Magnetic Bubbles in TGD Universe: Part I

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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 this 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.

Contents

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 [E7] (`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 [E7], 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 [K1]. 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 [L8, L17, L14, L25]. 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 [L11]. 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 [E4]. 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 [E5]: 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.

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 Λ 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 the 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 [L9, L10, L16] 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 [L10], stellar cores involve a flux tube spaghetti [L11]. 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 $H = 72$ kms^{-1}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 Λ 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 ρ_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 Λ_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:

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

   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 ΔR_B one obtains the estimate

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

This gives for the thickness of the bubble the estimate

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

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 ΔR_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 $\rho_{MW} = .5 \times 10^6 \times m_p$ m^3. Could the reduction of ρ_{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 gives $M \simeq 10^3 M_{Sun}$.

   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 ρ_{MW} would be needed. One can imagine that the primary stars, which became later supernovae, took place via the thickening of cosmic strings.

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

1. The radii of Fermi bubbles are about 2.5×10^3 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 3.8×10^{-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 1.5×10^{-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 Λ 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 Λ_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 [L8, L17, L14, L25].

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 [K14, K12, L11].

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, L13, L22, L18].

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 h_{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_n+E_V is minimized as a function of S [L6]. The total density for the flux tube determines the effective cosmological constant Λ_{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 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) [K17] [L28]. 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 Λ_{loc} approach cosmological values. Therefore one could model the emerging expanding space sheet as a local Big-Bang with the help of the parameters Λ_{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 [L21]. 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 Λ_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 Λ_{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 [K8, K9] 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 $h_{eff} = nh_0$ 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 Schwartschild 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 Λ_{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 ate 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 [E5] (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 [L9, L10, L16].

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 [E4] (`hhttps://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 note 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 [L9, L10, L16] 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. The 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 Λ 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 the blackhole matter should be dark.

3. The values of the $\hbar_{eff}$ 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 Λ_{gr} is $GM/\beta_0 = r_S/2\beta_0$ and for $\beta_0 = 1$ it is equal to one half of the Scwartschild 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 $a_{0,gr} = AU/5^2 \simeq 6 \times 10^9$ m [K14]. The gravitational Compton length for the Sagittarius A* is $\Lambda_{gr} = r_S/2 = 6.2 \times 10^9$ m 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, L12] 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 calso "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 for stellar BOs, the thickness of the flux tube would be given by proton Compton length [L10] 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 WOs 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 [E4]

   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 [L16]. 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 spaghettis and fuse to the spaghetti defining the GWO.

3.3 Einstein rings give support for the TGD view of dark matter

There was an interesting popular article in Science-Astronomy.com with the title "Einstein rings says dark matter behaves more like a wave,not particle" (`https://rb.gy/e6fgo`). The article told about the article published by Amruth and his team published in Nature Astronomy as an article with title "Einstein rings modulated by wavelike dark matter from anomalies in gravitationally lensed images" (`https://rb.gy/mw7cq`). Unfortunately, the article is hidden behind paywall.

Dark matter is known to exist but its real character has remained a mystery. The models assume that its interactions with ordinary matter are very weak so that it makes itself visible only via its gravitational interactions. Two basic kinds of particles have been proposed: weakly interacting massive particles (WIMPs) and light particles, of which axions are the basic example. WIMPs behave like point-like particles whereas axions and light particles in general behave like waves. This difference can be used in order to find which option is more favoured. Axion option is favored by the behavior of dark matter in dwarf galaxies and by its effects on CMB.

The study of Amruth and his team found further support for the axion option from the study of gravitational lensing.

1. As light passes by a massive object, it bends both by the visible and dark matter associated with the object. This leads to a formation of Einstein rings: as if the light source would be a ring instead of a point-like object. If dark matter particles have some interactions with the photons , this causes additional effects on the Einstein rings. For instance, in the case of axions this interaction is known and corresponds to the electromagnetic analog of instanton term.

2. The effect of point-like particles on light is different for WIMPs and light particles such as axions. From the abstract of the article one learn that WIMP option referred to as ρ_{DM} option leaves well documented anomalies between the predicted and observed brightnesses and positions of multiply lensed images, whereas axion option referred to as ψ_{DM} option correctly predicts the level of anomalies remaining with ρ_{DM} lens models. Therefore the particles of dark matter behave as if they were light particles, that is having a long Compton length.

What TGD allows us to conclude about the findings?

1. TGD predicts that dark matter corresponds to phases of ordinary matter labelled by a hierarchy of Planck constants $h_{eff} = nh_0$. The Compton length of dark particles with given mass is scaled up by factor h_{eff}/h. Could this be more or less equivalent with the assumption that dark particles are light?

2. Gravitational Planck constant is an especially interesting candidate for h_{eff} since it plays a key role in the TGD based view of quantum gravitation. Gravitational Planck constant obeys the formula $\hbar_{gr} = GMm/\beta_0$ for two-particle system consisting of large mass M and small mass m ($\beta_0 \leq 1$ is velocity parameter) and is very large.

The gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = GM/\beta_0$, which does not depend on the mass m of light particle (Equivalence Principle), is very large and and gives a lower bound for quantum gravitational coherence length. For instance, for the Sun it is rather near to Earth radius, probably not an accident.

3. Gravitational Compton length for particles at the gravitational magnetic body, which for stars with solar mass is near to Earth radius if the velocity β_0 in $\hbar_{gr}$ has the same value $\beta_0 \sim 2^{-11}$, makes dark variants of ordinary particles to behave like waves in astrophysical scales.

4. What happens in the scattering of a photon on a dark particle in the TGD sense. It seems that the photon must transform temporarily to a dark photon with the same value of h_{eff}. Photon wavelength is scaled up h_{eff}/h but photon energy is not affected in the change of Planck constant.

   Suppose that the scattering takes place like in quantum mechanics but with a modified value of Planck constant. In the lowest order in expansion in powers of $\alpha_{em} = e^2/4\pi\hbar_{eff}$ the scattering cross section is the same and whereas the higher corrections decrease. This provides actually a good motivation for the dark matter in TGD sense: the phase transition increasing the value of Planck constant reduces the value of gauge coupling strength and makes perturbation series convergent. One could say that Nature is theoretician friendly and takes care that his perturbation theory converges.

In the lowest order of perturbation theory the scattering cross section is given by the classical cross section and independent of $\hbar_{eff}$. The Nishijina formula for Compton scattering (`https://rb.gy/n28zk`) indeed shows that the scattering cross section is proportional to the square of the classical radius of electron and does not depend on $\hbar_{eff}$. The result is somewhat disappointing.

1. On the other hand, for large values of $\hbar_{eff}$, in particular $\hbar_{gr}$, one can argue that the scattering takes place on the entire many-particle states at the flux tubes of the magnetic body so that superposition of scattering amplitudes on different charged particles at the flux tube gives the cross section. This can lead to interference effects.

   If the charged dark matter at the flux tube has a definite sign of charge this would give rise to amplification of the scattering amplitude and it would be proportional to the square N^2 of the number N of charged particles rather than to N. Scattering amplitudes could also interfere to more or less zero if both signs of charges are involved.

   One can also argue that only particles with a single value of mass are allowed since $\hbar_{gr}$ is proportional to m so that particles would be like books in the shelves of a library labelled by $\hbar_{gr}$.

2. The effects of axion Bose-Einstein condensates have been indeed studied and it has been found that the scattering of photons on cold axion Bose-Einstein condensate could cause what is called caustic rings for which there is some evidence (`https://rb.gy/2bubj`). Could the quantum coherent many-particle states at gravitational flux tubes cause the same effect?

The optimistic conclusion would be that astrophysicists are gradually ending up with the TGD view of dark matter. One must of course that the above argument only suggests that the effects of scattering on Einstein's ring could be large for a large value of h_{eff}.

3.4 Is the 60 year old mystery of quasars solved?

The following considerations were motivated by a Sciencedaily article telling about a possible solution of 60 year old problem related to the huge intensity of radiation arriving from quasars (`https://rb.gy/889hk`). The article tells about the article "Galaxy interactions are the dominant trigger for local type 2 quasars" of Pierce et al published in Monthly Notices of the Royal Astronomical Society (`https://rb.gy/1wnfo`).

The proposed explanation of quasars is in terms of the collision of galaxies in which matter, which usually stays at circular orbits, falls into the galactic blackhole-like objects (BHOs) having huge gravitational fields. In this process a huge amount of radiation is emitted.

The key problem of this view is that the radii of the orbits of stars are measured in kiloparsecs: somehow the matter should get to a distance of order parsecs. This requires that the orbiti matter gets rid of the conserved angular momentum somehow. The proposal is that the collision of galaxies generates tidal forces making this possible. My impression from the article was that this is one possibility and they support this option but certainly do not prove it.

The researchers claim that the finding could be understood if the colliding objects are BHOs. Tidal forces in collisions would make it possible for them to draw matter from their surroundings and this process would generate huge radiation power. They do not do this usually but only because the collision creates the circumstances causing the ordinary matter at their circular orbits to fall to the BHO(s). I am not specialist enough to decide how convincing the calculations of the researchers are.

Consider now the TGD based explanation baed on the general view of the formation of astrophysical object dicussed in [L26, L27].

1. In TGD, galactic blackhole-like objects (BHOs) could be associated with cosmic string-like objects, which thicken to monopole flux tubes by phase transitions. The phase transition is analogous to the decay of inflaton field producing ordinary matter. In this process dark energy would transform the energy of the cosmic string to dark matter assignable to BHOs. This would also explain the quite recent finding that dark energy seems to transform to galactic BHOs. Part of the dark matter of BHO would transform to the ordinary galactic matter in a transition reducing gravitational Planck constant and liberating energy as an explosion.

