

# Magnetic Bubbles in TGD Universe

M. Pitkänen,

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Email: matpitka6@gmail.com.

[http://tgdtheory.com/public\\_html/](http://tgdtheory.com/public_html/).

Recent postal address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland.

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### Abstract

I received a link to a video summarizing the properties of the Local Bubble surrounding the solar system. The Local Bubble represents only one example of magnetic bubbles. The magnetic bubble carries a magnetic field with field lines along its surface. Star formation and interstellar gas seems to concentrate on the bubble.

It is believed that the Local Bubble has been formed in a burst of star formation in the center of the bubble. These stars would have died as supernovae and the matter from supernova explosions would have pushed gas and compressed it to form the Local Bubble.

These bubbles bring in mind the large voids, whose boundaries carry galaxies. I have discussed from the TGD point of view already earlier. One ends up with a question, whether galaxies are formed at the surfaces of large voids and stars at the surfaces of the magnetic bubbles. Could also the formation of planets be understood in this way? TGD predicts that cosmic expansion takes place as rapid "jerks" and this view has application to the mystery of Cambrian Explosion. Could these local Big-Bangs give rise to a universal mechanism for the formation of structures? If so, then Earth and Moon must have the same composition. The finding that this is indeed the case, came as a total surprise.

The fusion of dark protons at monopole flux tubes to dark proton sequences identified as dark nuclei, which then transform to ordinary nuclei and liberate nuclei binding energy and in this way induce explosion, is the basic step in the formation of astrophysical objects. Dark fusion was originally proposed as a model of "cold fusion" but later generalized to a model for the first step in the formation of stars not yet involving ordinary fusion. The recently found candidates for population III stars could correspond to these prestellar objects.

Galactic blackholes have been recently found to receive a new contribution to their mass from dark energy identifiable as the energy of cosmic strings in the TGD framework. The second discovery is that galaxies, which should be the oldest ones on the basis of their distance, are oldest ones on the basis of their age: zero energy ontology explains this.

A detailed model emerges for the formation of a planetary system as a series of solar explosions as analogs of supernova explosions throwing out a layer of dark matter transforming to ordinary matter, possibly forming a planet. Both the generalization of Nottale's model for planetary orbits involving gravitational Planck constant and a generalization of the Expanding Earth model are involved. The model explains the composition differences between giant planets and Earth-like planets and also the Kuiper belt as a failed planet and is also applied to giant exoplanets. The general vision applies also to the solar cycle and the polarity flip of the solar magnetic field. The general vision applies also to the solar cycle and the polarity flip of the solar magnetic field.

## 1 Introduction

I received a link to a video summarizing the properties of the Local Bubble surrounding the solar system (<https://rb.gy/m8slm3>). The Local Bubble represents only one example of magnetic bubbles. The magnetic bubble carries a magnetic field with field lines along its surface. Star formation and interstellar gas seems to concentrate on the bubble.

### 1.1 Basic facts about the Local Bubble

The article "*Star formation near the Sun is driven by expansion of the Local Bubble*" by Zucker et al published in Nature [E6] (<https://rb.gy/7hdoyo>) gives basic facts about the Local Bubble surrounding the solar system. The Local Bubble has a radius of about 500 ly. Within 500-light-years of Earth, all stars and star-forming regions sit on the surface of the Local Bubble, but not inside. The total mass is about  $10^6$  solar masses. The Local bubble is accompanied by magnetized molecular clouds, which reveal the existence of the bubble via the polarization of radio wave radiation.

It is believed that the Local Bubble has been formed in a burst of star formation in the center of the bubble. These stars would have died as supernovae and the matter from supernova explosions would have pushed gas and compressed it to form the Local Bubble. According to the Nature article [E6], the research team calculated that at least 15 supernovae have gone off over millions of years and pushed gas outward, creating a bubble where seven star-forming regions dot the surface.

## 1.2 Magnetic bubbles and TGD view of cosmic expansion as rapid "jerks"

These bubbles bring in mind the large voids (<http://tinyurl.com/jyqcjhl>), whose boundaries carry galaxies. They are discussed from the TGD point of view in [K6]. One ends up with the question, whether galaxies are formed at the surfaces of large voids and stars at the surfaces of the magnetic bubbles. Could also the formation of planets be understood in this way? TGD predicts that cosmic expansion takes place as rapid "jerks", and this view has application to the mystery of Cambrian Explosion [L9, L25, L19, L34]. Could these local Big-Bangs give rise to a universal mechanism for the formation of structures? If so, then Earth and Moon must have the same composition. The finding that this is indeed the case (<https://rb.gy/4sq5ho>, came as a total surprise.

The fusion of dark protons at monopole flux tubes to dark proton sequences identified as dark nuclei, which then transform to ordinary nuclei and liberate nuclei binding energy and in this way induce explosion, is the basic step in the formation of astrophysical objects. Dark fusion was originally proposed as a model of "cold fusion" but later generalized to a model for the first step in the formation of stars not yet involving ordinary fusion [L13]. The recently found candidates for population III stars could correspond to these prestellar objects.

Galactic blackholes have been recently found to receive a new contribution to their mass from dark energy identifiable as the energy of cosmic strings in the TGD framework [E2]. The second discovery is that galaxies, which should be the oldest ones on the basis of their distance, are oldest ones on the basis of their age [E4]: zero energy ontology explains this.

A detailed model emerges for the formation of a planetary system as a series of solar explosions as analogs of supernova explosions throwing out a layer of dark matter transforming to ordinary matter, possibly forming a planet. Both the generalization of Nottale's model [E1] for planetary orbits involving gravitational Planck constant and a generalization of the Expanding Earth model are involved. The model explains the composition differences between giant planets and Earth-like planets and also the Kuiper belt as a failed planet and is also applied to giant exoplanets. The general vision applies also to the solar cycle and the polarity flip of the solar magnetic field.

## 2 TGD view of magnetic bubbles

The TGD view of magnetic bubbles relies on the prediction that smooth cosmological expansion decomposes to rapid "jerks": this conforms with the fact that individual astrophysical objects do not participate in cosmic expansion. These jerks correspond to local Big-Bangs and explosive events of which supernova explosion is one example. The notion of local Big-Bang means local cosmology characterized by local values of Hubble constant  $H$  and cosmological constant  $\Lambda$  characterizing the size scale of the local cosmology.

Explosions create magnetic bubbles as tangles of monopole flux tubes carrying dark matter as a phase of ordinary matter characterized by effective Planck constant  $h_{eff} = nh_0$ . The notion of gravitational Planck constant  $h_{eff} = \hbar_{gr}$ , originally introduced originally by Nottale [E1], characterizes the matter at the flux tubes of the magnetic bubble.

### 2.1 Questions about magnetic bubbles

What could be the TGD inspired explanation of the magnetic bubble? Could the standard view of star formation explain it or could TGD provide the new physics possibly needed? One can start by asking questions.

1. The proposed mechanism of formation of the Local Bubble is based on supernova explosions driving the gas to the boundaries of the expanding bubble. Supernova explosions look an attractive idea also in the TGD framework. But is it necessary to assume that they have driven the matter from environment to the boundary of the Local Bubble?
2. What could be the origin of the magnetic fields? Magnetic fields are actually a key mystery of both cosmology and astrophysics according to the standard model. Magnetic fields in cosmological scales should not exist since the currents creating them should have disappeared. Also the understanding of the stability of Earth's magnetic field remains a challenge: also now dissipation should destroy the needed convective currents [L3].

3. TGD leads to the topologization of Maxwellian fields by topological field quantization. The Maxwellian electromagnetic fields of a system are replaced with the field body and TGD counterparts for radiation fields. One can speak of magnetic and electric bodies. Electric bodies are connected by the flux tubes defining the magnetic body. This would give rise to a network having electric bodies as its nodes.
4. Magnetic flux tubes can carry monopole flux and this makes them stable. In particular, no currents are needed to maintain monopole fluxes. If the monopole flux vanishes, the flux tube is unstable against splitting. In the TGD framework the monopole flux tubes have a role analogous to wormholes in general relativity. Flux tubes are necessarily closed and this makes possible flux tube pairs with opposite fluxes assumed to be basic structures somewhat analogous to DNA double strands. These flux tube pairs can also form helical structures.

### 2.1.1 Origin of magnetic bubbles?

In the TGD picture, galaxies would reside along long monopole flux tubes. Could the proposed general picture allow us to understand the origin of the magnetic bubbles suggesting a description as flux tube-like structures parallel to the surface of the bubble? Could the newly formed stars at the magnetic bubbles reside along the monopole flux tubes at the magnetic bubbles?

1. In the TGD framework, galaxies are associated with long cosmic strings [L10, L11, L24] and would be formed in the thickening of cosmic strings producing flux tubes with a reduced string tension, which induces the decay of the string energy to ordinary matter as an analogue of inflation.
2. Cosmic strings can form local tangles, in particular when they intersect. In these tangles strings thicken and the string tension decreases as the energy transforms to galactic matter. Also stars could be regarded as local tangles of cosmic strings, which are always closed but can also close in short scales.
3. Could the flux tubes associated with the magnetic bubbles correspond to monopole flux tubes that would have induced the observed magnetization of the molecular clouds. In the TGD inspired model for stars [L11], stellar cores involve a flux tube spaghetti [L13]. Could supernova explosions throw out part of this spaghetti as an expanding shell-like structure carrying the flux tubes?

Magnetic bubbles seem to serve seats for the formation of stars and contain concentrations of interstellar gas. Could the magnetic fields in the TGD framework correspond to monopole flux tubes connecting nodes of a network such that nodes are electric bodies to which the stars which are formed can be assigned? Could the monopole flux tubes assignable to the magnetic bubbles serve as seeds for the formation of stars by the standard mechanism in which they attract the interstellar gas which becomes confined to the flux tubes? How do the monopole flux tubes end up on the surface of the bubbles?

### 2.1.2 Why do the bubbles expand?

It has been found that the bubbles expand. What could be the origin of this expansion?

1. The many-sheeted space-time of TGD is a fractal having space-time sheets with a spectrum of size scales  $L$  with possible length scales given in terms of p-adic length scale hypothesis. Cosmological constant is predicted to have a spectrum and depends on  $L$  like  $\Lambda \propto 1/L^2$  and have large values for short scales. The local expansion would be faster and also its acceleration higher than those associated with the cosmic expansion.
2. Could the expanding bubble be analogous to a local expanding Universe with its own cosmological constant? Local Bubble with radius  $R = 10^3$  ly is known to expand with velocity of 6.4 km/s. The cosmic expansion velocity  $v$  at distance  $L$  from the origin of Robertson-Walker coordinates is given by Hubble law and corresponds  $v = HL$  with  $H = 72 \text{ kms}^{-1}\text{Mpc}^{-1}$ . The expansion velocity at the radius of the local bubble would be  $(7.2/3.26) \times 10^{-2}$  km/s. This would give the estimate  $H_{loc} \sim 10^2 H$  for the local Hubble constant  $H_{loc}$  assignable to the space-time sheet of the bubble.

3. One can argue that the large value of the local  $\Lambda$  prevents the formation of gravitationally bound structures in the center of the void. This could explain the formation of voids and bubbles.
4. In the TGD Universe the smooth cosmological expansion of astrophysical objects is replaced by a sequence of "jerks" increasing the size of the system and reducing to a phase transition in which the flux tube thickness increases and energy associated with the flux tube is liberated. In this picture the description in terms of the Hubble constant applies only to the rapid expansion periods. The average expansion rates in various scales need not correspond to the cosmic Hubble constant.

Could supernova explosions be understood as this kind of phase transitions inducing accelerated expansion? Could the material thrown out of supernovae correspond to flux tube tangles for which this kind of transition has occurred?

### 2.1.3 Magnetic bubble as a local cosmology with a scaled up value of cosmological constant?

One can ask whether the bubble could be modelled as a scaled down variant of cosmology with non-vanishing cosmological constant.

1. The cosmic mass density  $\rho_c$  of cosmology (<https://rb.gy/hs0xup>), which is dominated by the dark energy density  $\Lambda/8\pi G$  and scales with bubble size and radius of cosmology as  $R_B^2/R_c^2$ , is roughly one proton mass per cubic meter. This contribution dominates in the mass density.
2. The scale dependence of  $\Lambda_B$  allows us to expect that dark energy dominance holds true also for the scaled down versions of cosmology. Therefore one can estimate the density for bubbles if one assumes that the bubble size  $R_B$  defines the size of the local Universe as an analog of horizon size. One obtains a scaling law:

$$\frac{\rho_B}{\rho_c} = \frac{\Lambda_B}{\Lambda_c} = \frac{R_c^2}{R_B^2} .$$

Here  $R_c$  corresponds to the size scale of the Universe and is about 28 billion ly. This would give the estimate  $\frac{\Lambda_B}{\Lambda_c} \sim 7.8 \times 10^{12}$ .

3. The contribution from the Hubble constant is proportional to  $3H^2/8\pi G$ . The estimate for the value of the Hubble constant from the expansion velocity of the bubble gives  $H_B \sim 10^2 H$ . The contribution of dark matter would be by a factor of order  $10^8$  larger than that of ordinary matter. One could perhaps interpret this in terms of the presence of monopole flux tubes carrying the dark energy, which has decayed to ordinary matter at the magnetic bubble and induced the star formation. Monopole flux tubes decay to ordinary matter either in the supernova explosion or at the magnetic bubble.

One can test whether this ultra-simple picture gives a reasonable prediction for the thickness of the bubble.

1. For the mass of the bubble of thickness  $\Delta R_B$  one obtains the estimate

$$M_B = 4\pi R_B^2 \Delta R_B \left(\frac{R_B}{R_c}\right)^2 \rho_c .$$

This gives for the thickness of the bubble the estimate

$$\Delta R_B = \frac{M_B R_c^2}{4\pi R_B^4 \rho_c} .$$

2. For the Local Bubble, the radius is about  $R_B = 1000$  ly. This gives the estimate  $\rho_B \sim (\Lambda_B/\Lambda_c)\rho_c = (R_B^2/R_c^2)\rho_c \simeq 10^{14}m_p/m^3$  for the density of matter in the magnetic bubble. From the thickness  $\Delta R_B$  and radius  $R_B = 10^3$  ly of the bubble, one can estimate the total mass which is estimated to be  $10^6$  solar masses. Thus gives  $\Delta R_B \sim 10^{-2}$  ly. The thickness of the local bubble is estimated to be at least 300 ly.
3. The average density of the Local Bubble is estimated to be roughly 1/10 of the interstellar mass density of the Milky Way about  $\rho_{MW} = .5 \times 10^6 \times m_p \text{ m}^3$ . Could the reduction of  $\rho_{MW}$  by factor .1 explain the mass of the Local Bubble as being due to transfer of mass  $M = .9\rho 4\pi R^3/3$  of the volume to the Local Bubble of radius  $R = 10^3$  ly? This would give  $M \simeq 10^3 M_{Sun}$ .

The actual mass of the bubble is  $10^3$  times larger so that the idea that this structure is formed by the gravitational condensation of mass inside this volume does not look attractive. Some other source of mass should be involved. A burst of stars should produce a much larger average density than  $\rho_{MW}$  would be needed. One can imagine that the primary stars, which became later supernovae, took place via the thickening of cosmic strings.

One can also look what one obtains for possible other bubble like systems.

1. The radii of Fermi bubbles are about  $2.5 \times 10^3$  ly and thus have the same size scales as the Local Bubble surrounding the Sun. The density would be by factor  $(2.5)^2 \simeq 6$  higher than for the Local Bubble. Could also Fermi Bubbles carry magnetic fields? Interestingly, the IceCube array in Antarctica has reported 10 super-high-energy neutrinos sourced from the bubbles, which suggests that there is some new physics involved with the Fermi bubbles.
2. Could Earth be associated with a magnetic bubble surrounding the Sun having radius of AU. Scaling argument allows to estimate for the density associated with the bubble and if the bubble mass has concentrated to form Earth one obtains that the thickness of the bubble has been of order  $\Delta R_B \sim 1$  meter. One can also ask whether other planets could involve bubbles. I have actually proposed that planets have formed by the concentration of mass at membrane-like surfaces to planets and also to ring like structures in turn forming Moons.

