About the recent TGD based view concerning cosmology and astrophysics

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Abstract

This article is about various topics related to cosmology and to the physics of galaxies, stars and planets and was inspired by several inputs. The first section is about primordial cosmology and describes the TGD counterpart of inflation. The proposal is that the fluctuations of CMB background can be understood number-theoretically as being induced by the fluctuations of the effective Planck constant $h_{eff} = nh_0$ around $h_{eff} = h = n_0h_0$. This also suggests a solution of the problem posed by two different values of Hubble constants in terms of especially large local upwards fluctuation of the value of h_{eff} from $h_{eff} = h$.

The second section about several important aspects of TGD inspired cosmology. The findings of JWST force us to ask which came first: supermassive blackholes of galaxies. The recently discovered weak lensing effects lend support for the very long cosmic strings, which represent a key notion in TGD inspired cosmology. Besides dark matter there is also the problem of missing baryonic matter: for some reason 30 per cent of baryons are missing. Furthermore, the quite recent finding of JWST related to supermassive blackhole challenges the the GRT based notion of blackhole.

The third section is about the recent TGD view of the physics of stars and planets. The stimulus came from the discovery of a planet that should not exist: the planet has the mass scale of Neptune but the mass of the star is 1/9:th of the solar mass. TGD based model for the formation of galaxies, stars and planets is based on the notion of cosmic strings which produce monopole flux tubes provides and explanation for the finding and leads to considerably more detailed model for the evolution of stars making a rather dramatic prediction: the element abundances should depend only weakly on cosmic time: the first support for this prediction came already 20 years ago and JWST has provides additional support for it.

In the last section a model for planets and stars as gravitational oscillators inspired by the TGD variant of the Nottale's proposal is discussed. It turns out that the radius of the core of Earth corresponds to the Bohr radius for the first orbital, which suggests that the core of Earth, and more generally of the inner planets and Mars corresponds to an S-wave ground state. For the Sun the $n = 1$ S-wave orbital is 1.5 times the solar radius. The model applies also to the outer planets. Also the rings of giant planets can be understood at a rough quantitative level.

Contents

1 Introduction

This article is about various topics related to cosmology and to the physics of galaxies, stars and planets and was inspired by several inputs. The first section is about primordial cosmology and describes the TGD view of inflation that I have considered already 20 years ago in [L1] [K8]. The question of Marko Manninen forced me to realize that it is high time to update my views about inflation. This led to a proposal that the fluctuations of CMB background can be understood number-theoretically as being induced by the fluctuations of the effective Planck constant $h_{eff} = nh_0$ around $h_{eff} = h = n_0h_0$. This also suggests a solution of the problem posed by two different values of Hubble constants in terms of especially large local upwards fluctuation of the value of h_{eff} from $h_{eff} = h$.

The second section is about three important aspects of TGD inspired cosmology. The findings of JWST force us to ask which came first: supermassive blackholes of galaxies [E4]. The recently discovered weak lensing effects [**?**]end support for the very long cosmic strings, which represent a key notion in TGD inspired cosmology. Besides dark matter there is also the problem of missing baryonic matter: for some reason 30 per cent of baryons are missing. Furthermore, the quite recent finding of JWST related to supermassive blackhole challenges the the GRT based notion of blackhole.

The third section is about the recent TGD view of the physics of stars and planets. The stimulus came from the discovery of a planet that should not exist [E5]: the planet has the mass scale of

Neptune but the mass of the star is 1/9:th of the solar mass. TGD based model for the formation of galaxies, stars and planets is based on the notion of cosmic strings which produce monopole flux tubes provides and explanation for the finding and leads to considerably more detailed model for the evolution of stars making a rather dramatic prediction: the element abundances should depend only weakly on cosmic time: the first support for this prediction came already 20 years ago [E7] and JWST has provides additional support for it.

