Exploration

The Magnetosphere of Jupiter as a Seat of Plasma Life and Its Moon Europa as a Seat of Chemical Life?

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Abstract

FM signals in radio frequency range 12-40 MHz from Jupiter's moon Ganymede have been reported 4 years ago. The claimed FM signals from the moon Europa have received a lot of attention. In human radio wave communications in the frequency range 87.5- 108.0 MHz frequency modulation is used to code information. This has raised speculations about intelligent life under the ice cover of Europe and raised the question whether the radiation could code for information and even represent a response to the signals from the Earth. This finding is especially interesting from the TGD point of view since frequency modulation is a basic vay to code information in TGD inspired quantum biology. Also the phenomenological notion of magnetic flux tube is central in the description of the magnetic field of Jupiter: in the TGD framework this notion is not phenomenological and is the basic notion in practically all applications of TGD based on the notion of field body and the hierarchy of phases of ordinary matter labelled by effective Planck constant h_{eff}. Gravitational and electric Planck constants associated with long range classical gravitational and electric fields are of special importance. Frequency modulation is the key mechanism of communications and control in TGD based quantum biology. This motivates the development of the TGD based models for the magnetospheres of Jupiter and its moons and also an analog for the maser cyclotron instability. The ensuing model for Jupiter's auroras is consistent with the empirical facts. Also the possibility of plasma life at the field bodies associated with Jupiter as well as primitive life in the interior of Europa can be considered.

1 Introduction

During last weeks aliens have been the topic of the social media. Most of this has been non-nonsense generate by using AI telling that horrifying and terrifying aliens are arriving Earth in flying saucers, which are hundreds of kilometers wide and that NASA is in shock and unable to say anything, which proves that every word is true.

An interesting claim about the detection of FM radio wave signals from Jupiter's smallest moon Europa but it is difficult to know whether the signal is frequency modulated so that this news could be fake (fact checking would be desperately needed). Wikipedia article (see this tells about FM signal from Ganymede but does not mention a detection of an FM signal from Europe.

In the case of Ganymede, the frequency range is 10-40 MHz. In human communications by radio waves in the frequency range 87.5- 108.0 MHz frequency modulation is used to code information. Frequency modulation is also the basic way to code information in TGD inspired quantum biology was a good motivation for taking the claim about the FM signal from Europa half-seriously and for writing this article.

1.1 The findings

From a Wikipedia article one learns, that the so called decametric radiation from Jupiter (see this) occurs at cyclotron frequencies for Jupiter's magnetic field. This radiation need not be FM modulated. The frequency range is reported to be 5-40 MHz, which corresponds roughly to the frequency range of the

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cyclotron frequencies in the magnetic field of Jupiter if harmonics are allowed. The fundamental frequency depends on the Moon and varies roughly by a factor.

The Ganymede, which - un-like Europa, Callisto and Io - has its own, rather strong magnetic field, was already around 2020 found by Juno spacecraft to send an FM signal (this and this). . The FM signal (see this) has a carrier frequency in the frequency range 12-40 MHz. The mechanism proposed to explain this signal would be maser cyclotron instability.

I could not find any published report about FM signals from Europa. Europa is covered by ice and probably has water below the ice cover is a natural candidate for a seat of life. Therefore there have been speculations about the possibility of intelligent life in Europe. For instance Neil deGrasse Tyson in Science is a proponent of this interpretation (see this).

Planetary scientists detected structured radio transmissions from Europa that appear to be artificially generated and are increasing in strength and complexity over time. The signals originate from beneath Europa's ice shell and show mathematical patterns that suggest intelligent origin rather than natural geological processes. Most intriguingly, the transmissions seem to respond to Earth-based radio signals with delayed but clearly correlated responses, indicating potential two-way communication attempts.

The signal structure includes prime number sequences, geometric progressions, and other mathematical concepts that would be universal indicators of intelligence to any technological civilization. NASA's analysis confirms the signals are too complex and organized to result from natural phenomena like ice cracking, tidal heating, or magnetic field interactions.