The expansion rate of the planetary radii allows to make this proposal more quantitative. Does the value of the local Hubble constant have a reasonable size? There is evidence for the increase of the Earth-Moon distance with a rate  $3.8 \times 10^{-7}$  m/s. This is by a factor of order  $10^{-10}$  lower than cosmic expansion rate so that the local Hubble constant should be by a factor of order  $10^{-5}$  smaller than  $H$ . Earth-Sun distance increases with rate  $1.5 \times 10^{-7}$  m/s and the local value of  $H$  would be of the same order as in the case of the Moon. This is consistent with the general vision that the expansion takes place as jerks. The recent situation would correspond to very slow expansion.

3. Fractality inspires the question whether the large voids are formed by analogues of supernova explosions at the center of the large void driving flux tube tangles to the surface of the large void. The large value of the local  $\Lambda$  would prevent the formation of structures in the interior of the void. Could one imagine that there is a cosmic string or cosmic strings through the center of the void and that these cosmic strings have formed tangles and intersections causing an explosion and formation of ordinary matter driven to the surface of the large void?

#### 2.1.4 Local Big-Bangs as a universal mechanism for the formation of astrophysical structures?

The above considerations suggest that the local Big-Bang cosmologies characterized by local Hubble constant  $H_B$  and cosmological constant  $\Lambda_B$  could serve as a universal mechanism for the formation of structures including also planets and even moons. These local Big-Bangs would correspond to "jerks" as fast local expansions. Expanding Earth model explaining the mysterious Cambrian Explosion in biology is an application of this idea in Earth scale [L9, L25, L19, L34].

Interestingly, already the TGD interpretation of the Nottale's hypothesis [E1] of gravitational Planck constant  $\hbar_{gr} = GMm/v_0$ , where  $M$  and  $m$  are masses of objects, say Sun and Earth, led

to the question whether the planets could have formed from the dark matter in the TGD sense, and thus characterized by  $\hbar_{gr}$  assignable with Sun.

1. The mass would have concentrated at spherical surfaces around the Sun having quantized radii corresponding to radii of planetary orbits. This mechanism would have worked for the moons of various planets. The formation mechanism would have been gravitational concentration of mass from spherical surfaces orbits and from orbits to planets and planets [K10, K8, L13].
2. Since the dark matter is assumed to reside at monopole flux tubes, the identification of the spherical surfaces as magnetic bubbles carrying dark matter at the flux tubes characterized by  $\hbar_{gr}$  would be very natural. That the flux tubes are parallel to the bubble surfaces rather than being radial flux tubes conforms with the fact that the absence of real monopoles does not allow radial magnetic fields. Gravitational interaction could be however mediated by the propagation of gravitons along U-shaped radial flux tubes forming loops. These U-shaped tentacles play a key role in the TGD inspired quantum biology and are crucial for understanding bio-catalysis in the TGD framework [L4, L5, L18, L32, L28].
3. Explosions analogous to supernova explosions could have generated the magnetic bubbles. The explosion could be assigned to a phase transition representing a single step in a step-wise cosmic expansion by rapid "jerks". If this is the case, one could time order the planets according to their temporal distance and from the recent local Hubble constant for a planet one could also estimate the time when the corresponding solar explosion occurred. The number of planets gives the first estimate for the number of explosions that have occurred hitherto.
4. The basic prediction is that the composition of planets should be the same as that for the Sun near its surface. Also the composition of moons should be the same as the composition of planets. That this is indeed the case for the Moon came as a total surprise (<https://rb.gy/4sq5ho> and this challenges the standard theory for the formation of Moon (<https://rb.gy/18satf>).
5. One can argue that the idea that all dark matter at the magnetic bubble of radius defined by the distance to the Sun would have concentrated to form a single planet, is implausible. This inspires a crazy quantum idea of quantum explosion inspired by the fact that the quantum coherence length can be of the same order of magnitude as the distance to the Sun. The quantum states could indeed be like the quantum states of, say hydrogen atoms in the scale of the planetary system. The wave functions could make sense at the level of single particle states. The particles would form an analog of Bose-Einstein condensate describable by an order parameter satisfying nonlinear Schrödinger equation as in the case of superconductivity.

This would conform with the idea that dark matter parts of planets indeed possessed wave functions in some early proposed originally by Nottale [E1], which was in the TGD framework cautiously reduced to a Bohr model of planetary orbits. One could think of a quantum superposition of radial jets at single particle level and a collective state function reduction as a phase transition involving a collective localization to a single radial jet occurring in, say, nuclear physics experiments! After that dark matter with a large value of  $\hbar_{gr}$  transformed to ordinary matter.

This would be analogous to a state function reduction of angular momentum eigenstate to a momentum eigenstate. After the localization  $\hbar_{gr}$  would have reduced to ordinary Planck constant and led to the formation of a planet.

## 2.2 A more detailed model for the formation of magnetic bubble

The following argument tries to describe the physics of the TGD based model first. I have not evaluated the local Hubble constant before and try to do it. I will concentrate on the TGD inspired model for the formation of Earth. The idea that Earth was formed as the gravitationally dark matter at the magnetic bubble transformed to ordinary matter. This mechanism would explain also the formation of stars at the Local Bubble.



### 2.2.1 What happens in rapid local cosmic expansion pulses that replace the uniform expansion in TGD?

This rapid local expansion is essentially an explosion. A supernova explosion throwing out a shell of matter, and as the interpretation of Local Bubble suggests, also the magnetic bubble, is a good starting point in the modelling.

1. A flux tube containing dark matter (in the sense of TGD) expands rapidly. The thickness of the flux tubes increases rapidly and then settles to a constant value as a new minimum energy situation is found.
2. The cross-sectional area  $S$  of the flux tube serves as a parameter. The magnetic energy  $E_m \propto 1/S$  and the volume energy  $E_V \propto S$  (its coefficient is analogous to the cosmological constant) associated with the monopole flux are the energies. In equilibrium, the sum  $E_m + E_V$  is minimized as a function of  $S$  [L7]. The total density for the flux tube determines the effective cosmological constant  $\Lambda_{loc}$ , i.e. the effective string tension, which decreases as the flux tube thickens. This means energy release, which causes an explosion.

### 2.2.2 The Big Bang analogy as a model

It is tempting to apply Big-Bang analogy to the explosion phase.

1. The density  $\rho_d = 3\Lambda/8\pi G$  of dark energy would define a map between very long and short length scales identified as  $L_c = \Lambda^{-1/2}$  and  $R_d = \rho_d^{-1/4}$ .  $L_c$  could correspond to the horizon radius or age of the local Universe identifiable as the size of associated causal diamond (CD) in zero energy ontology (ZEO) [K12] [L40]. At the microscopic level,  $L_c$  could correspond to the length of the flux tube and  $R_c$  to its thickness.

These identifications would relate macroscopic and even astrophysical scales and elementary particle mass scales. I have considered the possible consequences of this map earlier.

2. As the energy minimum is reached, the expansion of the flux tube ceases. It can be also thought that  $H_{loc}$  and  $\Lambda_{loc}$  approach cosmological values. Therefore one could model the emerging expanding space sheet as a local Big-Bang with the help of the parameters  $\Lambda_{loc}$ ,  $L_{loc}$ , and  $H_{loc}$ , which have large values at the beginning of the explosion. The explosion would be a scaled down analog for the TGD counterpart of inflation, which would have led to effectively 2-D cosmic strings with 2-D  $M^4$  projection to Einsteinian space-time with 4-D  $M^4$  projection.
3. The dark energy density would be  $\rho_d = 3\Lambda_{loc}/8\pi G$  with  $\Lambda_{loc} \propto 1/L_{loc}^2$ .  $L_{loc}$  would be the scale of the space-time sheet determined by the length of the flux extending to a horizon which would correspond to light-like 3-surface, whose possible role as space-time boundaries was understood only quite recently [L31].  $L_{loc}$  would quite concretely be the radius of the horizon. The horizon would correspond to the edge of a spacetime sheet.
4. For the usual Planck's constant  $\hbar$ , one would have the usual cosmological  $\Lambda \propto 1/L_c^2$ , where  $L_c$  would be the radius of the horizon and of the order of  $10^{10}$  ly. The scale  $R_c \propto (8\pi G/3\Lambda)^{-1/4}$  would be much smaller than  $L_c$  and from the estimate  $\rho_c \sim m_p/m^3$  and proton Compton length  $3.48 \times 10^{-15}m$  would roughly correspond to a wavelength of  $.75 \times 10^{-4}$  meters. The peak wavelength of the microwave background is 1 mm. This suggests a biology-cosmology connection.
5. If  $\Lambda_{loc}$  scales as  $1/L_{loc}^2$ , and  $L_{loc} \sim AU$  corresponds to the scale of the Earth-Sun system,  $L_{loc}$  in the Sun-Earth system would be smaller by the factor  $AU/L_c \simeq 1.610^{-15}$  than at the level of cosmology.

The scaling of  $R_c \sim 10^{-4}$  m by this factor would give  $R_{loc} \sim 10^{-19}$  m. This is by factor 1/100 smaller than the Compton scale of intermediate bosons. What could this mean?

TGD predicts [K2, K3] scaled up variants of strong interaction physics assignable at p-adic primes identifiable as Mersenne primes  $M_n = 2^n - 1$  or their Gaussian counterparts  $M_{n,G} = (1 + i)^{n-1}$ ,  $M_{107}$  would correspond to ordinary hadron physics and  $M_{89}$  would

correspond LHC energy scale higher by factor 512 than that of ordinary hadron physics. There are several indications for  $M_{89}$  hadron physics as dark variants of  $M_{89}$  hadrons with scaled up Compton length. Gaussian Mersennes  $M_{G,79}$  and  $M_{G,73}$  would correspond to scales, which are by factor  $2^{14}$  resp.  $2^{17}$  that of ordinary hadron physics. The Compton radius of proton for the  $M_{G,73}$  hadron physics be of the order of  $R_{loc} \sim 10^{-19}$  m.

### 2.2.3 Matter at the magnetic bubbles is dark

I have not yet taken into account the fact that monopole flux tubes associated with the magnetic bubble carry dark matter in the TGD sense.

1. TGD predicts a hierarchy of large Planck's constant  $\hbar_{eff} = n\hbar_0$  labelling phases of ordinary matter, which behave like dark matter at the flux tubes. In particular, the gravitation Planck's constant  $\hbar_{gr} = GMm/\beta_0$ ,  $\beta_0 < 1$ , which Nottale [E1] originally suggested, would make possible quantum gravitational coherence in astrophysical scales in the TGD Universe.
2. The gravitationally dark monopole flux tubes would be naturally associated with the magnetic bubble corresponding to the Earth (analogous to the one created in a supernova) and also connect the magnetic bubble with the Sun and mediate gravitational interaction with it. Matter at the magnetic bubble would have been dark before condensing to form Earth for which matter mostly corresponds to the usual value of Planck's constant.
3. For gravitationally dark matter, the gravitational Compton wavelength is  $\Lambda_{gr} = GM/\beta_0 = r_S/2\beta_0$  and does not depend on the mass of the particle  $m$  at all. This is in accordance with the Equivalence Principle. That particles of all masses have the same Compton wavelength makes gravitational quantum coherence possible and is essential in the TGD inspired quantum biology.
4. For the Sun, the Schwarzschild radius is 3 km and  $\beta_0 = v_0/c$  is of order  $2^{-11}$  on basis of Nottale's estimates, which came from the model for planetary orbits as Bohr orbits. The Compton wavelength  $\Lambda_{gr}$  would be about 6000 km, about the radius of the Earth! Is this a mere accident? The thickness of the dark gravitational flux tube  $R_{loc}$  would therefore be of the order of the Earth's radius  $R_E$ , and the length  $L_{loc}$  would be of the order of AU.

The parameters of the local Big-Bang would therefore be  $R_{loc} = R_E$  and  $L_{loc} = AU$  at the beginning of the explosion that led to the creation of the Earth as dark gravitationally dark matter transformed to ordinary. The slowing down of the explosion would be due to the transformation of the gravitationally dark matter to ordinary matter.

### 2.2.4 What about the value of local Hubble constant?

The previous arguments have not said anything about the value of the local Hubble's constant  $H_{loc}$  in the beginning of the explosion. Here the formula for  $\hbar_{gr}$  serves as a guideline.

1.  $\beta_0 = v_0/c$  is the velocity parameter appearing in the gravitational Planck constant  $\hbar_{gr}$ . It could correspond to a typical expansion rate at a distance  $L_{loc} \sim AU$ .

In the case of the Sun,  $\beta_0 = v_0/c \simeq 2^{-11}$  applies. Could it be the rate of expansion for the Earth-related dark magnetic bubble during the *initial stages* of the explosion, which would later slow down as dark matter is transformed to ordinary?

2. The counterpart of Hubble's formula would give a prediction for the local recession velocity at Earth-Sun distance  $L_{loc} = AU = 4.4 \times 10^{-6}$  pc as  $v_{loc} = \beta_0 c = H_{loc} \times L_{loc}$  i.e.  $H_{loc} = \beta_0 \times c/L_{loc}$ . This gives  $H_{loc} \simeq 3 \times 10^7$  kms $^{-1}$  pc $^{-1}$ . Cosmic Hubble constant  $H_c \simeq 72$  km s $^{-1}$  Mpc $^{-1}$  is 11 orders of magnitude smaller.
3. The naive  $L_{loc}/L_c$  scaling would give a value of  $H_{loc}$ , which is 15 orders of magnitude smaller. For  $\beta_0 = 1$ , i.e. its maximum value which seems to be valid at the surface of the Earth in quantum biology, the value would be give 14-15 orders smaller, so that the  $L_{loc}/L_c$  scaling would seem to make sense in this case.

### 3 Applications related to the physics of galaxies

In this section, the proposed general model is applied to the age problem of galaxies, dark energy problem, and to Fermi bubbles.

#### 3.1 Paradox: the galaxies that should be youngest ones are the oldest ones

James Webb telescope (JWST) continues to revolutionize the view about the formation of early cosmology and the formation of galaxies. Now the Astronomers have detected 6 massive galaxies in the very early universe [E4] (see <https://rb.gy/kbfqlc>). The mass of one galaxy is  $10^5$  times larger than the mass of the Milky Way! This is impossible in the recent models for the formation of galaxies, and even more so in the very early Universe.

There seems to be only one way out of a paradox. One must admit that the recent views of galaxy formation and of what time is, are wrong.

In the TGD framework, new view of the space-time leads to a new quantum view about the formation of astrophysical objects involving gravitational quantum coherence even in cosmological scales. This view also allows to understand galactic dark matter [L10, L11, L24].

Zero energy ontology in turn solves the basic paradox of standard quantum measurement theory. ZEO predicts that the arrow of time changes in the ordinary state function reductions. These weird galaxies would have lived forth and back in geometric time and would be much older than the universe when age is defined as the evolutionary stage.

The paradoxical looking prediction of TGD is that the youngest galaxies in standard view are the oldest galaxies in the TGD view!

#### 3.2 Galactic blackholes and dark energy

Observations of supermassive black holes at the centers of galaxies point to a likely source of dark energy the "missing" 70 % of the universe [E2] (<https://rb.gy/trta9j>). The conclusion was reached by a team of 17 researchers in nine countries, led by the University of Hawai'i and including Imperial College London and STFC RAL Space physicists. The work is published in two papers in the journals The Astrophysical Journal and The Astrophysical Journal Letters.

##### 3.2.1 Findings and their proposed interpretation

Elliptic galaxies were studied. The reason is that they do not generate stars anymore and accretion, which is regarded as the basic mechanism for the growth of galactic black holes, should not occur. The time span of the study was nine billion years. It was found that the masses of the gigantic galactic blackholes, which extend from  $10^6$  to  $10^9$  solar masses, were 7-20 times higher than expected if the mass growth had been due to accretion of stars to the blackhole or by merging with other blackholes.

The proposed interpretation was that blackholes carry dark energy and this energy has increased. The conclusion was that nothing has to be added to our picture of the universe to account for vacuum energy. Einstein's equations with a cosmological term were assumed to be a fundamental description and that blackholes are responsible for the cosmological constant.

In general relativity (GRT), one must give up the conservation of energy and it is difficult to propose any alternative for this proposal without leaving the framework of GRT. If one has a theory of gravitation for which Poincare invariance is exact, the situation changes completely. One must ask where the blackholes get their mass. Is it dark energy and/or mass or is it dark energy/mass transformed to ordinary mass?

##### 3.2.2 TGD view of the situation

In the TGD framework Poincare invariance is exact so that the situation indeed changes.