In the last section a model for planets and stars as gravitational oscillators inspired by the TGD variant of the Nottale's proposal is discussed. Nottale's model [E1] for planetary systems suggests Bohr orbitals for planets with gravitational Plack constant $\hbar_{gr} = GMm/\beta_0$. The value of the velocity parameter $\beta_0 = v_0/c \leq 1$ is from the model of Nottale about 2^{-11} for the inner planets and possibly 1/5 times smaller for the outer planets. This might reflect the fact that originally the planets or what preceded them consisted of gravitationally dark matter or that the Sun itself consisted of gravitationally dark matter and perhaps still does so.

The model of stars and planets as gravitational harmonic oscillators turns out to be surprisingly successful. It turns out that the radius of the core of Earth corresponds to the Bohr radius for the first orbital, which suggests that the core of Earth, and more generally of the inner planets and Mars corresponds to an S-wave ground state. For the Sun the $n = 1$ S-wave orbital is 1.5 times the solar radius. The model applies also to the outer planets. Also the rings of giant planets can be understood at a rough quantitative level.

2 About the TGD counterpart of the inflationary cosmology

The question of Marko Manninen related to the inflation theory (see this) inspired the following considerations related to the TGD counterpart of the inflationary period assumed to precede the radiation dominated phase and to produce ordinary matter in the decay of inflaton fields. I have considered the TGD analog of inflation already 12 years ago [L1] [K8] and the recent discussion brings in the progress in the understanding occurred during these years.

Recall that inflation theory was motivated by several problems of the standard model of cosmology: the almost constancy of the temperature of the cosmic microwave background; the nearly flatness of 3-space implying in standard cosmology that the mass density is very nearly critical; and the empirical absence of magnetic monopoles predicted by GUTs. The proposal solving these problems was that the universe had critical mass density before the radiation dominated cosmology, which forced exponential expansion and that our observable Universe defined by the horizon radius corresponds to a single coherent region of 3-space.

The critical mass density was required by the model and exponential expansion implying approximate flatness. The almost constant microwave temperature would be due to the exponential decay of temperature gradients and diluted monopole density. The model also explained the temperature fluctuations as Gaussian fluctuations caused by the fluctuations of the mass density. The generation of matter from the decay of the energy density of vacuum assigned with the vacuum expectation values of inflaton fields was predicted to produce the ordinary matter. There was however also a very severe problem: the prediction of a multiverse: there would be an endless number of similar expanded coherence regions with different laws of physics.

A very brief summary of the recent view of the TGD variant of the inflation theory proposed earlier [L1] is in order before going into the details.

1. The TGD view is based on a new space-time concept: space-time surfaces are at the fundamental level identified as 4-D surfaces in $H = M^4 \times CP_2$. They have rich topologies and they are of finite size. The Eisteinian space-time of general relativity as a small metric deformation of empty Minkowski space M^4 is predicted at the long length scale limit as an effective description. TGD however predicts a rich spectrum of space-time topologies which mean deviation from the standard model in short scales and these have turned out to be essential not only for the understanding of primordial cosmology but also the formation of galaxies, stars and planets.

2. In TGD, the role of inflaton fields decaying to ordinary matter is taken by what I call cosmic strings, which are 3-D extremely thin string-like objects of form $X^2 \times Y^2 \subset M^4 \times CP_2$, have a huge energy density (string tension) and decay to monopole flux tubes and liberate ordinary

matter and dark matter in the process. That cosmic strings and monopole flux tubes form a "gas" in $M^4 \times CP_2$ solves the flatness problem: M^4 is indeed flat!

TGD also involves the number theoretic vision besides geometric vision: these visions are related by what I call $M^8 - H$ duality, see for instance [L14, L15] for the odyssey leading to its recent dramatically simplified form [L34]. The basic prediction is a hierarchy of Planck constants $h_{eff} = nh_0$ labelling phases of ordinary matter behaving like dark matter: these phases explain missing baryonic matter whereas galactic dark matter corresponds to dark energy as the energy of monopole flux tubes.

