Evidence for quantum brain

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Abstract

The recent findings of Kerskens and Lopez suggest quantum coherence in the brain scale. The quantum coherence would make itself visible in the magnetic resonance imaging (MRI). The underlying idea is that gravitation somehow induces spin entanglement between objects of mesoscopic scale and MRI allows us to see the presence of this entanglement by eliminating the effects of ordinary sources of entanglement. It is reported that heartbeat inducing very weak evoked potentials is visible in the MRI pattern and that this demonstrates the existence of some unknown mechanism generating entanglement in scale of 10^{-4} meters.

In this article a proposal of Bose et al for generating entanglement by quantum gravitational interaction between mesoscopic objects is first discussed from the TGD point of view. A superposition of two locations for the objects is required. It is assumed that it is possible to correlate the locations with spin values. Entanglement would be generated by different phases, which evolve to different pairs of components of objects.

Mechanisms generating quantum coherence in scales of at least 10^{-4} meters and giving rise to a superposition of locations are needed but are difficult to imagine in the standard view of quantum gravitation.

In TGD, the mechanism is different. Gravitational Planck constant $\hbar_{gr} = Gm/v_0$ associated with Earth-test particle interaction could generate quantum coherence in even brain scale and gravitational Compton length $\Lambda_{gr} = GM/v_0 \simeq .45$ meters, where $v_0 \simeq c$ a velocity parameter characterizes the lower bound for the quantum gravitational coherence scale. The analogs of magnetized states assignable to microscopic objects of size scale 10^{-4} meters take the role of spins and spin-spin interaction generates the entanglement, which is detected by measuring the spin of either object just as in the case of ordinary spins.

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1 Introduction

The recent findings suggest quantum coherence in the brain scale. The quantum coherence would make itself visible in the magnetic resonance imaging (MRI). The findings are described in the popular article in Scitechdaily (`https://cutt.ly/0NtnxwZ`). The research article "Experimental indications of non-classical brain functions" by Christian Matthias Kerskens and David Lopez Perez [J1] is published in Journal of Physics Communications (`https://cutt.ly/0NtnEKz`).

The system studied is the brain and cyclotron resonance of protons in "brain water" is involved. The goal was to find whether there exists evidence for macroscopic quantum entanglement. The work was based on the proposal that some quantum coherent, non-classical, third party, say quantum gravitation, could mediate quantum entanglement between protons of brain water. NMR methods based on so-called multiple quantum coherence (MQC) act as an entanglement witness.

The work of Kersens and Perez was inspired by a theoretical work of Bose et al in which a possible method allowing to witness quantum gravity by spin entanglement [B1](`https://cutt.ly/CNhF2Ev` was discussed.

In the sequel, the proposal of Bose et al for generating entanglement by quantum gravitational interaction between mesoscopic objects is first discussed. A superposition of two locations for the objects is required. It is assumed that it is possible to correlate the locations with spin values. Entanglement would be generated by different phases, which evolve to different pairs of components of objects and measurement of spin would demonstrate the presence of entanglement.

Mechanisms generating quantum coherence in scales of at least 10^{-4} meters and giving rise to a superposition of locations are needed but are difficult to imagine in the standard view of quantum gravitation.

In TGD, the mechanism would be different. Gravitational Planck constant $\hbar_{gr} = Gm/v_0$ associated with Earth-test particle interaction could generate quantum coherence in even brain scale and gravitational Compton length $\Lambda_{gr} = GM/v_0 \simeq .45$ meters, where $v_0 \simeq c$ a velocity parameter characterizes the lower bound for the quantum gravitational coherence scale. The analogs of magnetized states assignable to microscopic objects of size scale 10^{-4} meters take the role of spins and spin-spin interaction generates the entanglement, which is detected by measuring the spin of either object just as in the case of ordinary spins.

2 Could spin entanglement be used as a witness for quantum gravitation

The basic idea of the two [J1] and [B1] is that quantum gravitation can be witnessed by the entanglement induced by it.

2.1 Could quantum gravitation generate spin entanglement for quantum superpositions of locations?

In the article "A Spin Entanglement Witness for Quantum Gravity" of Bose et al [B1](`https://cutt.ly/CNhF2Ev` a detailed proposal how the quantum gravity could generate entanglement in scale $d \sim 10^{-4}$ meters.