2. This explosive process would involve new physics predicted by TGD involving the transformation of dark matter to ordinary matter in a transition reducing the value of gravitational Planck constant $\hbar_{gr} = GMm/beta_0$: here M is large mass and m a small mass and $\beta_0 = v/c \leq 1$ is a velocity parameter. This transformation could be also behind the formation of both stars and planets in explosions producing magnetic bubbles. This mechanism would replace the standard model assuming gravitational condensation. Quasars could be similar expolosions perhaps preducing BHOs.

3. The most conservative assumption is that quasars a BHOS are analogs of ordinary blackholes. The new physics would correspond to an analog of inflaton decay transforming dark energy to dark matter and in turn to ordinary galactic matter. Quasar would be produced by an explosion analogous to inflaton decay proposed to also produce other astrophysical objects.

4. The collision of galaxies could have led to an intersection of cosmic strings orthogonal to the galactic planes assignable to galaxies. The intersection would have induced a formation of dark BHO and its explosion by $\hbar_{gr} \to \hbar$ phase transition producing ordinary matter. this process could involve several steps reducing the value of h_{eff}. The distant ordinary matter circulating the galaxies would have nothing to do with the formation of quasars.

   These kinds of collisions are unavoidable for moving string-like objects in 3-D space. There is evidence that also the Milky Way center involves 2 cosmic strings which have collided. The structure MW would reflect the ancient occurrence of an analog of inflaton decay.

3.5 Two findings possibly related to cosmic strings in TGD sense

I learned recently of two very interesting findings, which relate to the TGD views about dark energy and galactic dark matter, about quasars and formation of galaxies.

3.5.1 A finding providing support for the TGD view of galaxy formation

The discovery challenges the standard view of quasars as blackholes and provides additional support for the TGD view of quasars and galaxy formation. Here is the abstract of the article published in Nature.

Quasars feature gas swirling towards a supermassive black hole inhabiting a galactic centre. The disk accretion produces enormous amounts of radiation from optical to ultraviolet (UV) wavelengths. Extreme UV (EUV) emission, stemming from the energetic innermost disk regions, has

critical implications for the production of broad emission lines in quasars, the origin of the correlation between linewidth and luminosity (or the Baldwin effect) and cosmic reionization.

Spectroscopic and photometric analyses have claimed that brighter quasars have on average redder EUV spectral energy distributions (SEDs), which may, however, have been affected by a severe EUV detection incompleteness bias.

Here, after controlling for this bias, we reveal a luminosity-independent universal average SED down to a rest frame of ~ 500 *Angstrom for redshift* $z \sim 2$ *quasars over nearly two orders of magnitude in luminosity, contrary to the standard thin disk prediction and the Baldwin effect, which persists even after controlling for the bias.*

Furthermore, we show that the intrinsic bias-free mean SED is redder in the EUV than previous mean quasar composite spectra, while the intrinsic bias-free median SED is even redder and is unexpectedly consistent with the simply truncated wind model prediction, suggesting prevalent winds in quasars and altered black hole growth. A microscopic atomic origin is probably responsible for both the universality and redness of the average SED.

What does TGD say about the discovery?

1. In the standard accretion disk theory inner luminosity is determined by the mass of the accretion disk entering into the blackchole. What is however found that the spectral energy distribution of light from quasar does *not* depend on the inner luminosity at all in the extreme UV (EUV) range! It can even decrease when the intrinsic luminosity increases! These paradoxical findings challenge the standard accretion disk theory.

2. TGD based view of quasars [L9, L10, L16, L26, L27] suggests an explanation of the anomaly. The galactic matter would be formed as dark energy and dark matter from a cosmic string like objects thickening to a monopole flux tube tangle with reduced string tension would emit dark particles transforming to ordinary matter forming the galaxy. Cosmic strings would be transversal to the galactic plane and their dark energy energy predicts the flat velocity spectrum of galaxies.

3. The radiation from the thickened flux tube (rather than from the energy liberated as matter of the accretion disk falls into the blackhole) could give rise to the spectral energy distribution in EUV and the inner luminosity at longer wavelengths would be determined by the accretion disk emission. The article suggests that galactic wind explains the energy spectrum: galactic wind would correspond to this EUV radiation from the monopole flux tube. This energy spectrum would be universal in the sense that it would reflect only the properties of the thickened cosmic string and universality is indeed claimed. Galactic wind would correspond to the flow of matter from the cosmic string tangle which is not stopped by the accretion disk.

The model of the quasar as a portion of a cosmic string thickened to a flux tube tangle and emitting dark energy and matter transforming to ordinary matter challenges the standard model as a blackhole. The outflowing matter would create an accretion disk as a kind of traffic jam and at least part of the luminosity of the accretion disk would be due to the heating of the accretion disk caused by the flow of the particles colliding with the accretion disk. Also now the gravitational field of the cosmic string and of the flux tangle associated with it is present and a natural classical expectation is that the matter in the accretion disk tends to flow back to the quasar.