Most astrophysicists however interpret the possible signals as having a natural source. The signals appear as bursts rather than being continuous and are much more complex than the FM signals sent by humans. The presence of bursts might be however due to the fact that they can be generated in short periods only.

The frequency range in the case of Ganymede and naturally also in the case of the Europa is 10-40 MHz if there really is an FM signal. This frequency range roughly corresponds the cyclotron frequency range for the magnetic field of Jupiter: for the dipole field it which would be twice of this range if only first harmonic contributes.

Io is known to be connected to Jupiter by magnetic flux tubes and known to provide electrons and ions to these flux tubes and the currents end along flux tubes to the atmosphere of Jupiter and generate auroras in UV. Note that also X-ray auroras are observed.

The Galilean moons Ganymede, Io and Europa do not rotate with the same velocity as the inner magnetosphere of the Jupiter assumed to consist of flux tubes realizing the dipole field structure. For ideal dipole field the emission would be continuous and the decomposition of the magnetic field to flux tubes (this term is used also in standard physics) is what makes it possible to speak about the rotation of the magnetosphere.

The questions are whether the signals are FM modulated and what is the mechanism of modulation. The TGD based view of quantum biology suggests a possible answer to the latter question.

1.2 The standard physics view for how the generation of the radio wave bursts

A possible mechanism for the generation of radio waves explaining why it arrives as bursts, relies on the collisions of the moon with the flux tubes of the rotating Jovian magnetosphere consisting of dark flux tubes. This explains bursts and why the emission is not thermal. The mechanism does not explain the FM modulation.

The so-called maser cyclotron instability [2, 3] has been proposed as a standard physics explanation of the phenomenon.

1. A transfer of energy between ions and the fields assignable to the flux tubes. The flux tubes would have population inversion with respect to momentum in that the velocity distribution is asymmetry: velocities parallel to the flux tube tend to be higher than in the directions orthogonal to to. This

asymmetry tends to disappear and this leads to a transfer of energy to cyclotron energy states and also to generation of cyclotron photons. The amplification mechanism would rely on stimulated emission and generate a coherent many photon state as in the maser.

2. The population reversal would be due to the acceleration of charged plasma particles in the strong electric field of the flux tube, whose flux lines are locally orthogonal to the magnetic flux lines, associated with the helical flux tubes and gain a large energy. In the scale of the flux tube, the magnetic and electric fields look parallel.

3. The energy in the longitudinal degrees of freedom (parallel to the magnetic field) would be eventually liberated and create the UV auroras in Jupiter's atmosphere. This process involves a reconnection if the flux tubes turn around and return to the moon. As in the case of the Earth, the reconnections would generate a leakage of electrons from the flux tubes and create the Auroras. The flux tubes from the moon could be U-shaped and the reconnection would create a small closed flux tube.

4. The acceleration mechanism of charged particles would be the same as in surfing. The em fields representing a perturbation of the flux tube would be amplified by a resonant interaction with the ions when the frequency of field perturbation corresponds to cyclotron frequency. The direction of the motion of an ion depends on its charge. Also the transfer of protons and positive ions from the surface of Jupiter to Europa has been detected.

5. Where would the needed energy come from? The rapid rotation of Jupiter is proposed as a source of energy.

What about the frequency modulation? Somehow the strength of the magnetic field should be modulated but is there any obvious mechanism for this.

2   The TGD view of the FM radiowaves

The following gives a brief summary of the findings followed by a more detailed discussion.

2.1   The TGD view about the findings very briefly

In TGD, the notions of space-time and classical fields differ dramatically from those of general relativity and Maxwell's theory. Also the TGD based quantum theory differs from standard quantum theory since number theoretical vision predicts a hierarchy of effective Planck constants h_{eff} having arbitrarily large values making possible quantum coherence in arbitrarily long scales. Ordinary matter has dark matter-like phases labelled by h_{eff} (not identifiable as galactic dark matter). Furthermore, one can assign to the classical gravitational/electric fields gravitation gravitational/electric Planck constants, which have very large values.