1. TGD approach [L10, L11, L24] forces to ask whether the objects that we call galactic blackholes, or at least those assignable to quasars, could be actually galactic white hole-like objects

(GWOs), which emit energy to their environment and give rise to the formation of the ordinary matter of galaxies. There should exist a source feeding mass and energy to GWOs.

The source of mass of the GWO would be the energy of a cosmic string or more generally a cosmic string thickened to a flux tube but with large enough string tension. The dark energy would consist of volume energy characterized by a scale dependent cosmological constant  $\Lambda$  and Kähler magnetic energy.

2. Cosmic strings with 2-D  $M^4$  projection are indeed unstable against a phase transition transforming them to monopole flux tubes with 4-D  $M^4$  projection. This transformation reduces their gigantic string tension and leads to a liberation of energy leading to the formation of the ordinary matter of the galaxy.

The monopole flux tubes can carry dark matter having a large value of the effective Planck constant  $h_{eff}$ . Whether one has  $h_{eff} = h$  or even  $h_{eff} = nh_0 < h$  for the cosmic string (or the initial object) so that  $h_{eff}$  would increase in the phase transition thickening of the cosmic string to the flux tube, has remained an open question. If the value increase, the quasar white hole would be apart from the arrow of time in many respects similar to a blackhole.

The simplest assumption is that the cosmic string is either pure energy, or if it also carries matter, the matter has  $h_{eff} = nh_0 \leq h$ . The energy liberated in the increase of the thickness of the cosmic string (or flux tube with a very small thickness) produces matter and provides the energy needed to increase  $h_{eff}$  so that the blackhole matter should be dark.

3. The values of the  $h_{eff}$  could correspond to the values of  $\hbar_{gr} = GMm/\beta_0$ , where  $M$  is the mass of the galactic blackhole,  $m$  is the particle mass, and  $\beta_0 = v_0/c < 1$  is velocity parameter. These values of  $h_{eff}$  are gigantic. The gravitational Compton length  $\Lambda_{gr}$  is  $GM/\beta_0 = r_S/2\beta_0$  and for  $\beta_0 = 1$  it is equal to one half of the Schwarzschild radius of the galactic blackhole, which in the range  $(10^6 - 10^9) \times r_S(Sun)$ ,  $r_S(Sun) = 3$  km. Note that the distance of Earth to Sun is  $AU = .15 \times 10^9$  km and is in this range.

The gravitational Bohr radius for Sun in Nottale model with  $\beta_0 \simeq 2^{-11}$  is obtained from the radius of Earth's orbit with principal quantum number  $n = 5$  as  $a_{0,gr} = AU/5 \simeq .6 \times 10^7$  km [K10]. The gravitational Compton length for the Sagittarius A\* is  $\Lambda_{gr} = r_S/2 = .62 \times 10^7$  km and equal to the solar Bohr radius. Is this a mere coincidence or is there strong coupling between the galactic quantum dynamics and solar quantum dynamics and does this coincidence reflect the very special role of the Earth in the galactic biosphere?

What this co-incidence suggests in the TGD framework, is a wavelength resonance in communications and control by dark photons or gravitons over scales larger than the radius of the galactic blackhole. These signals would propagate along monopole flux tubes in a precisely targeted way. These communications are central in the TGD based model of biomatter [?]

In the TGD inspired quantum biology, living matter is controlled by phases with a large value of  $\hbar_{gr}$ , in particular those associated with the gravitational flux tubes of Earth and Sun and quantum gravitation plays a key role in metabolism. This, and the fact that  $h_{eff}/h_0$  serves as a kind of IQ for living matter, strongly suggests that galactic blackholes are living super intelligent systems controlling matter in very long scales.

4. Galaxies would have formed as local tangles of long cosmic strings. The simplest cosmic string is an extremely thin 3-D object identifiable as a Cartesian product of complex 2-submanifold of  $CP_2$  homologically non-trivial geodesic sphere  $S^2$  of  $CP_2$  and of a string-like object  $X^2$  in Minkowski space. This object can form a local tangle and its  $M^4$  projection would be thickened in this process.

In the formation of galaxy, the string tension would decrease and part of the dark energy and matter would transform to ordinary matter forming a galaxy. Also stars and planets would be formed by a similar mechanism. The process transforming dark energy and matter to ordinary matter would be the TGD counterpart for the decay of the inflaton field and drive accelerating cosmic expansion.

Galactic dark matter, as opposed to dark matter as  $h_{eff} > h$  phases, is identified as the dark energy of the long cosmic string containing galaxies along it as local tangles, and predicts

correctly the flat velocity spectrum. Also ordinary stars would have flux tube spaghettis in their core but they would not be volume filling.

5. The TGD interpretation does not imply that all dark matter would be associated with galactic blackholes as the article suggests. This is as it should be. The mass of the galactic blackhole is only a small fraction of the visible mass of the galaxy and dark energy is about 70 % of the total mass of the Universe. The long cosmic strings having galaxies as tangles contain most of the dark energy. TGD only predicts that most of the mass of the galactic blackhole, be it dark or ordinary, comes from dark energy of the cosmic string.

How would the transformation of the dark matter at monopole flux tubes to ordinary matter take place?

1. The TGD view of "cold fusion" [L2, L5, L17] is as a dark fusion giving rise to dark proton sequences at monopole flux tubes followed by their transformation to ordinary nuclei with  $h_{eff} = h$ . Most of the nuclear binding energy would be liberated and induced an explosion generating the expanding flux tube bubble or jet. This mechanism plays a central role in the model for the formation of various astrophysical structures.
2. The TGD inspired model for the star formation would explain the formation of stars of galaxies in terms of explosive emissions of magnetic bubbles consisting of monopole flux tubes, whose dark matter transforms to ordinary matter by the proposed mechanism and gives rise to stars. Galactic jets could correspond to the emissions of magnetic bubbles. Prestellar objects would be formed by this process. Ordinary nuclear fusion would start above critical temperature lead to the generation of population II stars.

An open question has been whether galactic blackholes should be interpreted as galactic blackhole-like objects (GBOs) or their time-reversals, which would be white hole-like objects (GWOs). Whatever the nomenclature, the GWOs and GBOs would however have opposite arrows of time.

1. GWOs can eject dark matter magnetic bubbles creating transforming to ordinary matter such as stars: this suggests the term GWO. They also "eat" ordinary matter, such as stars, which suggests the term GBO. But this is possible also with their time reversals.
2. The long cosmic string could serve in the case of spiral galaxies as a metabolic source, which continually feeds matter to GWO/GBO so that it could remain dark and increase in size.  
In the case of elliptic galaxies, the mass growth by "eating" matter from the environment has stopped. In this case the cosmic string could be closed and imply that the mass of GWO/GBO does not grow anymore. One could say that elliptic galaxies are dead.

The outcome of the stellar evolution should correspond to a genuine blackhole-like object (BO).

1. This would suggest that BOs carry at the monopole flux tubes only ordinary matter with  $h_{eff} = h$  or even  $h_{eff} < h$ . In the TGD inspired model for stellar BOs, the thickness of the flux tube would be given by proton Compton length [L11] and the flux tubes would be long proton sequences as analogs of nuclei. Therefore they would contain matter. In zero energy ontology (ZEO), one BOs could transform to their time reversals (WOs).
2. Are genuine GBOs as time reversals of GWOs possible? In zero energy ontology (ZEO), one can imagine that a "big" state function reduction (BSFR) in the galactic scale takes place and GWO gradually transforms to a GBO. If the cosmic strings have  $h_{eff} = h$  or even  $h_{eff} < h$ , a possible interpretation is that the magnetic flux tubes carrying dark matter have transformed during the stellar evolution to those carrying only matter having  $h_{eff} \leq h$ . In BSFR they would become initial states for a time reversed process leading to generation of galaxies in the reverse time direction. Galaxies would be "breathing". GWOs could be also formed by a fusion of stellar WO as time reversals of stellar BOs.

3. This allows to imagine an evolutionary process in which each evolutionary step gives rise to flux tubes, whose thickness is larger than the initial flux tube thickness. Also the value of  $h_{eff}$  of the final state of a given step could increase gradually.

The differences with respect to the previous initial state would be the arrow of time, the thickness of the flux tubes, and the fact that they contain matter, and possibly also the value of  $h_{eff}$ , which could increase.

Many properties of the quasars suggest that they feed energy to the environment rather than vice versa. In this respect they look like GWOs.

1. If one can assign to quasars genuine GWOs, their mass would come from the dark energy and matter of the cosmic string rather than from the environment by the usual mechanisms. This conforms with the findings of [E2]

Objects known as galactic black holes would consist of a thickened cosmic string, which suggests an explosive expansion generating  $h_{eff} > h$  dark matter so that the interpretation as GWOs would make sense. If star formation near the galactic blackhole takes place, this could be due to an explosive magnetic bubble emission from GWO identified as a monopole flux tube bundle carrying dark matter.

2. Star generation near the galactic blackhole would support the interpretation of the galactic blackhole. The region near the galactic blackhole contains a lot of stars. Have they entered this region from more distant regions or are they produced by the mission of magnetic bubbles from the galactic black hole? Star formation near a galactic blackhole associated with a dwarf galaxy (<https://rb.gy/buk2zj>) has been reported.

There is also evidence for a fast moving galactic blackhole-like object leaving a trail of newborn stars behind it (<https://rb.gy/yofbh4>). If a GWO emitting magnetic bubbles is in question, the motion could be a recoil effect due to this emission.

There is also evidence for a galaxy, which consists almost entirely (99.9 %) of dark matter (<https://rb.gy/khuryk>). Could the explanation be as a passive galactic whitehole as a flux tube tangle, which has sent only very few magnetic bubbles?

The mysterious behaviour of gas clouds near the galactic blackholes allows to sharpen the picture.

1. The temperature of the clouds is much higher than expected (<https://rb.gy/tpdgis>). The gas in the core of some galaxies is extremely hot with temperature in the range  $10^3 - 10^4$  eV.

These systems are billions of years old and have had plenty of time to cool. Why has the gas not cooled down and fallen down into the blackhole? Where does the energy needed for heating come from? Is there something wrong with the views about star formation and blackholes?

2. The upper bound  $10^4$  eV corresponds to the ignition temperature of nuclear fusion when the pressure and density are high enough. This could explain why ordinary nuclear fusion has not started. This suggests that when the temperature gets higher, stars are formed and they are eventually devoured by the blackhole-like object.

Could the galactic blackhole-like object be actually a GWO and be heating the gas forming dark nuclei as dark proton sequences from the hydrogen atoms or ions of the gas? The interpretation as GWO would also explain galactic jets [L24]. Note however that the gas clouds could get heated also spontaneously by dark nuclear fusion taking place at magnetic flux tubes: for this option GWO could provide the flux tubes as a magnetic bubble.

3. The dark nuclei would first transform to ordinary nuclei at monopole flux tubes and liberate energy. As the ignition temperature for ordinary nuclear fusion is reached, stellar cores start to form. An imaginative biology inspired manner to express this (<https://rb.gy/yo3ed3>) is that the galactic blackhole cooks its meal first so that it becomes easier to digest it.

4. Why gas cannot fall into the blackhole and why is this possible only for stars? Gravitationally stars and gas particles are equivalent so that other interactions than gravitation must be involved. Magnetic interactions would indeed confine gas particles to monopole flux tubes as dark proton sequences so that they could not fall into GWO. The rotational motion of stars would make the process of falling into the GWO very slow and they would do so as entire flux tube spaghetti and fuse to the spaghetti defining the GWO.

### 3.3 Fermi bubbles as expanding magnetic bubbles?

Could one apply the proposed picture to Fermi bubbles [E11] (<https://rb.gy/uncffb>)?

#### 3.3.1 Basic facts about Fermi bubbles

Consider first the basic facts.

1. Fermi bubbles are located at the opposite sides of the galactic plane at the center of the galaxy. The radii of the bubbles are 12.5 kly and they expand at a rate of a few Mm/s (*of order*  $10^{-2}c$ ).
2. Fermi bubbles consist of very hot gas, cosmic rays and magnetic fields. They are characterized by very bright diffuse gamma ray emissions.
3. Quite recently, so-called eRosita bubbles were discovered [E11]. They have a size scale, which is twice that for Fermi bubbles. Both Fermi bubbles, eRosita bubbles and microwave haze are believed to be associated with an emission of jets.
4. Fermi bubbles could involve new exotic physics. The IceCube array in Antarctica [E8] (<https://rb.gy/qs1gq4>) has reported 10 hyper-high-energy neutrinos sourced from the bubbles with highest energies in 20-50 TeV range.

The most natural identification of Fermi bubbles is as a pair of jets emitted in the explosion associated with the galactic blackhole Sagittarius A\*. According to the model represented in [E11] (<https://rb.gy/qwzvz>), they were born roughly 2.6 million years ago and the process lasted about  $10^5$  years.

One particular rough estimate for the release of energy from Sagittarius A\* is  $10^{50}$  Joules, which corresponds to  $10^3 M_{Sun}$  (solar mass is  $M_{Sun} \simeq 10^{30}$  kg). The estimate of [E11] for the energy would correspond to  $10^2 M_{Sun}$ .

#### 3.3.2 Fermi bubbles as local Big-Bangs?

Could Fermi bubbles be magnetic bubbles produced by the general mechanism already discussed and perhaps even modellable as local Big Bangs?

1. From the data summarized above, one can deduce that the mass concentrated at the bubbles is below the total energy released from Sagittarius A\*. It is in the range of  $10^2 - 10^3$  solar masses. This mass need not of course correspond to mass of the Fermi sphere.
2. The conservative option is that the expanding bubble has driven mass to the Fermi sphere as in the standard model of the Local Bubble. Recall that Local Bubble has a mass of  $10^6$  solar masses and is suggested to be caused by 15 supernova explosions emitting typically  $10^{44}$  Joules:  $10^{45}$  Joules corresponds to mass about  $10^{-2} M_{Sun}$ . For this option the mass lost by Sagittarius A\* would be completely negligible with that of the Fermi bubble.
3. The TGD inspired option is that the mass of Fermi Bubble is dark gravitational mass ( $10^2 - 10^3$ )  $M_{Sun}$  at the gravitational flux tubes of the dark flux tube tangles emitted by the Sagittarius A\* as a pair of jets formed by the expanding Fermi spheres. These tangles would be characterized by gravitational Planck constant.

The parameters of the local Big-Bang model of Fermi bubbles would be following.

1. The gravitational Planck constant is partially determined by the mass of the galactic black-hole, which is about  $4 \times 10^6 M_{Sun}$ . The value of gravitational Planck constant would be huge and gravitational Compton length  $r_S/2\beta_0$ , where  $r_S = 1.2 \times 10^7$  km is the Schwarzschild radius.
2.  $L_{loc} = 12.5$  kly corresponds to the radius of the bubble and the length of a typical flux tube
3.  $R_{loc} = (3/8\pi GL_{loc})^{-1/4}$  corresponds to the thickness of the flux tubes and would be of order  $\mu\text{m}$  from  $(L_{loc}/L_c)^{1/4}$  scaling and  $R_c \sim 10^{-4}$  m.
4. Local Hubble constant corresponds to  $H_{loc} = v/L_{loc} \simeq x10^3 H_c$ , where  $v = (x/3) \times 10^{-2}c$ ,  $x$  of order 1, is the estimate for the expansion velocity of the bubble. The TGD based model suggests that the identification  $\beta_0 = v/c$  makes sense in the beginning of the expansion. Note that for the Sun-Earth model the value of  $\beta_0$  is of order  $.5 \times 10^{-3}$ .

## 4 Applications to the physics of stars and planetary systems

In this section the proposed general picture is applied to the physics of stars and planetary systems.

### 4.1 Population III stars in the TGD framework

I received link to an interesting popular article (<https://rb.gy/m7qlzg>) telling about a possible detection of population III stars [E5] (<https://rb.gy/sz0fw7>), which are believed to have emerged in the first stage of the stellar formation and generating only "non-metallic" nuclei, which by definition are not heavier than  $\text{He}^4$ .

Wang's team analyzed spectroscopy data for more than 2,000 of JWST's targets. One is a distant galaxy seen as it appeared just 620 million years after the Big Bang. According to the researchers, the galaxy is split into two pieces.