In atomic physics the quantization prevents the fall of electron to atomic nucleus. Could the same happen now and prevent the fall of matter from the accretion disk back to the quasar.

1. One can argue that a realistic quantum model for the matter around quasar is based on the treatment of the flux tube tangle as spherically symmetric mass distribution with the mass of the blackhole assigned to the quasars. Indeed, the straight portion of cosmic strings gives a large contribution to the gravitational force only at large distances so that the contribution of the tangle dominates.

2. The mechanism preventing the fall of matter to blackholes would be identical with that in the case of atoms. Also in the accretion disk model, the angular momentum of rotating matter in the accretion disk tends to prevent the fall into the blackhole and the angular momentum must be transferred away.

3. The orbital radii would be given by the Nottale model for planetary orbits with $r_n = n^2 a_{gr}$, where $a_{gr} = \frac{4\pi GM}{\beta_0^2} = 2\pi r_S/\beta_0^2$ is gravitational Bohr radius, and M is the mass M of the quasar blackhole estimated to be in the range $M/M_{Sun} \in [10^7, 3 \times 10^9]$ predicting that the Schwartschild radius r_S is in the range $3 \times 10^7 - 10^{10}$ km. The radius of r_{acc} should be larger than a_{gr}: $a_{gr} < a_{acc}$. Note that the size of the accretion disk is in some cases estimated to be few light-days: 1 light-day $\simeq 10^{10}$ km whereas the visible size of quasar is measured in light years.

4. The condition $a_{gr} < r_{acc}$ gives the condition $2\pi/\beta_0^2 < r_{acc}/r_S$ giving for β_0 an upper bound in the range $\beta_0 \in [.02, .2]$. The values of β_0 in this range are considerably larger than the value $\beta_0 \simeq 2^{-11}$ predicted by the Bohr model for the orbits of inner planets. Note that for the Earth the estimate for β_0 is $\beta_0 \simeq 1$.

3.5.2 Do cosmic strings with large string tension exist?

There is some empirical support for cosmic strings with a rather large string tension from gravitational lensing. Cosmic string tension T and string deficit angle $\Delta\theta$ for lensing related bia the formula $\Delta\theta = 8\pi \times TG$ if general relativity is assumed to be a good description. The value of TGD deduced from data is $TG = .05$ and is very large and corresponds to an angle deficit $\Delta\theta \sim 1$.

For the ordinary value of Planck constant, TGD predicts the value of TG has upper bound in the range $10^{-7} - 10^{-6}$. The flat velocity spectrum for distant stars around galaxies determines the value of TG: one has $v^2 = 2TG$ from Kepler law so that the value of TG is determined from the measured value of the velocity v. The value of TG can be also deduced from the energy density of cosmic string-like objects predicted by TGD and is consistent with this estimate. If one takes the empirical evidence for a large value of TG seriously one must ask whether TGD can explain the claimed finding.

Could a large value of h_{eff} solve the discrepancy? String tension T as the linear energy density of the cosmic string is determined by the sum of Kähler action and volume term. The contribution of Kähler action to T is proportional to $1/\alpha_K = g_K^2/4\pi\hbar$. If cosmic string represents dark matter in TGD sense, one must make the replacement $\hbar \to \hbar_{eff}$ so that the Kähhler contribution to T is proportional to $\hbar_{eff}/\hbar$. If the two contributions are of same order of magnitude or Kähler contribution dominates, $\hbar_{eff}/\hbar = n \simeq 10^5$ would give the needed large value TG.

The physical interpretation would be that the cosmic string is an n-sheeted structure with each sheet giving the same contribution so that the value of T is scaled up by $n \simeq 10^5$. There are two options. The n-sheetedness is with respect to M^4 so that one has a n-fold covering of M^4 or with respect to CP_2 in which case one quantum coherent structure consisting of n parallel flux tubes.

It is intereting to consider in more detail the quantum model for the particles in the gravitational field of cosmic string.

1. The gravitational field of a straight cosmic string behaves like $1/\rho$ as a function of the radial distance ρ from string, and Kepler's law predicts a constant velocity $v^2 = 2TG$ for circular orbits irrespective of their radius. This explains the flat velocity spectrum of stars rotating around galaxies.

2. Nottale proposed that planetary orbits obey Bohr quantization for the value of gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ assignable to a pair of masses M and M associated with the gravitational flux tube mediating the gravitational interaction between M and m.

3. If the mass M corresponds to a cosmic string idealized as straight string with an infinite length, the definition of $\hbar_{gr}$ is problematic since M diverges. Therefore the application of Nottale's quantization to a distant star rotating cosmic string is problematic.