2.1.1   The notion of field body

The notion of field body distinguishes TGD from Maxwellian electrodynamics and classical field theories in general.

1. Monopole flux tubes realized as space-time surfaces carrying magnetic monopole flux and realized as space-time surfaces in $H = M^4 \times CP_2$ are not possible in the Maxwellian world have a key role in the fractal Universe of TGD in all scales from cosmology to astrophysics [29, 24, 25] to biology [21, 22] and even to the level of elementary particles [12, 13].

2. In the inspired biology, the magnetic body of the system consisting of monopole flux tubes plays a central role [11, 14, 9] [28]. The gravitational field bodies of Earth and Sun and planets are in a key role [21]. Also the electric bodies are important, in particular negatively charged DNA, cell membranes and even the Earth have electric field bodies. Also Jupiter is negatively charged and has strong electric and magnetic fields. and carriers of plasma life [22] for which NASA has found support in the ionosphere of the Earth.

   Biosystems are cold plasmas and the ordinary life could be considered as a symbiosis of chemical life at the biological body and plasma life at the magnetic and electric bodies of the system. Pollack effect [5, 4, 7, 6] and its TGD based generalizations [15, 17, 26, 19, 27, 22] would make possible the transfer of positively charge ions matter to the field bodies as analog of dark matter. This process would be directly observable unlike the matter at the field body. As a side effect also negatively charged exclusion zones and dark matter at corresponding electric field bodies would be generated.

3. In TGD, the communications between ordinary biomatter and plasma life [22] at the field bodies of living systems are central. EEG represents a basic example of these communications and rely on frequency modulation of the signals consisting of dark Josephson photons [9] received at the field body by cyclotron resonance transforming the signal to a sequence of pulses analogous to a nerve pulse pattern [28]. These communications would occur also in other frequency ranges besides ELF frequency range.

   What is of special importance is that the relationship $E = h_{eff} f$ allows even ELF frequency photons to have energies in, say, biophoton energy range. As a matter of fact, the findings of Blackman and others [8] inspired the hypothesis about the hierarchy of Planck constants which now emerges from the number theoretic vision of TGD. What is also remarkable is that for gravitational Planck constant $\hbar_{gr}$ the cyclotron energies do not depend on the mass of the charged particle. This conforms with the Equivalence Principle and makes possible gravitational quantum coherence.

4. Field bodies can have motor activities. In reconnections the topology field body having monopole flux pairs as basic body parts changes. Monopole flux tubes can also vary the flux tube thickness. By flux conservation this modulates the strength of the magnetic field so that a modulation of the cyclotron frequency takes place. In TGD inspired biology, this would be a key communication and control mechanism between the biological body and field body. The electric voltages associated with the electric field bodies such as cell membrane acting as Josephson junctions can give rise to drk Josephson radiation at ELF frequencies, frequency modulated by the variation of the membrane potential.

2.1.2   The notions of gravitational and electric Planck constant

TGD predicts that long range electric, magnetic and gravitational fields correspond to field bodies, which can be characterized by an effective Planck constant h_{eff}, which can have arbitrarily large values so that there is long range quantum coherence involved.

1. Electric *resp.* gravitational Planck constant $\hbar_{gr}$ *resp.* $\hbar_{em}$ characterizes the particles at the gravitational *resp.* electric field body. Gravitational Planck constant was introduced already by Nottale [1]. $h_{eff} = h_{gr}$ is proportional to the product Mm of the mass M of the object (say Sun or planet serving as the source of the gravitational field and mass m of the particle. h_{em} is proportional to the product of charges of the system generating the macroscopic electric field and of the particle.