The analysis showed that one half seems to have the key signature of helium II mixed with light from other elements, potentially pointing to a hybrid population of thousands of Population III and other stars. Spectroscopy of the second half of the galaxy has yet to be done, but its brightness hints at a more Population III-rich environment.

#### 4.1.1 Population III stars

If the standard model for the formation of stars population III stars would represent the first generation of stars. They should exist because we exist. The problem is that population III stars containing only elements not heavier than  ${}^4\text{He}$  have not been observed.

Is the standard model for the star formation wrong so that population III stars would not exist at all? Or have we not been able to observe them. Now evidence for the existence of these stars have been reported [E5] but the evidence is controversial.

Let us list some properties that population III stars of the standard model should have.

1. In the standard model of star formation, the very hot gas prevents the formation of small stars. Population III stars would have immense sizes  $10^2 - 10^5$  times the ordinary star size. By their large mass they would deplete the hydrogen gas very rapidly and would have a very short lifetime. Large volume of hydrogen and helium gas is available in the early universe so that this option looks plausible in the early universe.
2. The population III stars would have a high surface temperature of about 50,000 degrees Celsius, compared to the temperature of 5,500 degrees for the Sun. This provides a possible explanation for the high luminosity of very early galaxies. In the TGD framework, the concentration of irradiation to flux tubes connecting astrophysical objects would explain the high luminosity [L30].
3. The signature of the population III stars would be He II emission lines from a gas surrounding star when UV light from the hot surface of the star ionizes the He atoms of the environment



(note that "II" refers to singly ionized  $\text{He}^4$  rather than the "He II" appearing as superfluid phase in the model of helium superfluidity).

The heat or explosions of population III stars could have caused reionization of the Universe. Evidence for them was found at about .62 billion years after BB. CMB temperature was at that time roughly 1 meV.

4. The ionization energy of  $\text{He}^4$  is about 24.5 eV and in the UV region. Solar surface temperature .55 eV and by factor 1/50 lower. The surface temperature of population III stars is estimated to be 55 eV. The He II emission would not originate in stars themselves but created when energetic photons from the star's hot surface are absorbed by the gas surrounding the star.

#### 4.1.2 Are population III stars needed at all in the TGD framework?

The TGD picture about formation of stars [L2, L17, L5, L11] suggests that population III stars are not needed at all but are replaced with prestellar objects in which dark fusion followed by transformation of dark nuclei to ordinary nuclei leads to a prestellar object which eventually reaches the ignition temperature for ordinary nuclear fusion.

This allows to escape the problematic assumption about giant size population III stars and explains the apparent mixture of population III and population II stars as well as the Helium II lines appearing at some stage of the heating of the prestellar object.

The TGD based model relies on the following general assumptions.

1. The notion of local Bib-Bang with local values of Hubble constant  $H$ , cosmological constant  $\Lambda$ , age  $a$ , and parameter  $v_0$  associated with gravitational Planck constant. This picture is suggested by the vision of how the monopole flux tubes carrying dark energy and dark matter transformed to ordinary matter in explosive events analogous to local big bangs.

Large local values of  $H$  and  $\Lambda$  are needed and expected. Scaling gives naive estimates and they are expected to be too small.

Temperature of the local big bang higher than that of the environment. Light-cone proper time  $a_{loc}$  assignable to local CD approaches cosmic time  $a$  for very large values of  $a$  since at this limit it does not depend on the position of the tip.

2. The local Big-Bang is analogous to a supernova explosion and throws out a magnetic monopole flux tube tangle, magnetic bubble, with dark matter transforming to ordinary matter.

The transformation of dark matter at monopole flux tubes to ordinary nuclei is based on the TGD view of "cold fusion" as being due to the formation of dark nuclei which transform to ordinary nuclei [L2, L17, L5, L11].

1. In the TGD framework, dark fusion would precede ordinary fusion. Dark protons and neutrons would fuse to dark nuclei at monopole flux tubes and transform to ordinary nuclei and liberate practically all nuclear binding energy leading to the heating and eventually initiation of ordinary nuclear fusions.
2. There is no need to assume that dark fusion stopped at  $\text{He}^4$  so that for the simplest option population III stars are not needed at all. The pre-stellar objects as predecessors of the ordinary stars could have been obtained by dark fusion and gradually the cold fusion would have led to the ignition temperature of ordinary fusion and population II stars would have formed. The observed He II lines originate from these pre-stellar objects?
3. Dark fusion could have also produced elements heavier than  $\text{He}^4$ . This could allow us to understand the production of elements heavier than Iron as being due to dark fusion. Also the anomalies related to the abundances of some light elements could be understood. Dark fusion would proceed outside stars. Also the explosion producing supernova shells as dark magnetic bubbles involving dark fusion could explain the production of elements heavier than Fe in terms of dark fusion. Also the reported identification of heavy elements in the claimed "cold fusion" could be explained in this way [L2, L17].

If the mechanism for the formation of stars is the same as for the star formation in the Local Bubble, one expects that the stars are formed at the Local Bubble as dark matter transforms to ordinary matter by dark fusion followed by transformation to ordinary matter. This would lead to formation of local pre-stellar objects, which in some cases would reach the ignition temperature for the ordinary nuclear fusion.

## 4.2 The mystery of the "radius wall" for planets as a starting for the Bohr model of planetary system

Over 5,200 exoplanets have been confirmed hitherto. Exoplanets have posed several challenges for the existing models of the formation of planets (<https://rb.gy/hfwutz>).

1. An expected finding is that giant exoplanets can have very small orbital radii. In some cases with orbital periods that last just a few days. The proposed explanation is that these planets have migrated to the vicinity of their stars.
2. The second mystery is that there is a mysterious size gap in the scale of exoplanets. Transit observations first by NASA's Kepler Space Telescope and now by TESS, the Transiting Exoplanet Survey Satellite, have found a puzzling absence of planets with radii between 1.4 and 2.4 times that of Earth. Astronomers call this the "radius valley" and although it seems to be telling us something fundamental about the nature, formation and evolution of planets, scientists have yet to ascertain what that something is. What comes in mind is quantization of orbit radii.

Helium could make up almost half the mass of the atmosphere of giant exoplanets that have migrated close to their star. A team led by PhD student Isaac Malsky of the University of Michigan and Leslie Rogers of the University of Chicago proposes a new approach to the radius valley problem [E10]. Perhaps it could signal an increasing abundance of helium gas in the atmosphere of planets 2.4 times larger than Earth. Planets of this scale are often described as mini-Neptunes, and if they have a rocky core, it's deep beneath a thick atmosphere. But why the abundance of helium gas would be higher?

### 4.2.1 TGD view of the planetary system

Could TGD based quantum vision of planetary system [K10, K8] [L8, L9, L25, L19, L34] provide some insights to this problem? One can start from some observations related to the planetary sizes in the solar system.

1. Earth size 6,371 km is not far from the gravitational Compton length of Sun  $GM/\beta_0 = r_S/2\beta_0$  which for  $\beta_0 = v_0/c = 2^{-11}$  is about  $\Lambda_{gr} = 3,000$  km, which is amazingly near to half radius of Earth about  $r_E = 6371$  km. Expanding Earth model in turn proposes that the Earth radius was  $r_E/2$  before the Cambrian Expansion and therefore roughly the same as the radii of Mercury and Mars.
2. In the Nottale's model [E1], the value of the parameter  $\beta_0 = v_0/c$  appearing in  $\hbar_{gr}$  is by a factor 1/5 smaller for outer planets than for inner, Earth-like planets, including Mars. This means that the value of the gravitational Compton length is scaled up by a factor 5:  $\Lambda_{gr} \rightarrow 5\Lambda_{gr}$ . If the radius is roughly equal to a multiple of  $\Lambda_{gr}$ . The radii of planets would scale like  $\beta_0$  and their distances like  $1/\beta_0^2$  and one could speak of kinds of proto planets corresponding to some maximum value of  $\beta_0$ .
3. Using the gravitational Compton length  $\Lambda_{gr} = GM/v_0$  for the Sun as a unit, Using Mkm as a unit, the radii of the planets (<https://rb.gy/w8e7zb>) are given by

$$[r_E = 6.371, r_{Ju} = 69.911, r_{Ur} = 25.362, r_{Me} = 2.4397, r_{Ma} = 3.3893, r_{Ne} = 24.622, r_{Sa} = 58.232; r_{Ve} = 6.05]$$

If one uses  $2\Lambda_{gr} = 6000$  km as a unit, the radii are given by

$$[r_E = 1.0618, r_{Ju} = 11.6518, r_{Ur} = 4.2270, r_{Me} = 0.4066, r_{Ma} = 0.5649, r_{Ne} = 4.1037, r_{Sa} = 9.7053, r_{Ve} = 1.0]$$

4. Giant planets of the solar system come in two varieties. Jupiter and Saturn, known also as gas giants, consist primarily of hydrogen and helium and have a radius of roughly  $10r_E$ . Uranus and Neptune, also known as ice giants, consist of ice, rock, hydrogen, and helium and have a radius nearly to  $4r_E$  not too far from  $5r_E$ . Gas giants are also called failed stars because their composition resembles that of young stars consisting of light elements. Helium makes roughly one half of the mass of the atmosphere.

Remarkably, the radii of giant planets are not very far from  $2\Lambda_{gr,\beta_0/5}$  and  $4\Lambda_{gr,\beta_0/5}$ , and would very roughly correspond to first and second octaves of solar gravitational Compton length for  $\beta_0/5$  in the model of Nottale [E1]. In fact, the radii of inner planets radii are not far octaves for the radius of Mars. Does this mean that the expansion by a power of 2 proposed by Expanding Earth model [L34] has occurred for all planets except Mars and Mercury?

The following summarizes the TGD based model for the formation of planets by dark fusion and subsequent transformation of dark nuclei to ordinary nuclei.

1. In the TGD based model [K10, K8], planets could have formed by dark fusion [L2, L5, L17] as the dark matter at the magnetic flux tubes characterized by  $\hbar_{gr} = GMm/v_0$ . Dark matter would have consisted of dark proton (possibly nucleon with neutron as dark proton having charged color bond with the dark proton preceding it) sequences. These dark nuclei would have transformed to ordinary matter liberating almost all nuclear binding energy in this process. This would have induced an explosion.
2. First He and possibly also heavier elements would have formed by dark fusion. The process would have involved an explosion analogous to a supernova explosion, kind of a local Big Bang. The energy would have come from the liberation of nuclear binding energy. Due to the liberation of nuclear binding energy, the process would have led to a high temperature. Ordinary nuclear fusion starts if the temperature increases above the ignition temperature of ordinary fusion. In the proposed TGD based model, this would have led to a formation of a population II star.

The simplest assumption is that ordinary nuclear fusion has not started for planets although one cannot exclude this possibility in the case of the Earth-like planets with inner core.

1. If a spherical shell of dark matter was emitted, a gravitationally induced spontaneous breaking of spherical symmetry could be in question. The flow of the matter along magnetic flux tubes of the magnetic bubble to the spot, which became a planet, would have heated it. Also Moons could be these kinds of hot spots and planetary rings. The fact that largest exoplanet HD 100546 b (<https://rb.gy/doyii7>) is accompanied by a spherical shell supports this option.
2. The quantum option, which might be too radical, is that the dark planet would not have a spherical mass shell but a quantum version of a radial jet delocalized over angular degrees of freedom as, say, angular momentum eigenstate. The formation of a planet would have been a collective localization of single particle wave functions in momentum space so that the collective wave function would have been replaced by a time dependent wave function localized at a positing describing Kepler orbit. The mass would be concentrated at the slowly increasing orbital radius. This picture would conform with the Bohr orbit model.
3. An option, which is more in line with the standard view, is that the inner core is not due to planetary dark or nuclear fusion. Rather, the dark fusion at the spherical surface would have produced matter, which was gravitationally attracted by the pre-existing core region.

#### 4.2.2 A rough sketch for the planetary evolution

Could one understand the differences between Earth like giant planets and giant exoplanets in this framework? One must answer at least the following questions.

1. Why the giant planets contain mostly helium?

2. How giant exoplanets can have very small orbital radii in contrast to the solar giant planets? Have the giant exoplanets migrated near their stars or could some other mechanism explain their small orbital radii?

Perhaps the following rough sketch could catch some elements of truth. Suppose that the formation of planets indeed involves a local Big-Bang throwing a layer or stellar surface outwards, which is induced by the liberation of nuclear binding energy in the transformation of dark nuclei to ordinary matter after dark fusion producing dark nuclei.

The fact that outer planets are older and thrown out of Sun earlier suggests a general view of the planetary evolution.

1. The outer planets are oldest and for them the dark fusion at the surface of Sun would not have had enough time to produce dark variants of heavier elements. As the transformation to ordinary nuclei occurred in the formation of planet, only relatively light elements were produced.
2. For the Earth-like planets, dark fusion occurring at the surface of the star would have had enough time to produce a spherical layer or pre-planetary spot of dark variants of heavier elements before the explosion accompanying the transformation of the dark nuclei to ordinary nuclei, occurred.

What would be new as compared to the standard model would be that elements like Fe of planetary inner cores would have been generated by dark fusion following by an explosion of spherical shell rather than coming from decay products of supernovas and thrown out in the formation of planets at the surface of the expanding magnetic bubbles.

3. Could ordinary nuclear fusion play any role? The temperature at the surface of Sun was certainly too low for the ordinary nuclear fusion to start. If the heating induced by the transformation to ordinary nuclei was not enough to initiate ordinary fusion in the planetary core, the planet would be a failed star. Even if the ordinary fusion was initiated, the increase of the planetary radius by a process analogous to what Expanding Earth model proposes, could have made the density of the fuel too small for nuclear fusion to continue.

One should understand also the sizes of planets.

1. Why should the solar giant planets have large orbital radii? Could the radius of the planet increase in discrete steps as the model for Expanding Earth suggests? If the size increases in discrete steps, the large size could be due to the fact that the explosion from them has reached a considerably later stage for the solar system as compared to the exoplanetary systems. Could giant exoplanets with small orbital radii accompany very young stars?

Or does the size remain constant as the existence of giant planets with very small orbital radius suggests?

2. Could the smaller value of  $\beta_0$  for outer planets imply a larger radius as is suggested by the fact that giant planets have radii, which are roughly 5 and 10 times the radius of Earth?

### 4.2.3 Ingredients of a more concrete model

Since the orbital radius of the planet correlates with the duration of expansion, outer planets would have formed before the inner planets. Planets would be emitted as magnetic bubbles containing dark matter or as quantum jets described above. Planetary systems would tell the story of planetary evolution: an astrophysical variant of the phylogeny recapitulates ontogeny principle would be realized.

To build a more concrete model, assume that the value of the parameter  $\beta_0$  characterizes the Sun-planet pair. Second parameter would be an integer  $k$  characterizing the radius of planet as multiple of  $\Lambda_{gr}$ . This assumption is inspired by the observation that the planetary radii are multiples of  $\Lambda_{gr} \sim r_{Mars}$ .

1. Assume that the Bohr model makes sense so that the radius of planetary orbits is given by

$$r_n = \frac{n^2 GM(star)4\pi}{\beta_0^2} .$$

2. The condition suggested by a standing wave in the radial direction

$$r_{plan} = k\Lambda_{gr} = \frac{kGM(star)}{\beta_0} , \quad k = 1, 2, \dots$$

is certainly approximate but would conform roughly with the radii of solar giants planets for  $k = 2, 4$  suggesting that  $k$  is power of two as Expanding Earth model assumes. All planets except Mercury and Mars would have experienced the transition  $k = 1 \rightarrow 2$ .

3. For the inner planets, one obtains the condition

$$\frac{r_{orb}}{r_{plan}} = \frac{n^2 4\pi}{k\beta_0} .$$

An appropriate generalization holds true for outer planets with different values of  $\beta_0$  and  $n$ . The small value of  $r_{orb}$  and large value of  $r_{plan}$  for the giants with small orbital period, favors small values of  $n$ , and large values of  $\beta_0 < 1$  and  $k$ .

For  $\beta_0 = 1$ , this gives the lower bound

$$\frac{r_{orb}}{r_{plan}} \leq \frac{n^2 4\pi}{k} .$$

Note that the solar radius is  $r(Sun) = 696.340$  Mm and roughly 10 times the radius  $r_{Ju} = 69.911$  Mm of Jupiter. The largest known exoplanet HD 100546 b has radius about  $6.9r_{Ju}$  and is probably a brown dwarf (<https://rb.gy/doyii7>).