   What is however clear that $\hbar_{gr}$ should be proportional to m by Equivalence Principle and one should have $\hbar_{gr} = GM_{eff}m/\beta_0$ for the cosmic string. $M_{eff} = TL_{eff}$, where L_{eff} is the effective length of the cosmic string is also a reasonable parametrization.

4. Kepler law does not tell anything about the value of the radius r of the circular orbit. If the value of $\hbar_{gr}$ is fixed somehow, one can apply the Bohr quantization condition $\oint pdq = nh_{gr}$ of angular momentum to circular orbits to obtain $vr = nGM_{eff}/\beta_0$ giving

$$r_n = nr_1 \quad , \quad r_1 = \frac{r_{S,eff}}{2\sqrt{2TG}\beta_0} \quad .$$

A reasonable guess is that β_0 and the rotation velocity $v/c = 2TG$ have the same order of magnitude. $v/c = x\beta_0 \leq 1$ would give $\beta_0 = \sqrt{2TG}/x$. The minimal value of the orbital radius would be $r_1 = r_{S,eff}/2x\beta_0^2$.

An interesting question relates to the size scale of the n-sheeted structure interpreted as a covering of CP_2 by parallel cosmic strings or flux tubes. The gravitational Compton length $\Lambda_{gr} = r_{S,eff}/2\beta_0$ could give an estimate for the size scale of this structure, which as flux tube bundle would be naturally 2-D. There would be about 10^5 flux tubes per gravitational Compton area with scale Λ_{gr}.

3.6 Fermi bubbles as expanding magnetic bubbles?

Could one apply the proposed picture to Fermi bubbles [E12] (`https://rb.gy/uncffb`)?

3.6.1 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 [E12]. 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 [E9] (`https://rb.gy/qslgq4`) 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 [E12] (`https://rb.gy/qwzvnz`), 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 [E12] for the energy would correspond to $10^2 M_{Sun}$.

3.6.2 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 tangeles 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 Schwartschild radius.

2. $L_{loc} = 12.5$ kly corresponds to the radius of the bubble and the length of a typical flux tube .

3. $R_{loc} = (3/8\pi G L_{loc})^{-1/4}$ corresponds to the thickness of the flux tubes and would be of order μm 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 β_0 is of order $.5 \times 10^{-3}$.

3.7 Bubbletrons as magnetic bubbles?

The popular article in Livescience (`rebrand.ly/hdaqw08`) told about giant "bubbletrons", which in the article "Bubbletrons" (`rebrand.ly/cq3mhe2`) are proposed to have played a key role in the early universe. Bubbletrons would be walls generated in first-order phase transitions. First order phase transition requires free energy or liberates it.

Note: First order means that the derivative of the free energy with respect to some variable is discontinuous: the usual phase transitions in condensed matter are first order. Magnetization is second order phase transition. Magnetization as the first derivative of free energy with respect to the external magnetic field is continuous but magnetic susceptibility as its second derivative is discontinuous.

The inner and outer surfaces of bubblerons could contain high energy particles and the collisions of bubbletrons would liberate energy accelerating particles to huge energies. These explosions could also generate dark matter assumed to be some exotic particles. In the fractal TGD Universe, magnetic bubbles generated in local analogs of the Big Bang, would have been basic structures in the emergence of astrophysical objects. They would serve as analogs of bubbletrons and would play a key role in the formation of all astrophysical structures, including even the formation of planets. I wrote in the beginning of this year two articles describing this vision in various scales [L26, L27].

The production of ordinary and dark matter from the TGD counterpart of dark energy associated with monopole flux tubes, in particular cosmic strings, would be an essential part of the mini big bang and give rise to the TGD analog of inflation. In TGD dark matter would correspond to $h_{eff} = nh_0 \geq h$ phases of ordinary matter and no exotic dark matter particles are needed.

The proposal is that the collisions of bubbletrons could have created gravitational waves causing the gravitational hum. This might be the case also for the magnetic bubbles of TGD but I think that this is not enough. TGD predicts tessellations of cosmic time=constant hyperboloids H^3: they are hyperbolic spaces. They appear in all scales. The tessellations are hyperbolic analogs of crystal lattices in E^3. There are 4 regular tessellations consisting of cubes, icosahedrons and dodecahedrons. In E^3 only the cubic regular tessellation is possible.

There is also the completely unique icosa-tetrahedral tessellation having tetrahedra, octahedra and icosahedra in its fundamental region: this tessellation is essential in the TGD based model of genetic code as a universal piece of quantum information processing, not only related to chemical life.

The large voids could correspond to the fundamental regions of icosahedral tessellations: icosahedrons are indeed the Platonic solids nearest to sphere. Also tessellations having stars with a typical distance of about 5 light years at their nodes can be considered. Hyperbolic diffraction

guides the gravitational fields to preferred directions and amplifies them: just as in X-ray diffraction. Quantum coherence in astrophysical scales predicted by the TGD view of dark matter also amplifies the radiation in these directions [L29].