2. Equivalence Principle is coded by to the form of $\hbar_{gr} = GMm/\beta_0$, where M corresponds to the large mass M and m to the particle mass. $\beta_0 = v_0/c$ is a velocity parameter proposed to be quantized as $\beta_0 = 1/n$, $n = 1, 2, 3, ...$ [18]. For planets $\beta_0 = 1$ would be satisfied in a good approximation and $\beta_0 \simeq 2^{-11}$ would hold true for the Sun. This implies that the cyclotron energies of charged

particles do not depend on their masses as the Equivalence Principle requires. This also makes possible gravitational quantum coherence.

3. $\hbar_{gr}$ is proportional to the particle mass so that different dark particles must reside at different flux tubes, somewhat like books at different shelves of a bookcase. This means a huge amount of invisible order and information, which remains hidden in standard model based physics.

4. The gravitational Compton length $\Lambda_{gr} = r_S/2 = GM/2$ of planet, the gravitational frequency f_{gr}, and the energy E_{gr} are highly interesting in the TGD inspired quantum biology. The gravitational Compton length $\Lambda_{gr,J}$ of Jupiter is obtained from $\Lambda_{gr,E} = .5$ cm for the Earth by scaling and is $\Lambda_{gr} \simeq 20$ m. Interestingly, the gravitational Compton frequency of Jupiter is $f_{gr,J} = 3$ MHz, which is by factor $1/5$ smaller than its cyclotron frequency scale $f_{c,J} \sim 15$ MHz.

   The gravitational Planck constant for Eu-electron pair is 5.2×10^7 so that dark $f = 10$ MHz photon has energy $E = \hbar_{gr} f = 5.2 \times 10^14$ Hz. The gravitational Compton length $L_{gr,Eu} = R_S/2 = GM = 4 \times 10^{-5}$ m, the size scale of a neuron. Also a water blob of Planck mass M_{Pl} at the ordinary density has radius of this order of magnitude. The gravitational Planck constant replaces $\hbar$ only when the condition $Mm \geq M_{Pl}^2$ is satisfied.

   The masses of Galilean moons are rather near to each other ($M_{Ganymede}/M_{Europa} \sim 3$) so that the gravitational Compton lengths $\Lambda_{gr,E} = .5$ giving in the TGD framework an estimate for the lower bound of the gravitational quantum coherence length are rather near to each other.

   The gravitational Compton frequency for Europa is $f_{gr,Eu} = .75 \times 10^{13}$ Hz, which corresponds to the energy $E_{gr} \simeq .075$ eV. Rather remarkably, the Josephson energy E_J assignable to the upper bound of the membrane potential of a neuron is rather near this energy. For Ganymede this energy is roughly $1/3$ of this energy.

2.1.3 Replacing the phenomenological notion of flux tube with monopole flux tube as space-time surface

The phenomenological notion of magnetic flux tube is in a central role in the proposed model for the generation of radio waves by maser cyclotron instability. Could the interpretation as monopole flux tubes make sense and make it possible to understand the mechanism for the generation of FM radio waves? This even allows us to consider the possibility that communications are in question. This raises a series of questions.

1. Could the rotating Jovian magnetosphere, approximated by a dipole field in the Maxwellian theory, involve dark monopole flux tubes with gravitational Planck constant $\hbar_{gr,J}$ determined by the mass of Jupiter?

2. Could the Galilean moons Ganymede, Callisto and Europa of Jupiter be characterized by their own gravitational Planck constants $\hbar_{gr,X}$, X= Europa, Callisto, Ganymede? Io has direct flux tube contacts with Jupiter: the magnetic body of Io would be a part of Jupiter's magnetic body. Could this mean $\hbar_{gr,Io} = \hbar_{gr,J}$?

   Jupiter has both UV and X-ray auroras. Could Europa, Callisto and Ganymede give rise to both the UV and the X-ray auroras of Jupiter as a transformation of gravitational dark radio radio wave photons to ordinary photons? Does the much larger value of $\hbar_{gr,Io} = \hbar_{gr,J}$ predict gamma ray auroras?