1. The masses $m_1 = m_2 = m$ considered are of order 10^{-14} kg and would correspond to a water blob of size about 10^{-5} m with mass of order $m \sim 10^{-3} m_{Pl}$. The masses m_i would be at a distance $d \sim 100$ μm, which corresponds to the size of a large neuron having mass about Planck mass. One has $\alpha_{gr} = Gm^2/\hbar \sim 10^{-6}$. So that the interaction energy at distance d would be $Gm^2/d \simeq 10^{-8}$ eV, which is much below the thermal energy.

2. The idea is that although the gravitational interaction energy is quite too small, quantum gravitational interaction between masses m_i could be detectable via a generation of quantum entanglement. The additional assumption, bringing in mind the Orch-OR hypothesis, is that superpositions of 2 locations are possible for the masses and the separation scale Δx is of order $d/10$. The mechanism causing this superposition is not discussed. What comes into mind is gravitational double well potential.

3. One considers a situation in which each mass is a superposition L+R of locations for the center of mass. One assumes that it is possible to assign to the locations L and R opposite spins so that the measurement of spin would perform a state function reduction inducing a localization to either R or L configuration.

   The distance of the masses has the scale d. One assumes that the masses behave like quantum coherent objects describable by a scalar field, and assumes that they fall freely in the gravitational field of Earth for a time of order of a few seconds.

4. The mathematical model assumes standard perturbative quantization of the gravitation using quantum field theory in Minkowski space. The situation is assumed to be static so that only the component g_{tt} of the metric and radiation part of the gravitational field matters in the description of the interaction.

5. The initial state is an unentangled product of states but their mutual quantum gravitational interactions LR and RL corresponding to distances $d + \delta x$ and $d - \delta x$ of masses generate different phase factors. After this, these analogs of photon beams superpose again and interference takes place. The predicted difference of the phase angle is of order 10^{-4} and might be measurable with recent technology.

2.2 NMR as a witness for quantum gravitational entanglement

The experiment carried out by Kerskens and Perez [J1] was not based on interferometry but on nuclear magnetic resonance imaging (MRI).

It is far from clear that the ordinary NMR signals can contain quantum correlations of the spectrum in the hot and wet brain environment. Therefore a witness protocol, which eliminated the "classical" background from known sources was used.

To achieve this, the "classical" sources of entanglement had to be eliminated. This was achieved by irradiation of the brain region with a radiation inducing cyclotron transitions to higher energy state so that the situation would become saturated and one would have a statistical dynamic equilibrium. In a statistical sense, the temporal patterns associated with the transitions from a higher state to a lower state causing cyclotron radiation patterns visible in MRI would be absent. In this back-ground the presence of "non-classical" sources of cyclotron emission would be visible. This source could correspond to a formation of pure entangled state which would decay by emitting cyclotron radiation.

What was found, was a periodic pattern in MRI with a frequency of heart beat, interpreted in terms of evoked membrane potentials. This pattern is too weak to be visible in the ordinary MRI. What looks surprising is that the frequency was that of heart beat; one would expect some resonance frequency of EEG, say 10 Hz. Premumably, the the possible evoked potentials due to the heartbeat were intentionally chosen as as a target of attention.

The finding fits very nicely with the TGD view of brain and quantum biology, in particular the TGD view of genetic code [L1, L6, L3, L5].

1. In the simplest model, sequences of dark protons (ordinary protons with effective Planck constant $h_{eff} = nh_0$, which can be very large) at the flux tubes of the magnetic body associated with DNA would realize genetic code as sequences of dark proton triplets. Besides dark nucleotides, also dark codons and dark genes as quantum coherent dark 3N-protons would be possible and characterized by very large value of h_{eff}.

   Also dark photon triplets would realize codons and give rise to dark genes as sequences of dark codons: 3N-photons. Communications between dark genes and would occur using dark 3N-photons by dark 3N-resonance. The 3N-frequency would serve as an address somewhat like in LISP and the modulation of frequency scale would create a sequence of resonances analogous to sequence of nerve pulses.

   EEG would closely relate to the dark photon radiation between the magnetic body and brain. Also generalizations of EEG to other frequency ranges are suggestive.