3.8 Large voids and CMB cold spot as magnetic bubbles?

Quanta Magazine post "How (Nearly) Nothing Might Solve Cosmology's Biggest Questions" (`rebrand.ly/21wz4w7`) tells about the mysterious large voids. There was also another interesting link to a popular article (`rebrand.ly/pxjx0cu`) in Big Think with the title "Our Universe is normal! Its biggest anomaly, the CMB cold spot, is now explained!"

3.8.1 TGD view of large voids

I have considered the problem of cosmic voids in the TGD framework for decades. I assumed that voids involve cosmic strings going through their center. At that time I did not realize that TGD allows us to consider a considerably simpler solution, which is not possible in general relativity.

In the TGD Universe, space-time consists of 4-D surfaces in $H = M^4 \times CP_2$. Einsteinian space corresponds to space-time surface with 4-D M^4 projections, I call them space-time sheets and they can be connected by extremely tiny wormhole contacts, which are in the simplest situation isometric with a region of CP_2 having 1-D light-like geodesic as M^4 projection. Wormhole contacts serve as basic building bricks of elementary particles. Space-time surfaces or at least their M^4 projections have outer boundaries. The boundaries of physical objects correspond to boundaries of 3-surfaces or of their M^4 projections so that we can see the TGD space-time directly with our bare eyes!

Also other kinds of space-time surfaces, such as cosmic strings with 2-D M^4 and CP_2 projections, are predicted and play a fundamental role in the TGD inspired view of the formation of astrophysical objects.

Concerning the problem of large voids, the key point is that it is possible to have voids in M^4 as regions of M^4 (or E^3) which contain very few or no 3-surfaces. Gravitational attraction could have drawn the 3-surfaces inside the voids to the boundaries of the voids. Could it be that we have been seeing TGD space-time directly for decades?

Also tessellations at the cosmic time= constant hyperboloids would be in a key role and one can imagine that they give rise to tessellations of voids with matter near the walls of the voids. There are 4 regular tessellations involving either cubes, icosahedron of dodecahedron (in E^3 only a cubic regular tessellation is possible) plus the icosa-tetrahedral tessellation consisting of tetrahedrons, octahedrons, and icosahedrons. This tessellation is completely unique and plays a key role in the TGD inspired model of the genetic code, which raises the question whether genetic code could be universal and realized in all scales at the level of the magnetic body [L24].

3.8.2 Could CMB could spot be a super void?

The article [E2] (see also the popular article at `rebrand.ly/pxjx0cu`) proposes the identification of the CBM cold spot as a supervoid. CMB cold spot is a huge region inside which the temperature of CMB background is about 70 μKelvin below the average temperature. What adds to the mystery is that it is surrounded by a hotter region. The idea is that the CMB cold spot corresponds to an expanding supervoid. I am however not at all sure whether our Universe is normal in the sense of general relativity.

Consider first the Sachs-Wolfe effect (`rebrand.ly/i2lpwy7`) which leads to the formation of cold and hot spots. Assume that a photon arrives at a gravitational well due to a mass distribution. The presence of matter induces first a blueshift as the photon falls in the gravitational potential of the region and then a redshift as it climbs out of it. The expansion however flattens the potential that there is a net reduction of the overall redshift due the average density of matter.

Since the local temperature depends on the local matter density, the low density region corresponds to a cold spot. If the cold spot corresponds to a region, which has a small density and expands during the period that photon uses to go through the cold spot, the redshift inside the region vanishes and is smaller than the redshift caused by the average region. The region appears to have lower density and lower temperature. There are a lot of these kinds of hot and cold spots

and they induce fluctuations of the CMB temperature. But there is also a really big cold spot surrounded by hotter regions. This cold spot has been problematic.

The idea is that the CMB cold spot could correspond to an expanding supervoid. It is not however obvious to me how this explains the higher temperature at the boundaries of the supervoid. In the TGD framework, one can however ask whether the supervoid could correspond to a magnetic bubble caused by a local big bang, which has feeded energy to the boundaries of the resulting void forming a magnetic bubble so that the temperature at the boundaries would be higher than inside the void. One can even consider the possibility that the supervoid is in a reasonable approximation a void in M^4 sense so that very few 4-D space-time surfaces would exist in that region.

3.8.3 Could M^4 voids allow to test the TGD view of space-time?

The existence of M^4 voids might allow to test TGD view of space-time. The physics predicted by TGD is extremely simple in the case of a single-sheeted space-time sheet. The observed space-time is however many-sheeted. One can think using analogy with extremely thin glass plates with M^4 corresponding to the 2-D plane and CP_2 corresponding to its thickness. Einsteinian space-time sheets correspond to 2-D surfaces inside the plate, which are slightly curved and are connected by wormhole contacts. At the QFT limit one must replace the many-sheeted structure with a region of M^4 and define gauge and gravitational fields as sums of the induced fields associated with various sheets (and determined by the surface geometry alone). The extreme simplicity is lost.