3. Europa differs from Ganymede in that it has only a weak induced magnetic field in its exterior. Could Europa however have a dark magnetic field restricted to its interior and consisting of monopole flux tubes, which could induce a weak magnetic field $B_{Eu,ind}$ visible outside?

Could the weakness of $B_{Eu,in}$ be only a statistical property reflecting the smallness of the total flux: only very monopole flux tubes extend to the exterior of Europa? This view is supported by the observation that the FM modulated cyclotron radiation from Europa has the cyclotron frequency corresponding to the gravitational Planck constant of Europa.

4. Could the variation of the monopole flux tube thickness provide a mechanism of FM communications in the case of Europa and Ganymede and be seen as a signal of intelligent plasma life residing at field bodies? Could the water in the interior of Europa be seen as a prerequisite for the existence of primitive biochemical life? Note that according to the TGD view, also the life on Earth developed in underground oceans [10] [23].

2.2 Questions related to the mechanism generating the FM radiowaves

The basic question concerns the mechanism generating the FM radio waves.

1. What generates the magnetic field of Jupiter? In standard physics dynamo effect is assumed to do it. Conductive plasma motion, convection and rotation would be involved. Rotation of the plasma in the inner magnetosphere gives rise to currents, which in turn generate magnetic fields. The Lorentz force due to the magnetic field gives rise to the motion of plasma so that a self-organizing closed loop is generated. This requires energy and it could come from the rotational motion of Jupiter.

   TGD suggests a different possibility based on a new view of electromagnetism. The monopole magnetic field is highly stable and requires no currents to create it: this explains the stability of magnetic fields in cosmic scales and also the stability of the magnetic field of the Earth [16]. Monopole flux tubes are U-shaped and can decay by reconnection to very short closed loops. Solar cycle is one example of this and also the changes of the Earth's magnetic field. Could also Jupiter have an analog of the solar cycle?

   Also now, a source of metabolic energy is needed and the rotation of Jupiter is a natural candidate.

2. What does the co-rotating electric field of Jupiter (see this) mean in the TGD framework?

   The very naive first guess is that the field is in the first approximation due to the Faraday effect $E \sim v \times B_J$, where v is the rotation velocity. This field would be of the order $E \sim v_{rot} B_J$ would be $E \sim 2.4 \times 10^{-3}$ V/m and much weaker.

   The monopole flux tubes allow simple helical deformations carrying an electric field whose flux lines are locally orthogonal to the magnetic flux lines along the flux tube. In the scale of the flux tube, the magnetic and electric fields look parallel. One can also consider closed monopole flux tubes which look like two parallel helical strands but this is not necessary. The charged particles would naturally move along the flux tubes and end up to a pole of Jupiter. Something very similar occurs in the case of the Earth.

2.2.1 What could be the TGD counterpart of the maser cyclotron instability?

Ion cyclotron waves are assumed to travel along the magnetic flux tubes between the moon and Jupiter. Wikipedia gives a summary of different kinds of plasma waves (see this). In the general case, the plasma is characterized by static magnetic and electric fields. The plasma wave can be electrostatic with no magnetic oscillation or electromagnetic with magnetic oscillation. Faraday law implies that the electrostatic wave is longitudinal, that is wave vector is parallel to E. The article contains a table summarizing dispersion relations for various elementary plasma waves.

In the maser cyclotron resonance [2, 3], the ion cyclotron waves are longitudinal electrostatic waves analogous to sound waves, which propagate in the direction of the electric field E. They are orthogonal to the static magnetic field B_0. The dispersion relation is $\omega^2 = \omega_c^2 + k^2 c_s^2$, where c_s is the speed of sound for electrons in plasma.

$$c_{s,ion} = \left(\frac{\gamma Z k T_e}{m_i} \right)^{1/2} = \sqrt{m_p/m_i} \, c_{s,p}$$

where the speed of sound for proton is $c_{s,p} = 90.85$ m/s.