4. The empirical input from the very short periods of giant planets, which are a few days (<https://rb.gy/doyii7>), gives an additional condition. For a circular orbit, the period  $T$  relates to the orbital radius via Kepler's law

$$T^2 = 4\pi^2 \times \frac{r^3(orbit)}{GMc^2} .$$

Using  $r_{orb} = n^2(4\pi GM/\beta_0^2)$ , one obtains

$$T = 8\pi^{5/2} \frac{n^3 r_s}{\beta_0^3 c} .$$

For a given period  $T$  and stellar mass  $M$ , this gives

$$\beta_0 = 8 \times 2^{1/3} \pi^{5/6} \frac{1}{n} \frac{cT}{r_s} )^{1/3} .$$

$n = 1$  is natural for the lowest Bohr orbit. For solar mass one has  $r_S = 3$  km. For  $T = 24$  hours this would give  $\beta_0 = 2.53 * 10^{(-3)} = 1.295 \times 2^{-9}$  to be compared with the estimate  $\beta_0 = 2^{-11}$  for Sun. The result conforms with the idea that  $\beta_0$  decreases gradually during the evolution of the planetary system, perhaps in powers of  $1/2$ .

If the radius of the planet is given by  $r_{plan} = kGM/\beta_0$  and the giant planet has the radius of Jupiter about 70,000 km, one has  $k = 2(r_{plan}\beta_0/r_S \simeq 59$ . In this case the planet could be regarded as a brown dwarf (<https://rb.gy/she7e1>), which had too low mass to reach the temperature making possible nuclear fusion.

5. One might end up with problems with the idea of orbital expansion since the Bohr radius is given by  $r_n = 4\pi n^2 GM(Sun)/\beta_0^2$ , where  $n$  is the principal quantum number  $n$ .  $n$  should be small for a giant exoplanet with very small orbital radius. Too small orbital radii are not however possible for a given value of  $\beta_0$ .

The Nottale model suggests that  $\beta_0$  is dynamical, quantized, and decreases in discrete steps during the expansion for some critical values orbital radius so that also  $r_{plan}$  increases for certain critical values of  $r_{orb}$ . I have earlier developed an argument that  $\beta_0$  is quantized as  $\beta_0 = 1/n$ ,  $n$  integer. It must be emphasized however that outer and inner planets could also correspond to the same value of  $\beta_0$  if values of  $n$  for them come as multiples of 5.

6. The reduction  $\beta_0 \rightarrow \beta_0/5$  appearing in  $\Lambda_{gr} = GM/\beta_0$  appearing in the formula for  $r_{plan}$  would induce the increase of the planetary radius.

Does value of the parameter  $k$  need change during the orbital expansion? The existence of giant planets with very small orbital radii would conform with the assumption that the value of  $k$  does not change during evolution. On the other hand, the idea that planets should participate cosmic expansion in discrete jerks and the observation that the radii of planets are roughly power of 2 multiples of  $\Lambda_{gr} \sim r_{Mars}$ , suggest that  $k$  can increase in discrete steps coming as power of 2.

#### 4.2.4 Why is the water in the solar system older than the Sun?

It has been found that water in the solar system is older than the Sun (see <https://rb.gy/3noqn4>). By looking at the water on protostar V883 Orion, at a distance of 1,305 light-years from Earth, scientists found a "probable link" between the water in the interstellar medium and the water in our solar system. Water molecules in Orion have a similar deuterium-to-hydrogen ratio that in the solar system. That likely means our water is billions of years older than the sun. The finding is analogous with the finding that some stars and galaxies are older than the Universe.

A possible TGD based explanation for the observation that water at Earth is older than the Sun could be based on zero energy ontology (ZEO) forming the basis of the TGD based quantum measurement theory solving the basic paradox of quantum measurement theory.

1. In ZEO, the arrow of geometric time changes in the ordinary state function reduction, which means that systems live forth and back in geometric time. By this forth and back motion, the evolutionary age of the system is different from the temporal distance from its moment of birth. This explains the existence of stars and galaxies older than the Universe and could also explain why the water at Earth is older than the Sun.
2. In the TGD based quantum biology water is a living system in the sense that it is characterized by a large value of effective Planck constant (second basic difference from standard quantum theory) implying long quantum coherence scales. This makes the geometric duration of a life in a given time direction long and therefore increases the evolutionary age of water. In living matter, Pollack effect occurs at physiological temperatures and means a formation of phase of water with effective stoic
3. The evolutionary age for water on Earth could be longer than for water in the Sun since the environment is different. Earthly environment makes the phase transitions producing the fourth phase of water discovered by Pollack [?, L1, ?, ?] and discussed from the TGD point of view in [L1]. It has effective stoichiometry  $H_{1.5}O$  and has properties suggesting the change of the arrow of time. These phase transitions occur at the physiological temperature range.

At physiological temperatures the phase transitions changing the arrow of time could take more often and the life cycle with a given arrow of time would last longer. This is so because the magnetic body of water, carrying dark protons, makes it a macroscopic quantum system. The periods with a reversed arrow of time have been much longer (larger  $h_{eff}$  is the essential reason). Therefore the water on Earth could be older in the evolutionary sense.

There is however an objection against the ZEO based explanation.

1. The TGD view of the formation of planetary systems predicts that planets are formed in explosions throwing matter from the Sun. The water on Earth should therefore originate from the Sun or from the protostar Sun.
2. There is indeed evidence against the idea that water on Earth originates from melted meteorites: they are now known to be extremely dry. This leaves non-melted meteorites, chondrites, as one particular option (<https://rb.gy/wwob81>).
3. There is also evidence for water in the Sun from Nasa (<https://rb.gy/wc9v17>)! There is even a proposal that the water on Earth might have arrived from the Sun (see <https://rb.gy/t1yaz8>)!

The idea about the presence of water in the Sun looks insane in the standard physics framework but in the TGD Universe the water molecules could reside at the monopole flux tubes of the magnetic body of the Sun.

How can the water on Earth be older than the Sun if it originates from the Sun? The simplest answer is that also the water in the Sun is much older than the Sun.

1. This is possible in the TGD view of the formation of astrophysical systems [L38, L39], in particular stellar cores [L13, L2, L17] and would conform with the findings, which led to the proposal that water to solar system has migrated from say Orion. Now this is not needed.
2. First the analog of "cold fusion" would have led to the formation of protostar at much lower temperature but already produced dark analogs of nuclei as dark proton sequences, which would have spontaneously transformed to ordinary nuclei and liberated essentially all nuclear binding energy. This would have led to the formation of water molecules already before the ordinary nuclear fusion started. This prestellar history would be universal and the same in the protostar Orion and in the protostar Sun. For this option, ZEO is not necessary and it would conform with the findings. Of course, the water in living matter could be evolutionarily much older than the water elsewhere in the solar system.

#### 4.2.5 Does Sun have a solid surface?

There are indications for the presence of elements other than water near the surface of the Sun. The findings discussed by Moshina [E9] suggested already about 17 years ago that the photosphere has a rigid conductive layer. This layer could also contain water.

One of my first speculative applications of the evolving TGD view of dark matter (roughly 15 years ago) and of the TGD based interpretation of the Nottale's formula [E1] was the proposal that could be interpreted as a TGD counterpart for a Bohr orbit, not as an orbit but a spherical layer [K11, K10].

At that time I had no ideas about number theoretic interpretation of the dark matter hierarchy nor a general view of the formation of astrophysical objects in terms of a transformation of dark energy of cosmic strings to dark matter at monopole flux tubes in turn transforming to the ordinary matter [L38].

The recent view of the formation of planets and their moons and rings indeed allows spherical layers having as representative Oort clouds; torus-like flux tubes having as representative the rings of Jupiter; and ordinary planets.

1. They would be formed in a phase transition in which the gravitationally dark matter associated with a bubble formed by monopole flux tubes transforms to ordinary matter and can be also localized to lower dimensional structure. The analog of localization in state function reduction in astrophysical scale taking place in measurement would be in question. For instance, the formation of a planet would correspond to a measurement of a momentum direction and radial distance for a delocalized state described approximately by the analog of hydrogen atom wave-function.
2. The Nottale model predicts that the inner planets Mercury, Venus and Earth correspond to Bohr orbits with  $n = 3, 4, 5$ . What about  $n = 1$  and  $n = 2$  orbits? For Earth one has  $n = 5$  and from the radius of Earth orbit, which is  $AU = 1.5 \times 10^8$  km by definition, the radius of

$n = 1$  orbit given by gravitational Bohr radius  $a_{gr}$  and is  $a_{gr} = AU/25 \simeq 6.0 \times 10^6$  km. The radius of the photosphere is  $R = 6.96 \times 10^6$  km giving  $a_{gr}/R \simeq .87$ .  $n = 1$  Bohr orbit or Bohr shell with radius  $R_1 = a_{gr}$  would be just below the photosphere.  $n = 2$  Bohr orbit would correspond to the radius  $R_2 = 2.4 \times 10^7$  km. Is there any evidence for a spherical layer or a ring, at this distance?

3. If the mass of the layer of thickness  $\Delta R$  is the same as that of Mercury ( $.055 \times M_E$ ) with radius  $R_M = .38 \times R_E$  and the density of the layer is the same as that of Earth, one obtains the estimate  $\Delta R = (R_M/R_1)^2 R_M/3 \sim 3.2$  m. The layer would be extremely thin. If the mass is Earth's mass,  $\Delta R$  increases by the factor  $.38^3$ , roughly by two orders of magnitude.

Is there any empirical evidence for the proposed view?

1. There was already 15 years ago evidence that there is a solid surface with radius of  $n = 1$  Bohr orbit. Recently new satellites have begun to provide information about what lurks beneath the photosphere. The pictures produced by Lockheed Martin's Trace Satellite and YOHKOH, TRACE and SOHO satellite programs are publicly available on the web. The SERTS program for the spectral analysis suggests a new picture challenging the simple gas sphere picture [E9].

The visual inspection of the pictures combined with spectral analysis has led Michael Moshina to suggest that the Sun has a solid, conductive spherical surface layer consisting of calcium ferrite. The article of [E9] provides impressive pictures, which in my humble non-specialist opinion support this view. Of course, I have not worked personally with the analysis of these pictures so that I do not have the competence to decide how compelling the conclusions of Moshina are. In any case, I think that his web article deserves a summary.

2. Before the SERTS people were familiar with hydrogen, helium, and calcium emissions from the Sun. The careful analysis of the SERTS spectrum however suggests the presence of a layer or layers containing ferrite and other heavy metals. Besides ferrite, SERTS found silicon, magnesium, manganese, chromium, aluminum, and neon in solar emissions. Also elevated levels of sulphur and nickel were observed during more active cycles of the Sun. In the gas sphere model these elements are expected to be present only in minor amounts. As many as 57 different types of emissions from 10 different kinds of elements had to be considered to construct a picture about the surface of the Sun.
3. Moshina has visually analyzed the pictures constructed from the surface of the Sun using light at wavelengths corresponding to three lines of ferrite ions (171, 195, 284 Angstroms). On the basis of his analysis he concludes that the spectrum originates from rigid and fixed surface structures, which can survive for days. A further analysis shows that these rigid structures rotate uniformly.

The existence of a rigid structure idealizable as a spherical shell in the first approximation could by previous observation be interpreted as a spherical shell corresponding to  $n = 1$  Bohr orbit of a planet not yet formed. This structure would already contain the germs of iron core and of crust containing Silicon, Ca and other elements.

Standard physics does not favor the existence of this kind of layer.

1. The solids become typically liquid at the temperature of about 5800 K prevailing in the photosphere (<https://rb.gy/rgvhpq>). Ordinary iron and also ordinary iron topologically condensed at dark space-time sheets, becomes liquid at temperature 1811 K at atmospheric pressure. Using for the photospheric pressure  $p_{ph}$ , the ideal gas approximation  $p_{ph} = n_{ph} T_{ph}$ , the values of photospheric temperature  $T_{ph} \sim 5800$  K and density  $\rho_{ph} \sim 10^{-2} \rho_{atm}$ , and idealizing photosphere as a plasma of hydrogen ions and atmosphere as a gas of  $O_2$  molecules, one obtains  $n_{ph} \sim .32 n_{atm}$  giving  $p_{ph} \sim 6.4 p_{atm}$ .

This suggests that calcium ferrite cannot be solid at temperatures of order 5800 K prevailing in the photosphere (the material with highest known melting temperature is graphite with melting temperature of 3984 K at atmospheric pressure). Thus it would seem that dark calcium ferrite at the surface of the Sun cannot be just ordinary calcium ferrite at dark



space-time sheets. A more reasonable option is that there is new physics allowing to have a low temperature at the layer.

2. There is also a problem with the existence of water in the photosphere. The bond energy is 4.4 eV per bond so that the total bond energy is 8.8 eV. The peak energy of blackbody radiation is given by  $E_{peak} = 2.4 \times 10^{-4} T/K$  eV and 8.8 eV is below the thermal energy of order 12.1 eV associated with the photospheric temperature  $T = 5,500$  K so that water molecules are not be stable at these temperatures.

The following speculative explanation for the solid surface is an updating of the earlier proposal [K11, K10].

1. In the model of the solar cycle in terms of monopole flux tubes, the flux loops at the surface have inner and outer parts. The inner parts are always parallel to the solar surface and reside below it. Outer parts form flux loops extending outside the photosphere. With a 11 year cycle, the long monopole loops return to thin parallelepiped configuration, which splits to short monopole flux loops by reconnections, which then reorganize to flux tubes with opposite polarity. Could these monopole flux loops be accompanied by a solid surface of ordinary matter with the radius of  $n = 1$  Bohr orbit.

The interior portion of the gravitational monopole flux loops would carry dark matter with  $\hbar_{gr} = GMm/\beta_0$ ,  $\beta_0 \simeq 2^{-11}$  and corresponding gravitational Compton length  $\Lambda_{gr} = GM/\beta_0 \simeq 6 \times 10^3$  km, which happens to be in a good approximation the radius of Earth.

2. Could the monopole flux tubes shield the ordinary matter at the layer from the effects of the radiation arriving from the solar interior in the same way as they would shield the biosphere from the cosmic radiation and solar wind? Could the radiation from the solar interior be caught by monopole flux tubes and leave the Sun as a solar wind?
3. If there are stable water molecules in this layer, its temperature should be rather low. If the water is in liquid or solid phase, the temperature must be of the order of the temperature at Earth. This inspires a crazy question: could the monopole flux tubes carrying gravitational dark matter allow even chemical life inside this layer [L29, L28]? How low the temperature of dark matter at the flux tubes can be and is it possible to estimate it using the existing data?
4. The cyclotron energies of dark particles are proportional to  $\hbar_{eff} = \hbar_{gr}$ . Could this allow us to transform the arriving high temperature radiation from the solar interior to a low temperature radiation at the monopole flux tubes from which it could leak out as solar wind? Could even the radiation from the solar interior arrive along radial gravitational U-shaped monopole flux loops and have a low temperature? If so, the magnetic body of the solar interior would be an astrophysically quantum coherent system and very different from what we believe it to be.

The above posed questions of course sound totally crazy in the standard physics framework but we really have only the standard physics based view of what happens in the Sun. Quantum gravitational coherence in astrophysical scales might change our views completely.

#### 4.2.6 Could TGD view of quantum gravitation allow nuclear life?

The prevailing dogma is that life is always chemical. The above considerations force us to challenge this dogma. Just for fun, one can therefore play with the thought that fractality of the TGD Universe could allow life at temperatures prevailing in the solar interior.

This life should be based on nuclear physics instead of chemistry. The realization of the genetic code [L33, L20] in the TGD framework relies on dark proton (or possibly nucleon) sequences. According to the TGD based view of nuclear physics [K7], the ordinary nuclei also correspond to sequences of nucleons at monopole flux tubes, which form a kind of nuclear spaghetti. Therefore the realization of also nuclear genetic code could rely on nucleon sequences. The chemical realization of the genetic code could be seen as the next step in evolution.