2. The dark magnetic flux tubes would be associated with water and its numerous thermodynamic anomalies and exceptional role in biology, could be understood by the presence of a dark phase involving long gravitational flux tubes carrying dark protons with $h_{eff} = h_{gr}$.

The required values of h_{eff} are huge, and this led to a connection with the Nottale hypothesis of gravitational Planck constant $\hbar gr = GMm/v_0$, $v_0 \leq c$ is a velocity parameter. One would have $\hbar_{eff} = \hbar_{gr}$. The value of velocity parameter can be estimated from various applications. It would have a spectrum with the largesty value $v_0/ \simeq 1$ in the case of Earth with $M = M_E$.

3. TGD leads also to an identification of B_{end}. TGD predicts monopole flux tubes (CP_2 homology is non-trivial) distinguishing TGD from Maxwellian electrodynamics. $B_{end} = 2B_E/5$ is identified as the monopole flux part of the Earth's magnetic field. The monopole flux tubes would carry dark matter and since they have huge quantum coherence scales, would naturally control ordinary biomatter. The control would involve frequency modulation by the variation of the thickness of the monopole flux tubes which would affect the field strength by the conservation of the monopole flux. The variation of the frequency scale would induce at the end of the receiver sequences of cyclotron resonance analogous to nerve pulse patterns.

4. Magnetic body of DNA carrying dark DNA is expected to act as controller of the ordinary biomatter using cyclotron resonance mechanism. In particular, important biorhythms could correspond to cyclotron frequencies. Heartbeat defines one such biorhythm.

   DNA nucleotide cyclotron frequencies are about 1 Hz for B_{end} assigned to the monopole flux tubes. Also for DNA sequences, such as codons and genes, the average cyclotron frequency would be around 1 Hz because the nucleotides carry the same charge and charge to mass ratio Ze/m, so that the cyclotron frequency depends only very weakly on the length of quantum coherent dark DNA segment.

5. The variation of the heart beat frequency could be understood in terms of the variation of the monopole flux tube thickness for dark DNA. This variation would be basic motor action of MB making possible control of biomatter using frequency modulation inducing sequences of resonances manifesting as pulses. Nerve pulse patterns could be one manifestation of this mechanism.

2.3 How quantum gravitation could generate spin entanglement in TGD Universe?

One source of theoretical inspiration for the work of Kerskens and Perez [J1] was the article "Spin Entanglement Witness for Quantum Gravity" of Bose et al [B1].

Classical interactions, be their gauge or gravitational interactions, cannot generate entanglement whereas their quantum counterparts do so in scales smaller than the scale of quantum coherence.

1. The first open question is whether quantum gravitation is able to generate quantum coherence in long length scales such as the scale of the brain. The fact that gravitation has infinite range and is unscreened might allow this. This however requires a new view of quantum gravitation.

   A gravitational 2-particle interaction or interaction induced by quantum gravitation is needed to entangle the systems. If spins or possibly magnetizations are in question, the entanglement can be detected by spin measurements as done in the experiment. The interaction must be such that it can be distinguished from ordinary magnetic interactions.

2. If objects with mass above Planck mass behave like quantum coherent particles with respect to quantum gravitation rather than consisting of small quantum coherent units such as elementary particles, the gravitational fine structure constant $\alpha_{gr} = GM_1M_2/\hbar$ between objects satisfying $M_1M_2 > m_{Pl}^2$ becomes strong and one expects that the situation becomes non-perturbative.

   The condition $M_1 = M_2 = m_{Pl}$ is satisfied for a water blob of radius $\sim 10^{-4}$ meters and corresponds to the size of a large neuron [L2, L5]. The gravitational interaction energy GM_1M_2/d for distance $d \sim 10^{-4}$ m is about 10^{-2} eV and of the same order of magnitude as thermal energy.

3. In the interferometer experiment a much larger phase difference could be generated in the TGD framework but the problem is that it is difficult to imagine a mechanism for creating a superposition of 2 locations of mesoscopic or even microscopic objects.

4. It is also difficult to imagine a mechanism creating 1-1 correlation between location and spin direction (analogous to entanglement associated with spin and angular momentum).

2.3.1 The notion of gravitational Planck constant

The basic problem is what makes the quantum coherence scale so long.