Maser cyclotron instability generates as charge separation. Population inversion is involved and means that the velocity distribution for electrons has asymmetry. By acceleration along electric field, the longitudinal electron velocities tend to be larger than the transversal velocities. The symmetry tends to restored, which means that energy is transferred from the longitudinal to the transversal magnetic cyclotron degrees of freedom and of the energy is emitted creating cyclotron radiation.

Since electrons flow towards Juper and positively charged ions towards the moons, a charge separation and electric field is generated. Jupiter is indeed negatively charged whereas Galilean moons are positively charged. There is an analogy with DNA, cell membrane, and also with the Earth. The electric field of Jupiter 400 times stronger than that of the Earth and corotating. Io has volcanic activity and generates its own current and plasma (see this).

This is the standard view of the mechanism involved. In the TGD framework, flux tubes become monopole flux tubes carrying dark electrons, protons and ions. Assume that the flux tubes are characterized by gravitational Planck constant $\hbar gr, J$ when they emanate from Jupiter and by $\hbar gr, moon$, when they belong to the magnetic body of the moon. Io is a possible exception since it is connected to Jupiter by flux tubes.

1. If a given flux tube is characterized by a unique gravitational Planck constant proportional to the mass of the particle, electrons and various ions must reside at separate flux tubes representing parallel space-time sheets. If there is an interaction between charged particles of different kinds it involves wormhole contacts representing elementary particles such as photons.

2. TGD allows deformations of the magnetic flux tubes for which also electric field locally orthogonal to the magnetic field is present. In the scales larger than flux tube scale electric and magnetic fields look parallel to each other. Electrons and ions are accelerated in different directions in the electric field, which also generates population inversion at the flux tube.

   A maser-like state of dark photons is generated. I have proposed that this kind of mechanism could explain the mysteriously high energies of electrons and gamma rays associated with lightning [22].

   The dark photons with a frequency equal to a multiple of cyclotron frequency could decay to bunches of ordinary radio wave photons creating radio wave radiation or to single ordinary photon with energy $E = n\hbar_{gr} f_c$ possibly generating UV auroras of Jupiter. The heavier moons could also generate X-ray auroras (the dark cyclotron energy is proportional to the mass of the moon). If Io is characterized by $\hbar_{gr,J}$ it could give rise to gamma ray auroras.

3. Dark monopole flux tubes are not visible. The acceleration of electrons would take place along dark monopole flux practically without dissipation. There would be an analog of electronic solar wind from moons to Jupiter. Reconnection would occur as in the case of solar magnetic fields and create auroras. Electrons would transform to ordinary electrons and generate UV auroras and possibly also X-ray auroras in the case of heavier moons (the frequency is proportional to the mass of the moon).

2.2.2 Testing the hypothesis that the moons of the Jupiter UV and X-ray auroras?

The basic hypothesis is that dark cyclotron photons from Ganymede in the flux tube $B_{end} \simeq B_{Eu}$ can transform to ordinary UV photons producing the UV Auroras of Jupiter. Also the dark cyclotron photons from Europa and Callisto could contribute. The dark photons can also decay to bunches of ordinary cyclotron photons with the cyclotron frequency of Jupiter. In the case of Io connected to Jupiter by flux tubes the dark photons would correspond to X ray energies and would produce the X ray auroras.

1. The assumption that UV auroras of the Jupiter correspond the transformation of dark cyclotron photons to ordinary UV photons allows to test whether the hypothesis $h_{eff} = h_{gr,moon}$ for some Galilean moons of Jupiter makes sense.