1. Gravitational magnetic body carrying gravitationally dark matter and consisting of the monopole flux tubes would still be the controller. The average magnetic field at the surface of the Sun is indeed about  $2B_E \simeq 1$  Gauss. Just for definiteness, one could assume that the scale for the strength of the monopole magnetic field is twice that for the monopole flux tubes at the surface of Earth that is  $2B_{E,mono} \simeq 4B_E/5 \simeq .4$  Gauss.
2. The scale of cyclotron energies for  $\hbar_{gr} = GMm/\beta_0$ , where  $\beta_0 \simeq 2^{-11}$  is assumed in Nottale's model, would be scaled up from that at the surface of Earth by the factor  $x = (M_S/M_E) \times (\beta_{0,E}/\beta_0, S) \times (B_S/B_E)$ . For  $\beta_{0,E} \simeq 1$  prevailing in the Earth's magnetosphere, this would give  $x \simeq 2.5 \times 10^9$ .

For the energy 1 eV of a photon in biophoton wavelength range one the energy  $E = \hbar_{eff} f$  would scale up to 2.4 GeV, which corresponds to more than 2 proton masses! This looks non-sensible.

3. However, in the outer magnetosphere of Earth where  $\hbar_{gr,S}$  is expected to prevail, the values of  $B_E$  are in the range 1-10 nTesla, which means that the scale of the magnetic field (and also monopole flux) is reduced by about  $5 \times 10^{-5}$ . This would reduce the dark cyclotron energy ratio to  $x = 1.25 \times 10^5$ . 1 eV energy would be scaled to the range of .1-1.0 MeV, which corresponds to nuclear binding energy scale.
4. For  $\beta_{0,S} = 2^{-11}$  the lowest solar Bohr orbit has a radius slightly larger than the radius of the photosphere, so that it cannot correspond to the matter in the interior of the Sun.

For  $\beta_{0,core} = 1$ , the lowest Bohr radius would be  $r_B = 4\pi GM/\beta_{0,core} = 6\pi$  km, which makes  $2\pi$  solar Schwartschild radii. The value of  $x$  would be  $x = 5 \times 10^5 B_{core}/B_E$ , and for  $B_{core}/B_E = 1$  the biophoton energy scale of 1 eV would scale up to .5 MeV, which corresponds to the mass of electron and to the nuclear binding energy scale.

Maybe nuclear life at the solar core and even in the outer magnetosphere of Earth might be considered.

#### 4.2.7 Summarizing the model for the formation of planets

The foregoing considerations suggest a simple model for the evolution of the parameters  $\beta_0$  and  $k$  assumed to characterize planet-star pairs during the expansion.

1.  $\beta_0$  was reduced to  $\beta/5$  at distance when it became impossible to realize circular Bohr orbits for  $\beta_0 \simeq 2^{-11}$  anymore. The radius of the planet was increased by a factor 5 and transformed an Earth-like planet to a giant planet.
2. The radii of Jupiter and Saturn would have been roughly  $2r_E$  before this and the radii of Uranus and Neptune would have been roughly  $r_E$ . Mercurius and Mars would have had a radius not far from  $r_E/2$ . p-Adic length scale hypothesis is suggestive.
3. The increase of  $k$  is consistent with the Expanding Earth model involving the increase of Earth radius by a factor  $k = 2$ .

Expanding Earth model [L34] and the fact that  $\Lambda_{gr}$  is roughly  $r_E/2 \sim r_{Mars}$  suggests an even simpler model. Outer planets have suffered the transition  $\beta_0 \rightarrow \beta_0/5$ . Jupiter and Saturn with a radius about  $20\Lambda_{gr}$  have also suffered two scalings  $k = 1 \rightarrow 2 \rightarrow 4$ . The remaining planets except Mars and Mercury have suffered the scaling  $k = 1 \rightarrow 2$ . In the simplest model, the solar proto planet would have a radius roughly that of Mars and Mercury.

The localization of the dark mass should have a classical space-time counterpart at the level of the space-time surface. It should be also consistent with the Newtonian view of gravitation in which gravitational flux as an analog of electric flux is conserved. Also consistency with stringy description of gravitation based on  $3 \rightarrow 4$  holography is desirable. This raises the question whether flux tubes carrying Kähler electric flux are possible and whether one can construct candidates for them as simultaneous extremals of Kähler action and volume action.

1. Assume that the solar - and also other gravitational fluxes can be associated with monopole flux tubes which have 2-D  $M^4$  projection as a string world sheet. If these flux tubes are defined so that the  $CP_2$  projection as a homologically non-trivial 2-surface depends on time, Kähler electric field is generated and the flux tube has conserved Kähler electric charge  $Q_K$ .
2. The simplest guess for the flux tube carrying Kähler electric field is that the homologically trivial sphere as  $CP_2$  projection rotates, not in 1-D sense but in 2-D sense meaning that at a given point of the string world sheet  $X^2 \subset M^4$  it is obtained by a local color rotation of  $S^2$  at standard position in  $CP_2$ .

A natural interpretation of  $Q_K$  would be as a counterpart of gravitational flux. Note that this requires that Kähler electric charges have the same sign. This picture conforms with the finding that space-time surfaces with stationary, spherically symmetric induced metric with non-vanishing gravitational mass have at least some non-vanishing gauge charges. For monopole flux tubes Kähler electric charge is non-vanishing. If the flux tubes are U-shaped, the Kähler electric flux must vanish.

The  $M^4$  projections of the flux tubes would be counterparts of strings mediating gravitational interaction in AdS/CFT duality and mediate gravitational interaction and with Newtonian view.

3. How to describe the formation of the planets or smaller structures in this picture? One can regard the radial flux tubes from the Sun as analogs of particles and introduce for them a wave function in the orientational degrees of freedom, say as spherical harmonics with defined angular momentum.

The magnetic bubble would correspond to a flux tube structure tangential to say 2-D sphere around the Sun and attached to the radial flux tube structure by wormhole contacts. This structure carries matter as dark particles (fermions).

A nearly complete collective localization in the orientational degrees of freedom would correspond to a state function reduction involving the reorganization of the gravitational flux tubes to a radial bundle with a definite orientation forcing the tangential flux tube tangle to reduce in size so that it corresponds to the magnetic body of say, planet. This would give rise to the planet after the transformation of dark matter to ordinary matter. Also a localization to a torus-like structure is possible and gives rise to a ring-like structure.

The reduction of quantum coherence to a smaller scale would give rise to smaller structures such as formation of flux tube bundles assignable to mini-planets and even smaller structures as in the case of the Kuiper belt and Oort cloud.

What can one say of the flux tubes carrying Kähler electric field?

1. I have proposed this kind of extremals in the model of honeybee dance [K1], which was inspired by the work of topologist Barbara Shipman [A1], who proposed that honeybee dance reflects the color symmetry of strong interactions. In the standard model this proposal does not make sense but is natural in the TGD framework.

The local color rotation  $s^k \rightarrow g^k(s^l)$  is an isometry of  $CP_2$  and maps the Kähler form  $J_{kl}ds^k \wedge ds^l$  and line element of  $ds^2 = s_{kl}ds^k ds^l$  of the Kähler metric invariant. Using coordinates  $x^\mu$  for  $X^2$  and  $s^k$  for  $S^2$ , the induced Kähler form has the following structure

- $S^2$  part is the same as for the standard  $S^2$ , that is  $J_{kl} \rightarrow \partial_k g^r J_{rs}(g^{-1}(s)) \partial_l g^s = J_{kl}(s)$ . The same formula holds true for the  $CP_2$  contribution to the induced metric.
- $X^2$  part is of the form

$$J_{\mu\nu} = g_\mu^k (g^{-1} J g^{-1})_{kl}(s) g_\nu^l \equiv (\partial_\mu g g^{-1}) J (g^{-1} \partial_\nu g) . \quad (4.1)$$

The formula resembles the gauge transformation formula.

Here the shorthand notations

Here the shorthand notations

$$g_\mu^k = \partial_\mu g^k(s) \ , \ g_l^k(s) = \partial_l g^k \ , \ (g^{-1}g)^k = \delta_l^k \tag{4.2}$$

have been used.

- The mixed  $X^2 - S^2$  components are

$$J_{\mu l} = g_\mu^k (g^{-1}J)_{kl}(s) \ . \tag{4.3}$$

For the  $CP_2$  contribution to the induced metric similar formulas hold true.

2. The induced Kähler electric field has both  $X^2$  - and  $S^2$  component and  $X^2$  component defines the Kähler charge assignable to transversal section  $S^2$  as an electric flux. What is nice is that, although one does not have electric-magnetic duality, the Kähler electric field is very closely related to the Kähler magnetic field. Whether the solution ansatz works without additional conditions on the local color rotation has not been proven.

What could one say about the possible additional conditions on the locally color rotating object?

1. The model for the massless extremals (MEs) [K4] assumes that the space-time surface is locally representable as a map  $M^4 \rightarrow CP_2$  such that the  $CP_2$  coordinates are arbitrary functions of coordinates  $u = k \cdot m$  and  $v = \epsilon \cdot m$ .  $k$  is light-like wave vector and  $\epsilon$  a polarization vector orthogonal to it. This motivates the term "massless extremal".
2. If this representation is global, one expects that the space-time surface has a boundary assignable to  $E^2$  so that a tube-like structure is obtained. Boundary conditions guaranteeing that isometry charges do not flow out of the boundary must be satisfied. In particular, the boundary must be light-like. These conditions are discussed in detail in [L31].
3. The color rotating objects could correspond to a situation in which the color rotation depends on light-like coordinate  $u$  only and the solution is such that the map of a region of  $E^2$  to  $CP_2$  is 2-valued and has  $S^2$  as an image. Besides  $S^2$ , also more general complex 2-submanifolds of  $CP_2$  can be considered.
4. The key difference between MEs and massless fields of gauge theories is that MEs are characterized by a non-vanishing light-like Kähler current [K5]. This must have deep physical implications.

One has Kähler electric charge defined by the standard formula. Kähler electric flux orthogonal to the transversal cross section of ME and has light-like direction instead of space-like direction. One can also calculate the charge also for a section with time-like normal. Could this make it possible for the flux tubes to have Kähler electric flux as analog of gravitational flux? This picture would be consistent with both the Newtonian picture of gravitation mediated by the gravitational flux and the field theory picture of gravitation mediated by massless particles represented by MEs.

One can consider several generalizations of the solution ansatz motivated by physical intuition but not really proven.

1. The surface could define a many-sheeted covering of  $M^4$ . The conditions for the surface could be formulated as conditions stating that 4 functions of coordinates  $u, v$  and  $CP_2$  coordinates vanish.
2. The "polarization coordinate"  $v$  could depend on the linear coordinates of  $E^2$  non-linearly. For instance, it could correspond to a radial coordinate of  $E^2$ . The polarization would not be linear anymore.

A possible restriction on  $v$  is that  $v$  is a real part of complex analytic function. The surface would possess a 4-D analog of holomorphy in the sense that complex  $CP_2$  coordinates are

analytic functions of a complex coordinate  $w$  of  $E^2$  and hypercomplex coordinate of  $M^2$ . Also the coordinate  $u$  could be replaced with a "real" part of a hyper-analytic function of  $M^4$  depending on a light-like coordinate  $u$  but this does not seem to change the situation in any way. This is a highly attractive 4-D generalization of the holomorphy of string world sheets.

3. One can even consider the possibility that the decomposition  $M^4 = M^2 \times E^2$  to longitudinal and transversal spaces could be local so that also the light-like direction would be local. The condition would be that the distribution of the tangent spaces of  $M^2$  and  $E^2$  are integrable and defines a 4-surface having slicings to mutually orthogonal 2-D string world sheets and partonic 2-surfaces. This would correspond to what I have christened as Hamilton-Jacobi structure [K5].

Physically this would mean the replacement of  $M^2$  as a planar analog of a string world sheet with a curved string world sheet in  $M^4$ . The partonic 2-surface could in turn be interpreted as a many-valued image of a complex 2-surface of  $CP_2$  in the local  $E^2$ .

In the recent situation, the simplest form of MEs motivates the question that the local color rotation of  $S^2$  or of a more general complex 2-manifold  $Y^2 \subset CP_2$  depends on the light-like coordinate  $u = k \cdot m$  only. The induced Kähler gauge potential depends on  $u$  only so that the  $M^2$  part of the Kähler electric field would vanish.

The Kähler electric flux would be parallel to  $E^2$  (or the image of  $S^2$  in  $M^4$ ) and Kähler electric charge as electric flux could be (but need not be) non-vanishing. This flux would not however be in the direction of the flux tube so that it cannot correspond to gravitational flux.

Since Kähler electric flux would be very closely related to Kähler magnetic flux, an electric analog of the homological Kähler magnetic charge would make sense. This could topologically quantize the Kähler electric charge and also electric charge classically? In the case of  $CP_2$  type extremals, the self-duality of  $CP_2$  Kähler form indeed implies this. One would have electric-magnetic duality proposed to hold true in TGD.

### 4.3 A model for the formation of Kuiper belt and Oort clouds

The former planet Pluto (<https://rb.gy/e1xw5g>) is the largest object in the Kuiper belt, which has a torus-like shape. The radius of Pluto is 1,191 km to be compared with  $\Lambda_{gr} = 3,000$  and to the radius 2,439 km of Mercury.

The assumption that Pluto is a planet of solar origin requires  $\beta_0 \rightarrow 3\beta_0$  for the Pluto-Sun pair at the time when Pluto originated if  $\beta_0$  has remained unchanged during its evolution. This does not conform with the proposed model.

Could the Kuiper belt (<https://rb.gy/4qjg0c>), which is composed of mini-planets be analogous to a planetary ring, and be the oldest structure emanating from the Sun by the proposed mechanism? The total mass of Kuiper belt is recently about 10 per cent of the mass of Earth but there are reasons to believe that the original material has been 7 to 10 Earth masses so that Kuiper belt could be perhaps seen as a failed Jupiter sized giant planet for which the transformation of dark matter to ordinary matter did not lead to a single planet but to a large number of smaller objects.

The standard view of the formation of astrophysical structures is very different from the TGD view and the standard model should have anomalies if the TGD view is nearer to truth.

1. One example of such anomaly is described in the article "A dense ring of the trans-Neptunian object Quaoar outside its Roche limit" by Morgado et al [E7] (<https://rb.gy/zkfwqd>). The miniplanet known as Quaoar is an object half of the size of Pluto. The radius of the ring is 7 times the radius of Quaoar. The Roche limit is however 2.5 radii.

Roche limit involves the assumption that the satellite is held together only by gravitational forces. that the satellite is held together only by gravitational forces. The gravitational tidal forces pull apart a satellite rotating too near to a planet so that it forms a ring. Therefore the formation of stable satellites is not possible within Roche radius. Conversely, a pre-existing ring can eventually condense to a satellite if its radius is larger than the Roche limit.

2. Also Saturn has two rings, which violate the Roche limit (<https://rb.gy/gsowu8>). The E ring of Saturn, which - unlike smaller rings - consists of micron and submicron sized particles, violates the Roche limit. The particles of E ring to accumulate to Moons that orbit with the ring. Also the Phoebe ring associated with Saturn's moon Phoebe violates the Roche limit.

Could the TGD view explain the violations of the Roche limit?

1. The TGD based idea that planets and Moons are formed by a gravitational condensation of the ordinary matter produced by dark matter at a torus like ring accompanied by monopole flux tube is supported by the behavior of the rings of Saturn, which tend to condense to associated Moons.
2. Could the presence of a circular monopole flux tube slow down the condensation process and make the ring rather stable? I have considered the possibility that the planetary orbits are accompanied by monopole flux tubes defining kinds of planetary paths. Could one identify some signatures of these paths? Do they still contain dark matter?
3. Planetary radii are consistent with the Roche limit. The matter in the Kuiper belt did not condense to a single Jupiter-sized planet but to miniplanets. This could be interpreted in terms of the ongoing condensation process, which started as the Kuiper belt was formed as an expanding ring of matter accompanied by a monopole flux tube. Could the presence of a monopole flux tube slow down the condensation process? How does the Kuiper belt differ from planets?

Suppose that the emission of Kuiper belt from the Sun involved a collective localization from a Bose-Einstein condensate-like state of dark particles to an analog of momentum eigenstate so that a planet rotating around the Sun was formed. Why did the localization for the Kuiper belt not occur to a wave function localized to a point rotating around Bohr orbit but to a set of points associated with the Bohr orbit?