1. In the TGD framework, the non-perturbative character of the situation for $Mm \geq m_{Pl}^2$ motivates a generalization of the Nottale's hypothesis stating that the gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0 < c$ a velocity parameter. $\hbar_{eff} = nh_0 = \hbar_{gr}$ would be associated with gravitational flux tubes to which interacting masses M and m are attached, and would replace $\hbar$ with the gravitational fine structure constant $\alpha_{gr} = GMm/\hbar > 1$ meaning that $Mm > m_{Pl}^2$ is true. One could say that Nature is theoretician friendly and makes perturbation theory possible. This applies also to other interactions.

   The gravitational Compton length $\Lambda_{gr} = GM/v_0$ does not depend on the mass m at all. For the mass of order Planck mass assignable to a large neuron one has $\Lambda_{gr} = L_{Pl}/v_0$, which is of order Planck length. Much longer quantum coherence scale is however required.

2. In the case of the Earth, the basic gravitationally interacting pairs would be Earth mass and particles of various masses. The gravitational Compton length $\Lambda_{gr,E} = GM_E/v_0$ does not depend on the small mass and is about .45 cm for $v_0 \simeq c$ favored by TGD applications. By the way, this scale corresponds to the size of a snowflake [L4].

   $\Lambda_{gr,E} \simeq .45$ cm defines a minimum value for the gravitational quantum coherence scale but much larger coherence lengths, say of order Earth radius, are possible. The size scale of the brain or even body would define a natural scale of quantum coherence. For objects with a size of order of a large neuron, the gravitational interaction could be quantal in scales of the brain, and actually in the scales of the magnetic bodies assignable to the organism.

3. Earth-particle interactions can induce quantum coherence in the scale of the brain and the masses could be taken to be of the order of Planck mass so that they would correspond to water blob with size of 10^{-4}, so that their distance could be larger than d. This raises the hope that the effects of quantum gravitation quantum coherent in cell length scale or even longer scales could be measured although the interaction itself is extremely weak for elementary particles.

4. For $r = 10^{-4}$ meters, $M = M_E$ would give $E \sim e^2/410^2$ eV ~ 2.5 eV. For $r = 5 \times 10^{-4}$ meters this would give $E \sim .01$ eV, roughly the thermal energy at the physiological temperature.

TGD allows the possibility of detecting gravitational interaction energies for objects of mass of say Planck mass or larger. In fact, the large value of gravitational Planck constant increases the extremely tiny cyclotron energies of ELF photons in EEG range to energies above thermal energy at room temperature [K1, K2, K3] [L6].

2.3.2 A possible TGD based mechanism generating spin entanglement

These considerations suggest a TGD based mechanism for the generation of spin entanglement, which is not directly based on quantum gravitational interaction but on microscopic and even macroscopic qravitionally induced quantum coherence making possible a generalization of the spin-spin interaction as a way to generate entanglement.

1. Spin should correspond to an analogs of macroscopic magnetization rather than individual spin. Spin-spin interaction between "mesoscopic" defined by quantum coherent particles characterized by $\hbar_{gr}$ and having mass about Planck mass generates the entanglement which can be detected by measuring the "spin" of either particle. As a consequence also the "spin"

of the other particles is determined and one has a standard situation demonstrating that the particles were entangled before the measurement.

Large value of the energy due to the large value of $\hbar_{gr}$ could mean that one has a dark Bose-Einstein condensate like state with a large number of ordinary particles, say protons at the gravitational flux tube representing the quantal magnet behaving like spin.

In the TGD framework, Galois confinement provides a universal mechanism for the formation of many-particle bound states from virtual particles with possibly momenta with components in an extension of rationals . The total momentum would have integer components using the unit defined by the size scale of causal diamond (CD).

2. The dark cyclotron energy $E_c = \hbar_{gr} eB/m = \Lambda_{gr} eB$, $\Lambda_{gr} = GM/v_0$ of a mesoscopic particle whose particles are associated with (touching) the dark monopole flux tubes of the Earth's gravitational field, does not depend on its mass and is large.

   The magnetic field created by this kind of particle would correspond in the Maxwellian picture to a field $B \propto \hbar_{gr} e/mr^3$. This would give for the magnetic interaction energy of the mesoscopic particles the estimate $E \sim \mu_1 m_2/r^3 = e^2\Lambda_{gr}^2/r^3$.

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