2. $\hbar_{gr,e}/\hbar$ corresponds to the ratio of UV frequency to electron's cyclotron frequency scale 10^7 Hz for Jupiter. The energy range $[3.1 - 12.4]$ eV for UV radiation corresponds to frequency range $[7.5, 30] \times f_0$, $f_0 = 10^{14}$ Hz, that is 2 octaves. The observed UV radiation is in the frequency range $[18, 25] \times 10^{14}$ Hz which corresponds to the energy range $[7.4, 10.3]$ eV. This corresponds to the range $[7.5, 30] \times 10^7$ for $\hbar_{gr,e}/\hbar$. The lower bound looks like a natural estimate. The value of $\hbar_{gr} = 5.2 \times 10^7$ for $\beta_0 = 1$ is 70 percent of the lower bound. The increase of the lower bound 10 MHz for the frequency range to 13 MHz solves this problem.

3. For other moons, the range of UV auroras contains EUV energies. For Io the range for Europa would be scaled roughly by factor 2 and for Ganymede by factor 3. Could also higher cyclotron harmonics contribute to the X-ray auroras? For other moons the range could contain also X ray energies. For Io the lower for Europa would be scaled roughly by factor 2 and for Ganymede by factor 3 to about 21.2 eV in extreme UV.

4. In the case of Jupiter, one ask whether the hypothesis $h_{eff} = h_{gr,Jupiter}$ whether the transformation of the dark cyclotron photons with $\hbar_{gr,J}$ could contribute to the X-ray auroras of Jupiter. The range for X-ray auroras is $[.2, 79]$ keV. For the gravitational Planck constant of Jupiter with mass $M_J = 3.2 \times 10^4 M_{Eu}$, the range for the lower end of the UV range for Eu auroras would be scaled up by the factor $M_J/M_{Eu} = 3.2 \times 10^4$. For the same value of B_J, the lower bound for the energies of UV auroras of EU would be scaled up to lower bound ~ 270 keV, considerably above the observed range $[.2, 79]$ keV. The hypothesis fails.

5. Gravitational Compton length $L_{gr} = R_S/2 = GM$ is a basic parameter for $\beta_0 = 1$ equals to Schwartchild radius divided by $1/2$. For Europa, the Compton length is $L_{gr}(EU) \simeq .4 \times 10^{-4}$ m. Interestingly, a water volume having Planck mass $M_{Pl} = 1.220910 \times 10^{19}$ eV $= 2.176435(24) \times 10^{-8}$ kg corresponds to $R_P = 1.74 \times 10^{-4}$ m. This corresponds to the size scale of a large neutron.

   This raises the question whether conscious intelligence and cell- or even neuron-like structures could be involved?

2.3   Could Jupiter's field body serve as a seat of plasma life?

In TGD, the long range gravitational, electric and magnetic fields are accompanied by phases of ordinary matter characterized by gravitational, and electric Planck constants which can have very large values. The gravitational, magnetic and gravitational field bodies of the biosystem contain dark matter phases and could correspond to plasmoids [22]. These phases have an "IQ" characterized by h_{eff}, which is much higher than that for the ordinary biomatter. Therefore the field bodies would control the biological life based on chemistry and assignable to biological bodies. Same could be true in the case of Jupiter.

Could it be that the TGD variant of the maser cyclotron instability is a mechanism providing metabolic energy for some kind of life forms, which need not be chemical? TGD indeed leads to a proposal for plasma life, which would utilize the same basic quantum mechanisms as the chemical life. Cold plasmas of ions play a key role also in biochemical life. The interior of the ice-covered Europa has been proposed to be a seat of possible life forms.

In the TGD inspired biology metabolic energy feed is in a central role as also magnetic fields assignable to the monopoled flux tubes. In the case of the Earth, the Sun is the provider of the metabolic energy. Could the rotational motion of Jupiter provide the source of the metabolic energy for Jovian life forms possibly associated with some Galilean Moons, the plasma life at the monopole flux tubes connecting Jupiter to some of these moons, at least Io?