However, if M^4 vacua exists one could test TGD at the single-sheeted limit to see the predicted fundamental physics in its extreme simplicity. Things would indeed be simple. Not only are the induced fields determined by the minimal surface property of the space-time region but also holography holds and is realized in terms of a generalization of the 2-D holomorphy to 4-D case.

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 [E6] (`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 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 ^4He 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 [E6] 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 [L20].

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 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 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, L12, L5, L10] 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 Λ, 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 Λ 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 buble, 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, L12, L5, L10].

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 transforme 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 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 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, L12].

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 Janus faced white dwarf

Science Daily release (`rb.gy/jkoun`) told about a really weird object reported in [E3]: the surface of the white dwarf is made of hydrogen on one side and helium on the other. The organization of particles with different masses to layers occurs by gravitation but only in vertical direction.

It is believed that hydrogen is able to diffuse into the interior of the dwarf so that its surface density is reduced so that effectively helium begins to dominate. This would be analogous to a phase transition. But why would this take place only for the other side of the white dwarf and why such a sharp division to two regions.

Magnetic fields are proposed as a possible explanation.

1. Whether the surface layer or atmosphere as it is called in the article is dominated by hydrogen or helium depends on temperature and pressure. At lower temperatures a transition to helium atmosphere is expected to take place. A weak magnetic field could induce a reduction of pressure or temperature and also prevent mixing.

2. At the surface layer the magnetic fields tend to prevent the mixing of hydrogen and helium ions by forcing the ions to cyclotron orbits. Mixing requires that hydrogen, helium or both are ionized.

   Whether this is the case depends on temperature. Wikipedia article claims that white dwarf temperatures are in the range 150,000 K-4000 K (15 eV -.1 eV). The upper limit 15 eV is slightly above 13.7 eV which is the ionization energy of hydrogen in ground state so that hydrogen could be ionized. Helium would not be ionized. If there is no ionization, the magnetic moment of hydrogen is what matters. Helium nucleus has a vanishing magnetic moment. Non-ionized helium looks magnetically inert but not hydrogen, which could also be at cyclotron orbits.

3. The popular article informs that the temperature of the white dwarf is around 35,000 K (35 eV). For helium the ground state energy, proportional to Z^2 is 54.8 eV in the simplest model, which suggests that helium is not ionized and cyclotron orbits are not possible.

Two options are considered.

1. If hydrogen is ionized, it moves along cyclotron orbits and tends to be magnetically confined. Also the higher magnetic field strength at the hydrogen side reduces the mixing. Since helium is not ionized, it is not magnetically confined and will mix more easily. This is true in the standard physics picture, in which one has no monopole flux tubes, which confine even non-charged particles.

2. The higher value of the magnetic field implies a lower pressure and this would imply slower diffusion of the hydrogen to the interior. If the sum of the magnetic and ordinary pressures is constant, hydrogen oceans with a higher magnetic field strength and lower pressure could be formed.

Also I tend to believe that magnetic fields could solve the puzzle but not necessarily in the proposed way. What comes to mind after a minute of thinking is the following.

1. In the TGD framework, magnetic fields correspond to flux tubes and flux sheets. There are monopole flux tubes, something new, and ordinary flux tubes possible also in the Maxwellian world. There would be confinement inside the flux tubes. The flux tubes can also flatten to flux sheets.

2. In particular, the gravitational magnetic monopole flux tubes and sheets are possible. This is a purely TGD based phenomenon. The gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ ($\beta;_0 = v_0/c \leq 1$ is velocity parameter) is proportional to the mass M of the white dwarf and to the mass m of the particle, now helium or hydrogen.

The longstanding question has been whether a gravitational flux tube/sheet characterized by $\hbar_{gr}$

1. attaches only to/contains only particles with a fixed mass m,

2. or whether it attaches to particles with varying mass m. If so, the gravitational Planck constant would be 2-particle property and depend on m for a gravitational flux tube/sheet associated with mass m.

If the first option is true, the particles with different masses m would be arranged like books in the library, each in its own shelf defined by the gravitational flux tube/sheet (M,m). In the case of the weird white dwarf, helium and hydrogen would be on their own shelves located at different sides of the star as a gravitational library. For flux tube option there could be a mixing of the flux tubes. For large sheets the mixing would be absent.

What does the first option imply in the case of the weird white dwarf? One can consider two options.

1. Monopole flux tubes form roughly parallel layers along the surface of the white dwarf. The layers associated with hydrogen and helium should be disjoint: but why?

2. There are separate flux sheets associated with either hydrogen or helium but not both. If the flux sheets have boundaries orthogonal to the rotation axis, the hydrogen and helium layers are static. Since helium can mix in the tangential direction, it would prefer flux sheets. Hydrogen would not mix and could be also associated with flux tubes.

