taking the role of complex coordinate so that the two ideas are consistent with each other.

3.3 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

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

   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:

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

   The rate for emission of bio-photons would be now

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

   $k = 1$ 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.

Interestingly, 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.

4. The period of state function reductions taking place at fixed boundary of CD corresponds to a life-cycle of self (mental image of the self immediately above in the self hierarchy having CDs as imbedding space correlates) quantum jump to the opposite boundary "kills" the self, destroys quantum coherence, and also reverses the arrow of geometric time at the corresponding hierarchy level. Therefore the period of hyperbolic decay would correspond to the period of quantum coherence. Popp and Li have suggested for long time ago that hyperbolic relaxation is a sufficient condition for a fully coherent ergodic field [I3].

3.4 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://www.waterjournal.org/volume-2/del-giudice`) [I2]). 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-photons). 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.

3.5 Miscellaneous comments

Following represents some additional notes related to squeezing but not fitting under the subtitles above.

1. Squeezed states are somewhat problematic from the point of view of energy conservation since they are not energy eigenstates - that is eigenstates of the new Hamiltonian. The coherent states of Cooper pairs are even more problematic since fermion number is not well-defined for them. ZEO provides a solution of the problem: squeezed states are quantum superpositions of zero energy states for which the energy and even fermion number of the positive part of the state can vary.

2. A very interesting variant of squeezed state mentioned in `http://arxiv.org/pdf/1401.4118v1.pdf` [B1] is two-mode 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 biologically: 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 this kind of squeezing?

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