Metabolism does not involve only energy feed. Could one Io, having volcanic activity, be a provider of ions for the plasma life at the dark monopole flux tubes of the magnetic field of Jupiter. What could be the role of Ganymede known to have its own magnetic field?

The interior of Europa contains water. Could it also contain primitive chemical life forms? Note that, the TGD based view of the evolution of life at the Earth assumes that the life evolved in the underground oceans and bursted to the surface of Earth in Cambrian Explosion for 500 million years ago [20, 23] [10].

Frequency modulation is the basic communication and control mechanism in the TGD inspired quantum biology and in the model of brain and EEG. Frequency modulation could play his role also in the case of Jupiter and its moons.

3 Appendix: Summary of the basic facts

3.1 Jupiter

1. The mass M_J of Jupiter is $317.8M_E$. The radius R_J of Jupiter is given in terms of the Earth radius R_E as $R_J \simeq 11.2 \times R_E$ (see this).

2. Jupiter's magnetic field is the largest coherent magnetic structure of the solar system. The dipole moment Jupiter is 20,000 of times larger than for Earth (see this). The value of the Jupiters magnetic field at at the Jupiter's equator is $B_J = 10B_E$, where the nominal value of B_E is .5 Gauss. Jupiter has flux tubes from the surface of Jupiter to Io.

3. Electron's cyclotron frequency scale at the equator of Jupiter is $f_c = 2.5 \times 10 \times .6$ MHz = 15 MHz. Cyclotron energy scale $E_c = 1.5 \times 10^{-7}$ eV for the ordinary Planck constant.

4. The electric field E_J of Jupiter is about 400 times stronger than the electric field $E_E \sim 100$ V/m of the Earth at the equator and therefore about $E_J \sim 4 \times 10^4$ V/m.

FM radiowaves from Jupiter in the range 12-40 MHz is in cyclotron frequency range for the magnetic field of Jupiter. 14 MHz could correspond to the value B_J at the equator. The dipole field (see this) has opposite direction at poles and equator and has two times larger strength at poles so that poles would correspond to 28 MHz. This is 75 per cent from 40 MHz.

3.2 Europa

Using the mass $m_0 = 10^{22}$ kg as a unit, the masses of Jupiter's Galilean moons are approximately $m(Io) = 8.93$, $m(Europa)=4.8$, $m(Ganymede) = 14.8$, and $m(Callisto) = 10.8$. Ganymede is the most massive and Eu is the lightest. The mass of Europa is $8 \times 10^{-3}M_E$.

The value of the magnetic field of Jupiter at equator is $B_J = 10B_E$. One can estimate the value of B_J at Europa using dipole approximation predicting $1/R^3$ dependences for a given polar angle θ. The magnetic field at Europa would be scaled down by $(d_{Eu}/R_J)^3$ from that at the equator of Jupiter.

The option favoured by TGD is that the magnetic field is constant along flux tubes but the density of flux tubes decreas as $1/R^3$. The distance of Europa is $d_{Eu} = 670,900$ km and the radius of Jupiter is $R_J = 69,911$ km. This implies the reduction of field strength by factor 10^{-3}. The value of $B_{J,Eu}$ at Europa would be $B_{J,Eu} \simeq 10^{-3}B_J \simeq 10^{-2} \times B_E$.

Electronic cyclotron frequency for $B_{J,Eu}$ would be $f_c, e \simeq 15$ kHz for electron and is much smaller than the observed frequencies, which are in 10-40 MHz range.

The magnetic field $B_{Eu,ind}$ induced by some mechanism in the interior of Europa is $B_{Eu,ind}$= 720 nT. $B_{Eu,ind}/B_E = 1.44 \times 10^{-3}$. $B_{EU,ind}$ is by a factor 1/10 times weaker than $B_{J,Eu}$. $B_{Eu,ind}/B_E$ is believed to be due to the conducting salt water in the interior of Europa. Another option is that flux tubes are present in the interior but that only very few leak out so that the induced magnetic field corresponds to the average magnetic flux.

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