In quantum biology the first option would imply that at the level of dark matter associated with the magnetic bodies the biomatter would be extremely organized, in a complete contrast to the view that biomatter is a chaotic soup of biomolecules. The interaction by cyclotron frequency resonance occurs only between charged particles with the same h_{eff} and the same flux tube field strength: this requires the same mass in the case of gravitational flux tubes. Note that one can also talk about electromagnetic Planck constant. This supports the library like organization.

Charged particles with different gravitational Planck constant (masses m) can have gravitational cyclotron *energy* resonance but not *frequency* resonance: this reflects Equivalence Principle.

4.3 TGD view of the planetary system

Could TGD based quantum vision of planetary system [K14, K12] [L7, L8, L17, L14, L25] 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: $\Lambda_{gr} \to 5\Lambda_{gr}$. If the radius is roughly equal to a multiple of Λ_{gr}. The radii of planets would scale like β_0 and their distances like $1/\beta_0^2$ and one could speak of kinds of proto planets corresponding to some maximum value of β_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

   $$[r_E = 1.0618, r_{Ju} = 11.6518, r_{Ur} = 4.2270, r_{Me} = 0.4066, r_{Ma} = 0.5649, r_{Ne} = 4.1037, r_{Sa} = 9.7053, r_{Ve} = 1.$$

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 [L25] 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 [K14, K12], planets could have formed by dark fusion [L2, L5, L12] 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 collectve 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, whichwas gravitationally attracted by the pre-existing core region.

4.3.1 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 proecuts 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 β_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?

4.3.2 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 been 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 β_0 characterizes the Sun-planet pair. Second parameter would be an integer k characterizing the radius of planet as multiple of Λ_{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

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

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

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

   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 $k = 1 \to 2$.

3. For the inner planets, one obtains the condition

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

   An appropriate generalization holds true for outer planets with different values of β_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

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

   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 $6.9 r_{Ju}$ 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

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

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

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

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

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

$n = 1$ 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 β_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/she7el), 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 β_0.

The Nottale model suggests that β_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 β_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 β_0 if values of n for them come as multiples of 5.

6. The reduction $\beta_0 \to \beta_0/5$ 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.

4.3.3 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/wwob8l`).

3. There is also evidence for water in the Sun from Nasa (`https://rb.gy/wc9vl7`)! 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 [L26, L27], in particular stellar cores [L11, L2, L12] 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.

4.3.4 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 [E11]. 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?

4.3.5 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 [E10] 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 [K16, K14].

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 [L26].

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 ΔR 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, ΔR 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 [E10].

   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 [E10] 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/rgvhpg`). 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 [K16, K14].

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 [L19, L18]? 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.

4.3.6 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 [L23, L15] in the TGD framework relies on dark proton (or possibly nucleon) sequences. According to the TGD based view of nuclear physics [K10], 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 mopole 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 $E = h_{eff} f$ 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 5×10^{-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 2π solar Scwartschild 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.

4.3.7 Summarizing the model for the formation of planets

The foregoing considerations suggest a simple model for the evolution of the parameters β_0 and k assumed to characterize planet-star pairs during the expansion.

1. β_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 [L25] and the fact that Λ_{gr} is roughly $r_E/2 \sim r_{Mars}$ suggests an even simpler model. Outer planets have suffered the transition $\beta_0 \to \beta_0/5$. Jupiter and Saturn with a radius about $20\Lambda_{gr}$ have also suffered two scalings $k = 1 \to 2 \to 4$. The remaining planets except Mars and Mercury have suffered the scaling $k = 1 \to 2$. 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 $3 \to 4$ 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 [K5], 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 $s^k \to g^k(s^l)$ 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^μ 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 $J_{kl} \to \partial_k g^r J_{rs}(g^{-1}(s))\partial_l g^s = J_{kl}(s)$. The same formula holds true for the CP_2 contribution to the induced metric.
   - X^2 part is of the form

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

   The formula resembles the gauge transformation formula.
   Here the shorthand notations
   Here the shorthand notations

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

   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 K "ahler 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) [K11] assumes that the space-time surface is locally representable as a map $M^4 \to CP_2$ 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 ϵ 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 [L21].

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 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 [K3]. 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 [K3].

   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.

4.4 A model for the formation of Kuiper belt and Oort clouds

The former planet Pluto (`https://rb.gy/elxw5g`) 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 $\beta_0 \to 3\beta_0$ for the Pluto-Sun pair at the time when Pluto originated if β_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 [E8] (`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 condensed 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 $\hbar_{gr} \to \hbar_{eff} > \hbar$, which was followed by $\hbar_{eff} \to \hbar$ 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 $\hbar_{gr} \to \hbar_{eff} > h$ to smaller regions before the transition $h_{eff} \to h$, 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 $\hbar_{gr} \to \hbar_{eff} \to \hbar$ occurred directly so that a spherical cloud was created.

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