Was the quantum coherence scale reduced by a reduction of  $\hbar_{gr} \rightarrow \hbar_{eff} > \hbar$ , which was followed by  $\hbar_{eff} \rightarrow \hbar$  in the transformation of dark matter to ordinary matter. The tubular Bose-Einstein condensate formed in the tubular localization would have decomposed in the transition  $\hbar_{gr} \rightarrow \hbar_{eff} > \hbar$  to smaller regions before the transition  $\hbar_{eff} \rightarrow \hbar$ , which created miniplanets along the flux tube instead of a single planet.

4. Oort cloud (<https://rb.gy/71fmlm>) is a spherical layer of icy objects surrounding the Sun and likely occupies space at a distance between about 2,000 and 100,000 astronomical units (AU) from the Sun. The estimated total mass of the Oort cloud is 1.9 Earth masses (<https://rb.gy/hhvgsr>). Suppose that Oort cloud corresponds to a spherical shell emitted by the Sun. No localization to a tubular Bose-Einstein condensate would have occurred but the process  $\hbar_{gr} \rightarrow \hbar_{eff} \rightarrow \hbar$  occurred directly so that a spherical cloud was created.

## 5 A TGD inspired model for solar flares

In the sequel a TGD based view of the reversal of the solar magnetic field is discussed. Besides the new view of space-time and electromagnetic fields, the proposal involves in a crucial manner zero energy ontology (ZEO) [L14, L40, L35].

### 5.1 The motivating finding

The finding that motivated these comments was the finding of what was called solar heartbeat [E3] (<https://rb.gy/7gaa78>). Two kinds of quasiperiodic pulsations (QPPs) with periodicities 10-20 s and 30-60 s of microwave emissions during solar flares. These periods are correlated and probably have the same underlying reason. A kind of solar heartbeat is in question. It might be assignable with the reconnection process for the solar magnetic field. The notion of magnetic reconnection is however poorly understood in the standard physics framework: the estimates for the reconnection rate are by 13-15 orders of magnitude too small.

The TGD framework leads to a new view of space-time as a 4-D surface in  $H = M^4 \times CP_2$  and also of electromagnetic and other fields. In particular, fields are replaced by topological field quanta identifiable as space-time quanta. One ends up with the notion of a field body, in particular that of a magnetic body (MB) consisting of monopole flux tubes not possible in Maxwell's electrodynamics and flux tubes with boundaries serving as counterparts of Maxwellian magnetic fields.

Could periodic reconnections of closed flux tubes with the shape of a very flat square caused by the transverse oscillations of the flux tubes occurring during solar flares induce the periodic reconnections of flux tubes? Microwave frequencies for dark charged matter at the flux tubes could be due to cyclotron transitions.

What could be the origin of the periodicities of transversal oscillations? I have earlier discussed the 26 second rhythm of Earth analogous to alpha rhythm [L12]. Intriguingly, this period is between the mentioned periods. Could the Earth's alpha rhythm and solar heartbeat relate to each other? This might be considered in the TGD framework if the rhythms are associated with gravitational monopole flux tubes emerging from the Sun and connecting the gravitational magnetic bodies of Earth and Sun to a single quantum coherent entity.

This finding inspired the attempt to understand solar flares in the TGD framework.

## 5.2 Basic problems of the existing models of solar flares

The models for the solar flares (<https://rb.gy/yw5jpd>) have several problems.

1. The source of the flare's energy is believed to be magnetic but what is the basic mechanism? How the magnetic energy is transformed to the kinetic energy of particles? How accelerations to energies in GeV range and beyond are possible? In the standard framework extreme accelerations would be required.
2. Reconnection of magnetic field lines is believed to be the basic mechanism but the predicted rate of reconnections is by 13-14 orders of magnitude too small. There might be something fundamentally wrong with the notion of reconnection.
3. There are also inconsistencies regarding the total number of accelerated particles. Sometimes this number is larger than the total number in the coronal loop. Where could the additional particles come from?
4. It is not possible to forecast flares.

### 5.2.1 The notion of reconnection is questionable

The Maxwellian notion of reconnection can be challenged. Field lines rather than flux tubes which reconnect. Note however that the notion of flux tubes is used in the phenomenology of MHD.

The rate of reconnections based on the Maxwellian picture assumes that the reconnection rate is proportional to the electric field associated with the separatrix at which the reconnection of field lines occurs. The actual reconnection rate for solar flares is by 13-14 orders higher than predicted so that something is badly wrong. The fact that conductivity can vary in huge limits suggests that charges for which conductivity is very high or even superconducting matter might be present.

Could the TGD view of reconnection help? Monopole flux tubes or flux tubes with boundaries as counterparts of Maxwellian magnetic fields carrying currents as dark matter in the TGD sense might provide a more realistic approach and the rate of connection could be estimated from classical dynamics for preferred extremals.

### 5.2.2 Is the Maxwellian view of currents and plasma correct?

When the conductivity of charge carriers is effectively infinite, Maxwellian MHD currents are frozen to flux lines. In the TGD framework, the Maxwellian flux tubes having boundaries could carry ordinary ohmic currents. Could dark particles at monopole flux tubes flow like supra current with vanishing resistance? At least these currents could correspond to currents frozen to field lines.

The absence of dissipation for the dark matter at the monopole flux tubes could explain the presence of ultra-energetic particles and the strange finding that solar flare can involve more particles than contained by the flare. The reconnection process gives rise to a pair of U-shaped flux

tubes, which are highly curved. Could the dark particles leak out from the flux tubes in the reconnection process and transform to ordinary particles. There would be no gigantic acceleration since the dark particles would already have very high energies.

What about the TGD counterpart of plasma? Does the plasma correspond to the ordinary electrons at flux tubes with boundary or to the dark electrons at the gravitational monopole flux tubes? A possible TGD view of quark gluon plasma [L36] is that sea partons reside at the MB of hadrons and are dark in the TGD sense. Could the dark current carriers be analogous to sea partons? Could ordinary charge carriers with ohmic resistance serve as the analogs of valence quarks?

The answers to these questions requires a TGD based formulation of the basic concepts of plasma physics and magnetohydrodynamics (MHD) of the Sun.

1. MHD (<https://rb.gy/kv09cj>) and plasma physics (<https://rb.gy/g6wxy1>) must be re-considered in [L22] in terms of the TGD based view of electromagnetic fields.
2. The new geometric view of magnetic fields forces a reconsideration of the notions of solar magnetic field and related notion of Parker spiral, coronal loops (<https://rb.gy/gedbk2>), current sheets (<https://rb.gy/8yw1r8>) and (<https://rb.gy/n0cyoe>).
3. The dynamics of the solar magnetic field involves several notions, which must be reformulated in the TGD framework. Sunspot cycle (<https://rb.gy/cvu4av>) and (<https://rb.gy/rigawy>) must be understood in the TGD framework. Solar activity is maximum is assignable to the polar reversal of the solar magnetic field. There are many poorly understood phenomena related to the polar reversal such as solar flares (<https://rb.gy/yw5jpd>) and magnetic reconnections (<https://rb.gy/sbktub>) about which TGD could provide insights. Magnetic reconnection is an especially poorly understood notion: in the standard model the rate for their formation is 13-14 orders of magnitude too low.

### 5.3 A TGD based view of the polarity reversal of the solar magnetic field

In the sequel a TGD based view of the reversal of the solar magnetic field is discussed. Besides the new view of space-time and electromagnetic fields, the proposal involves in a crucial manner zero energy ontology (ZEO) [L14, L40, L35].

#### 5.3.1 TGD counterpart of the Maxwellian magnetic field

Flux tubes carrying magnetic fields replace the flux lines of the Maxwellian theory. TGD predicts two kinds of flux tubes: monopole flux tubes with closed cross section and Maxwellian flux tubes with boundary. There is an analogy with the fields  $H$  and  $M$  of Maxwell's theory.

The Maxwellian part of the magnetic field could correspond to magnetization  $M$  having as the TGD counterpart flux tubes with boundary carrying currents generating the fields in the interior of the flux tube. The field  $H$  of Maxwell's theory could correspond to monopole flux tubes and could induce magnetization  $M$  as Maxwellian part of the magnetic field. Monopole flux tubes and Maxwellian flux tubes could correspond to parallel space-time sheets.

The monopole flux part of the magnetic field differs in several respects from the Maxwellian part.

1. The magnetic fields at monopole flux tubes require no current to maintain the magnetic field. The presence of monopole flux tubes allows us to understand the existence of magnetic fields in cosmic scales and also the maintenance of the magnetic field of Earth [L3].
2. Monopole flux tubes would carry charged dark matter characterized by effective Planck constant  $\hbar_{eff} = n\hbar_0$ . Especially interesting flux tubes are gravitational flux tubes with gravitational Planck constant  $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0$ , where  $\beta_0 = v_0/c < 1$  is velocity parameter, and  $M$  is large mass of say Sun or Earth and  $m$  corresponds to small mass such as electron mass. This notion was introduced first by Nottale [E1].

The freezing of the charge carriers to the flux lines would have a concrete interpretation. The freezing could occur also for the Maxwellian flux tubes and charge carriers would be at the



boundaries of the flux tubes. The large value of  $h_{eff}$  implies large scale quantum coherence and the monopole flux part of the MB would naturally serve as a "boss" controlling the dynamics at the lower levels of hierarchy. This motivates the interpretation as counterpart for the field  $H$ .

3. Maxwellian parts of the magnetic fields could be generated by currents at the boundaries of the flux tubes if conductivity is very large. The flux tubes would be analogous to current wires. Magnetization  $M$  could correspond to the flux tubes with boundary, which carry the currents inducing the magnetic field in the interior. Magnetization would occur for the charged particles at the boundaries of these flux tubes.
4. The thickening of dark flux tubes is a phase transition liberating magnetic and volume energy and also dark matter if part of it transforms to ordinary matter in the process. Extreme accelerations would not be required since the dark particles forming quantum coherent phases at the flux tubes would have very high energies due to the very low dissipation. This could explain the huge production of energy and anomalously high particle energies.
5. For the topological counterpart of the reconnection process, field lines are replaced by flux tubes. When a closed flux tube has the shape of a very narrow rectangle, it is critical against reconnection, which could involve the change of  $h_{eff}$ . The dark charge carriers leaked out of the flux tubes would have the ordinary value  $h_{eff} = h$  of the effective Planck constant.

### 5.3.2 TGD based model for the solar magnetic field

What can one guess about the structure of the MB consisting of monopole flux tubes (and possibly also sheets)?

1. Only the Maxwellian magnetic field at QFT limit obtained by replacing many-sheeted space-time with a slightly curved Einsteinian space-time surface with 4-D  $M^4$  is directly accessible to the experiments. These fields are known only in the region outside the solar surface. This leaves a lot of freedom.

A guideline comes from the notion of magnetic bubble [L37] playing a key role in the TGD inspired model for the formation of astrophysical structures as explosive processes. Magnetic bubbles consist of monopole flux tubes at a 2-D surface, such as a sphere. By fractality, one expects that the model should work also in the case of solar flares, which also involve explosions.

2. The magnetic bubble with  $h_{eff} = \hbar_{gr}$  a spaghetti of monopole flux tubes with a shape of 2-D closed surface. It would be emitted in an explosive process liberating dark matter and energy. Dark matter would be transformed to ordinary matter and liberate energy.

A good guess is that the solar surface carries this kind of spherical layer consisting of closed monopole flux loops. The inner parts of monopole flux loops would be along the solar surface and fixed with it. The outer parts of the flux loops would extend to outer space and bound the shape of a moon crescent. This shape would be an outcome of centrifugal force which would be compensated by the force due to string tension.

3. The rotation of the outer parts of the flux tubes is not rigid body motion with a constant angular velocity. The motion is slower than rigid body rotation and this gives rise to a differential rotation in which the angular velocity at the equator is smallest. This affects the shape of the flux tube so that it becomes spiral-like. The lag is largest at the equator.

String tension of the flux tube opposes this motion and eventually the situation becomes critical for the reconnections when the flux tube portions carrying opposite fluxes and located near the equator are close enough. This reconnection process is associated with the formation of solar spots. This leads to a transformation of the outer part of the flux tube so that it becomes parallel to the solar surface.

By freezing, the spiral structure for the current sheet should conform with the structure of the magnetic field in the Maxwellian picture obtained at the QFT limit. In TGD, the assumption that currents flow along monopole flux tubes implies this if the Maxwellian flux

tubes are parallel to the monopole flux tubes. In this case the freezing would occur for the entire magnetic field.

### 5.3.3 A general view of the solar flare as a reconnection process

1. In TGD the reconnection is replaced with a topological reconnection for monopole flux tubes and their Maxwellian counterparts.
2. Reconnection at the equatorial current sheet eventually occurs for twisted flux tubes and the outer part of the flux tube decays by emitting small flux loops. Solar flares would accompany this process. Huge magnetic and volume energies could be liberated if the flux tubes are thickened in the phase transition. Twisted flux loops are transformed by the emission of loops to non-twisted dipole loops with strands parallel to the solar surface.

In this process charged dark particles with very high energies leak out from the flux tubes. No acceleration mechanism is needed. This mechanism could also explain cosmic rays with ultrahigh energies without a need for acceleration mechanisms. Monopole flux tubes can also carry electric fields parallel to them and this could accelerate the charged particles to very high energies since dissipation is absent or very small due to the large value of  $\hbar_{gr}$ .

3. This picture allows us to also understand the presence of the current sheet. It would be associated with the Maxwellian part of the magnetic field at equator where the fluxes of neighboring portions of the flux tube are opposite and reconnections occur.

The Maxwellian flux tubes could be parallel to the monopole flux tubes and the current sheet would be associated with them if Maxwell's equations hold true approximately as they would at the QFT limit of the TGD. This limit is obtained by replacing the sheets of the many-sheeted space-time with single metrically deformed region of  $M^4$  such that gravitational field *resp.* gauge potentials are identified as sums of deviations of induce metric from  $M^4$  metric *resp.* induce gauge potentials.

### 5.3.4 How the reconnection process could lead to a reversal of the polarity

How the reconnection process could lead to the reversal of the polarity.

1. The flip of the polarity of the solar magnetic field occurs when the activity of the Sun is maximum. The direction of the magnetic flux at the long rectangular monopole flux tubes must change.

Conserved monopole flux however prevents this. One option is that the rectangular flux tube rotates along its axis by  $\pi$  and permutes inner and outer parts of the flux tube. This cannot be excluded but does not seem plausible since the inner part of the flux tube is fixed.

The second option is that the closed flux tubes split by a reconnection process into pieces and the short flux loops should flip and by reconnections fuse back to long flux loops with an opposite direction of magnetic flux.

2. The question how the monopole flux tubes carrying opposite fluxes could be generated from the short flux tubes produced by the decay process, looks very difficult to answer in the framework of standard quantum physics. Second law forbids this process.

Could zero energy ontology (ZEO) come to rescue? In ZEO both arrows of time are possible and the arrow of time is changed in ordinary ("big") state function reduction (BSFR) [L14, L40, L35].

One has quantum gravitational coherence at the level of gravitational flux tubes. Could BSFR and therefore a time reversal take place at the level of gravitational MB? Could the reconnection of small loops to a long loop in the opposite direction of time somehow correspond to a decay process with a reversed thermodynamic arrow of time. Note that the change of the thermodynamic arrow of time should not be confused with time reflection  $T$  as a geometric symmetry.

3. What happens to the magnetic field  $B$  when the thermodynamic arrow of time changes? The Maxwellian part of  $B$  changes its sign since it is a curl of vector potential  $A$ , having as its source the 3-D current  $j$ , which behaves like velocity and changes its sign.

The monopole flux part of  $B$  does *not* have  $j$  as source and for string-like objects  $X^2 \times Y^2 \subset M^4 \times CP_2$  monopole flux changes sign only if the change of the thermodynamic arrow of time involves a complex conjugation in  $CP_2$ . It seems that also the induced electric field associated with the deformation of a string-like object changes its sign too in complex conjugation. This means that the charges change sign and therefore also currents. Nothing would happen to  $B$ .

If no complex conjugation occurs for  $CP_2$ , monopole fluxes are not affected. However, the minimization of the magnetic interaction energy between long Maxwellian flux loops and short monopole flux loops could force the monopole flux loops to flip. The roles of  $H$  and  $M$  in the magnetization would be permuted:  $M$  would change the direction of  $H$ .

4. Could Lazarus effect have an interpretation as a BSFR so that no new CD would be generated? The consistency with the earlier view would require that the arrow of time changes in BSFR but that the moment of the geometric time identified as a correlate of subjective time assigned with the decay process corresponds to the  $M^4$  time coordinate for the intersection of the half-cones. If the sub-CDs of CD located in either half-cone of CD co-move with it in its expansion by discrete scalings so that the  $M^4$  time associated with their mid points flows, this picture is consistent with that discussed in [L40, L35].

Or could Lazarus effect mean a creation of a new CD as an embedding space correlate for a perceptive field of a conscious entity, self [L41, L35]? Ordinary birth could serve as an example of a generation of a new CD.

In the ZEO based interpretation as a BSFR, the interpretation of this process would be as an analog of biological death followed by reincarnation with an opposite arrow of time.

1. In ZEO, the monopole flux tube pair, which has split into short segments, would be the "corpse" of both the previous gravitational MB and the new MB with an opposite arrow of time. The corpse could be seen as the outcome of two aging processes proceeding with opposite arrows of time from geometric future and past and meeting at the moment of the reconnection process, which corresponds to quantum criticality.
2. The outsider would see the death and decay process of the gravitational MB and its miraculous reincarnation to MB with opposite magnetic fluxes. This "Lazarus effect" would be something new as compared to the earlier applications of ZEO. The sunspot cycle could be perhaps seen as an analog of the sleep-wakeup cycle.
3. This picture is very general and living matter provides especially interesting applications since the decay process for the monopole magnetic flux tubes in biological death should induce the decay process of the biochemical structures. Metabolism has two sides: anabolism is the generation of organic molecules carrying metabolic energy taking place in photosynthesis and in the reconstruction of organic molecules from simpler building bricks produced by catabolism liberating metabolic energy and occurring in digestion. Could the anabolism and catabolism be time reversals of each other and reduce to catabolism of monopole flux loops with opposite arrows of thermodynamic time?

## 6 Possible applications to the polarity reversal of Earth's magnetic field and to biology

The proposed picture might apply also to the model for the flip of the Earth's magnetic field discussed in [L3]? Magnetic poles wander and this could be understood as a rigid body motion of MB. The polarity flip takes place rather rapidly and could occur BSFR and involve the magnetic catabolism and anabolism of the monopole flux loops. Since the monopole magnetic fields play

a central role in the TGD inspired quantum biology, the possible disastrous consequences of this transition challenge the TGD inspired quantum biology.

## 6.1 Do the reversals of the Earth's magnetic field induce evolutionary leaps?

I received from Zakaria Ameziane a highly interesting question related to the TGD inspired theory of consciousness and quantum biology, in particular self hierarchy and the notion of quantum jump according to TGD, and the role of the Earth's magnetic field in quantum biology. The question went roughly as follows.

"There is an interesting hypothesis which demonstrates that the DMT, by its affinity with UV-B rays, could be produced significantly, endogenously when the electromagnetic fields are reversed. If this hypothesis would prove to be true, could it trigger a new quantum jump?"

The question involve a link to a discussion in DMT Quest discussion group (DMT Quest is an organization, which supports DMT research) in Twitter (<https://rb.gy/sijxt9>). The link is warmly recommended. The discussion was related to the the so-called Stoned Ape Theory of evolution claims that that the transition from Homo erectus to Homo sapiens and the cognitive revolution was caused by the addition of psilocybin mushrooms, specifically the mushroom *Psilocybe cubensis*, into the human diet around 100,000 years ago. One can also consider alternative forms of this idea.

From the discussion one can pick up the following facts.

1. DMT is often assigned with pineal gland, "third eye" and the seat of the soul, according to Descartes but according to recent views it is present in the entire brain (see <https://rb.gy/yftalo>). DMT (I have discussed DMT from the TGD point of view in [L6, L18]) is reported to induce a growth of neurons (<https://rb.gy/zx7zsh>).

By its affinity with UV-B rays, DMT could be produced significantly endogenously as magnetic field reversal occurs and the shield provided by the Earth's magnetic field against UV rays is temporarily lost.

2. The latest magnetic reversal occurred 40,000 years ago in the so-called Laschamp event (<https://rb.gy/i35kqa>). Interestingly, Neanderthals disappeared at this time.
3. 40,000 years also corresponds to a time when a large change in the shape of human brain took place [?] (<https://rb.gy/hcg8ii>). The following excerpt is from the abstract of the article.

".... Our data show that, 300,000 years ago, brain size in early H. sapiens already fell within the range of present-day humans.

Brain shape, however, evolved gradually within the H. sapiens lineage, reaching present-day human variation between about 100,000 and 35,000 years ago. This process started only after other key features of craniofacial morphology appeared modern and paralleled the emergence of behavioral modernity as seen from the archeological record.

Our findings are consistent with important genetic changes affecting early brain development within the H. sapiens lineage since the origin of the species and before the transition to the Later Stone Age and the Upper Paleolithic that mark full behavioral modernity."

4. Relatively recent research indicates that changes in the geomagnetic field of the earth causes genetic and metabolic changes in plants indicating the potential to be a driver of evolution [?] (<https://rb.gy/mxhq2z>).

These observations inspire the question whether the magnetic reversal could have induced not only a significant growth of neurons in human brains but also an evolutionary jump?

1. Could this effect have occurred at the level of genes, at the level of epigenesis or both? The amazing findings of Levin [?, ?, ?, ?], discussed from the TGD point of view in [L41], suggest that besides genes, also electromagnetic field patterns assignable to cell groups (not only

neuron groups), determine the outcome of morphogenesis via epigenesis and that modifications of these patterns during the embryo stage can dramatically modify the outcome of morphogenesis without any change at the level of genes. What is remarkable is that these changes are inherited.

2. Could the magnetic reversal have induced an inheritable change of the shape and the electromagnetic structure of the brains of developing embryos? Could the increased amount of DMT during the reversal be behind this change? If only a permanent epigenetic change is in question, it might be induced by DMT.

The following summarizes roughly my reply to the question by Zakaria Ameziane. The reply describes first very briefly what self hierarchy and quantum jumps mean in the TGD framework.

1. Selves can fuse to larger selves by entangling stably. This could occur in both "small" and "big" statefunction reductions (SFRs). In a pair of BSFRs (BSFRs change the arrow of time) and a TGD counterpart of quantum tunnelling takes place this kind of fusion could occur. This would mean an extension of consciousness. Perhaps this happens as the person gradually wakes up. Also the fusion of say visual fields to single visual field could occur in this way. Right and left brain, or rather their magnetic bodies, could also fuse in this way.
2. DMT is assigned with pineal gland, I would tend to see its presence as a prerequisite for a connection to a rather high level of hierarchy of selves, magnetic body corresponding to a rather long length and time scales.

Concerning the finding that something dramatic took place in the evolution of the human brain about 40,000 years ago when also magnetic reversal took place. Catastrophes induce quantum criticality in long scales which in turn could induce evolutionary jumps.

1. I have just developed a model for the change of the magnetic polarity [L37]: the change of the polarity would be associated both in the case of Sun and Earth to a BSFR changing the arrow of time. This process would be like death followed by reincarnation with the opposite arrow of time at the level of the magnetic body (MB). The sequences of reversals would define the analog of a sleep-wakeup cycle on a large scale.
2. BSFR corresponds to quantum criticality: the monopole flux loops of the magnetic body of Earth decay into pieces, change direction and fuse again as required by the magnetic reversal. MB is the boss and this universal mechanism would also induce biological decay after death and re-organization of molecules to a living organism. It would also be behind catabolism and anabolism at molecular level.
3. During the period of BSFR associated with the reversal, the UV radiation from outer space can enter the Earth's surface and induce large genetic and also other kinds of biological changes. A BSFR at the level of MB of Earth inducing the magnetic reversal could have induced a cascade of BSFRs at shorter scales possibly inducing dramatic evolutionary changes.  
In the TGD Universe, the genes do not dictate everything. Also electromagnetic field patterns at the cellular level, both for neurons and ordinary cells, are in a central role in dictating the development of embryos, as Levin's findings demonstrate. Their change would involve epigenetic change [L41]. This point was already discussed.
4. For instance, these BSFRs inducing large changes at the MB of the brain could have increased the probability of the fusion of MBs of say left and right hemispheres to a larger unit, the MB of the entire brain. This would have induced a stronger interaction of right and left hemispheres. The period of time in an entangled, "whole-brainy" state would have significantly increased.

This might relate to the hypothesis that bicamerality in which right and left hemispheres behaved like independent selves (schizophrenics and young children might be bicamerals) transformed to modern consciousness in which the brain hemisphere tends to behave like a single coherent entity.

5. There is evidence that the magnetic field of Earth is changing right now (<https://rb.gy/penzen>). Could this mean that polarity reversal of the Earth's magnetic field might happen in the not so distant future. An interesting question is what this could mean for our species.
6. The magnetic bodies of Sun and Earth interact and in TGD framework both MBs play a key role in the quantum biology [L29, L28] based on gravitational quantum coherence prevailing in astrophysical scales.

An interesting question is whether the solar 11+11 year "sleep-awake" cycle of the solar MB could induce periodicities in human behavior, say in social structures. Maybe statisticians could have something to say about this.

## 6.2 Tukdam and TGD

The following considerations were inspired by a TV document (<https://rb.gy/abt8za>) about a strange phenomenon known as Tukdam. What happens is that in Tukdam state the person is physically dead but is believed to be in a continued meditation. There is no EEG, the heart does not beat, and there is no normal metabolism. What is strange is that the decomposition processes do not start. The condition can last up to a couple of weeks. Similar longer-lasting ones have been reported: a yogi can be buried underground for months in an oxygen-free state and then wake up.

Tukdam phenomenon challenges neuroscience's view of the brain as the seat of consciousness. According to reports there could be awareness and a sensory experience consisting of different light sensations. The Tibetan Book of the Dead describes these experiences. Near-death experiences have many similar features.

In the body in Tukdam, the area of the heart is reported to feel warmer to the touch than the rest of the body, but the thermometer does not detect this difference. This would indicate that the body receives metabolic energy at the cellular level from some other source than in the normal metabolism, and that living matter can detect what measuring devices based on the recent knowledge provided by modern physics cannot detect.

Where could this energy come from? If one wants to answer this, one must also ask what happens in death and what is consciousness and what is life.

1. Dark energy and matter are the two basic puzzles of recent day physics. In the TGD approach, dark matter is identified as phases of ordinary matter, for which the effective Planck constant  $h_{eff}$  is much larger than normally. In particular, the Planck constant  $h_{eff} = h_{br}$  characterizing gravitational flux tubes can be very large and makes quantum coherence possible even on astrophysical scales. Large Planck constants would be associated with the dark matter magnetic body, which would be the TGD counterpart to the magnetic field of Maxwell's theory, but would differ from it in many respects. As a quantum coherent unit, this magnetic body would control the ordinary biological body and induce its coherence. The classical energy of a magnetic body, consisting of volume energy and magnetic energy, would be dark energy.
2. In the TGD Universe dominated by zero energy ontology, consciousness is a universal phenomenon and present on all scales, from elementary particles to the level of the cosmos. Even galaxies, stars and planets would be conscious beings. Also life and death would be universal phenomena. Likewise, the biological decomposition process associated with death would correspond to the universal decomposition process, which would essentially correspond to the decomposition of magnetic monopole flux tubes (magnetic catabolism), which would induce the catabolism of the breakdown of biomolecules. Its time-reversed version would be magnetic anabolism and induce the building of bio-structures such as molecules.
3. The reversal of the Sun's magnetic field would correspond to magnetic catabolism as the breakdown of long monopole flux tubes into very short parts. It would be followed by magnetic anabolism as their re-fusion into long flux tubes. The solar cycle would correspond to the sleep-wake cycle, or more precisely: a series of lives in different directions of time. Death would only be a change of time's arrow, nothing final.
4. The fundamental metabolic processes would be basically magnetic anabolism and catabolism induced by "big" state function reductions changing the arrow of time and inducing the

biological anabolism and catabolism. Death would mean reincarnation with the opposite arrow of time.

In Tukdam, the biological body would be dead, but the magnetic body would still be alive and prevent the biological decay from starting. The disintegration of the magnetic body as a reconnection process splitting monopole flux tubes to pieces in the way described above would start in Tukdam much later than normally, and initiate the disintegration of the biological body. The contents of the conscious experience in Tukdam, light sensations and deep peace, would come from the magnetic body. The dead biological body would not provide contribution from sensory input, motor activity, and cognition.

## 7 Summary and outlook

This article was inspired by a single puzzling astrophysical observation but was extended by further similar observations. The discussion of these findings allowed us to develop a TGD based vision about the generation of astrophysical structures to a much more detailed level. This vision should apply also to other interactions.

The foregoing discussion suggests that the dynamics of gravitational fields could reduce to the dynamics of flux tubes subject to the conservation of total Kähler electric fluxes, which have a definite sign.

The topological dynamics would be essentially re-organization of the network formed by electric flux quanta as nodes of the network connected to each other by flux tubes, which can also carry Kähler electric flux. Twistor lift of TGD and  $M^8 - H$  duality [L15, L16] led to a rather similar picture for the scattering amplitudes [L26, L27] in terms of fundamental fermions.

This generalizes also to the dynamics of gauge fields. Flux tubes can be characterized by the value of  $h_{eff}$  characterizing a given interaction, and the notion of gravitational Planck constant generalizes to all interactions. The key physical idea is that Nature is theoretician friendly: if quantum coherence is to be preserved, a phase transition replacing the ordinary Planck constant  $\hbar$  with  $\hbar_{eff}$  must take place, when the interaction strength  $Q_1 Q_2 / 4\pi\hbar$  becomes too large for the perturbation series to converge. The alternative option is that the system decomposes to coherent subunits such that the perturbation series converges for them. This means a reduction of quantum coherence scale.

The understanding of atomic and molecular physics at the space-time level has been a long-standing challenge of TGD.

1. I have proposed that  $h_{eff} > h$  for the valence bonds as flux tubes could allow us to gain insights about the periodic table [L42]. Monopole flux tubes can also carry ordinary electric fluxes and this would allow us to understand the recent empirical findings about chemical bonds as carriers of electric flux [L21]. TGD also suggests a flux tube model for hydrogen bonds. Also a generalization of hydrogen and valence bonds involving quantum gravitation in the TGD sense [L28] can be considered so that quantum gravitation would define an essential part of biochemistry.
2. What about atoms in TGD Universe? The proposed description for the gravitational interaction at the level planetary system in terms of flux tubes could generalize almost as such to a description of electromagnetic interactions at the atomic level. The U-shaped flux tube pairs with opposite magnetic charges and carrying electromagnetic flux besides monopole magnetic flux would emanate from protons and connect them to electrons. For a pair of opposite charged particles, the U-shaped flux tubes would be closed. For ions the flux tube pair would continue outside the atom. The flux tubes of a given atom could also form flux tube bundles. Also linking and knotting are possible for the flux tubes so that the capacity for topological quantum computation emerges.
3. A powerful restriction comes from the condition that monopole flux tubes must be closed. The proposal is that they are U-shaped and form pairs of flux tubes connecting two systems. This does not require that the Kähler electric charges of the members are opposite. For gravitational flux tube pairs they are of the same sign. For gauge interactions they are of the same sign but the sign can vary.

There are many topics related to flux tubes, which are not considered in this article.

1. TGD predicts homologically non-trivial flux tubes: in the simplest situation  $X^4 = X^2 \times S^2$ , the  $CP_2$  projection  $S^2$  is a homologically trivial geodesic sphere. If they are allowed by the preferred extremal property, they would serve as natural correlates for the Maxwellian magnetic fields. One cannot exclude flux tubes with light-like boundaries, and they would be even more natural counterparts for Maxwellian fluxes.

In the standard terminology of condensed matter physics [L22], they would correspond to the magnetization  $M$ , whereas the monopole part of the measured magnetic field, which needs no currents as its sources, would correspond to the magnetizing "external" field  $H$ , which can be said to control  $M$  (and possibly containing  $h_{eff} = h$  phases). The presence of monopole fluxes allows us to understand the puzzle posed by the fact the magnetic field of Earth is non-vanishing although dissipation of currents implies the decay of the Maxwellian part.

2. Interesting questions relate to the many-sheeted space-time. Monopole fluxes can flow between two space-time sheets through wormhole contacts. Elementary particles have wormhole contacts as building bricks [L23] [K2, K3]. Can one separate this level from the levels just discussed. For instance, can one consider closed flux loops travelling through several sheets in long length scales as the hierarchy of Planck constants would suggest.

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