Quantum coherence becomes possible in arbitrarily long scales and in cosmic scales gravitational quantum coherence replaces the assumption that the observed universe corresponds to an exponentially expanding coherence region and saves it from the multiverse. This solves the problem due to the constancy of the CMB background temperature.

3. In the TGD framework, cosmic strings thickened to monopole flux tubes are present in the later cosmology and would define the TGD counterpart of critical mass density in the inflationary cosmology but not at the level of space-time but in $M^4 \subset M^4 \times CP_2$. The monopole flux tubes are always closed: this solves the problem posed by the magnetic monopoles in GUTs. Monopole flux tubes also explain the stability of long range magnetic fields, which are a mystery in standard cosmology even at the level of planets such as Earth.

4. The fluctuations of CMB temperature would be due to the density fluctuations. In inflation theory they would correspond to the fluctuations of the inflaton field vacuum expectation values. In TGD, the density fluctuations would be associated with quantum criticality explaining the critical mass density ρ_{cr}. The fluctuations $\delta\rho_{cr}$ of the critical mass density for the monopole flux tubes would be due to the spectrum for the values of effective Planck constant h_{eff}: one would have $\delta T/T \propto \delta h_{eff}/h_{eff}$. This would give a direct connection between cosmology and quantum biology where the phases with large h_{eff} are in a fundamental role.

2.1 Some basic notions of TGD

2.1.1 Cosmic strings and monopole flux tubes

In the TGD Universe space-times are 4-D surfaces in $H = M^4 \times CP_2$.

1. Cosmic strings [K3, K8] are 3-D string like objects which have 2-D M^4 projection and do not have any counterpart in GRT. They are of the form $X^2 \times Y^2 \subset M^4 \times CP_2$, where X^2 is a string world sheet and Y^2 is a complex sub-manifold of CP_2, say geodesic sphere. They can be arbitrarily long and have length measured even in billions of light years. They are not possible in string models or in GUTs.

2. Cosmic string world sheets are unstable against the thickening of their 2-D M^4 projection making it 4-dimensional. This thickening creates what I call Einsteinian space-time. The thickening reduces the string tension and liberates energy as ordinary matter and the TGD counterpart of galactic dark matter. This decay process is the TGD counterpart of inflaton field decay.

   This process repeats itself as a similar process for monopole flux tubes but the liberated energy liberated decreases. The recent accelerating period of expansion could correspond to this kind of phases transition. The thickening *need not* involve exponential expansion of these space-time surfaces. This decay wold lead from the cosmic string dominated phase to a radiation dominated phase and generate Einsteinian space-time and cosmology.

3. The energy of the cosmic strings generates transversal $1/\rho$ gravitational field and cosmic strings orthogonal to galactic planes explain galactic dark matter yielding the flat velocity spectrum of stars in the galactic plane. No dark matter halo is needed as in ΛCDM model. Galactic dark matter as dark energy would not form a halo but a string-like structure. The prediction is that galaxies are formed as tangles of thickened cosmic strings along these very long cosmic strings. Zeldowich discovered these linear structures formed by galaxies decades ago [E8] but they have been "forgotten".

2.1.2 $M^8 - H$ duality

Before proceeding, one must say something about $M^8 - H$ duality.

1. In the earlier versions of $M^8 - H$ duality [L6, L7, L8, L14, L15, L28], the integer n appearing in $h_{eff} = nh_0$ corresponds to a dimension of an algebraic extension of rationals assignable to a single octonion polynomial $P(o)$ with integer coefficients defined in the space of complexified octonions O_c. The polynomials would have as roots possibly complex mass shells in $M_c^4 \subset M_c^8$ and these would partially define the 3-D data of number theoretic holography in M^8.

2. It turns out that a correct spectrum of fluxtuations is predicted if one has $n = n_1 n_2$ where n_i are identical or nearly identical. One can consider several variants for the composition of n to a product of integers. For instance, for the polynomimals defined as functional composites of polynomials P_i have dimension of extension which is product $\prod_i n_i$ of the dimensions n_i for the polynomials P_i. The decomposition of n to product could physically correspond to various interactions.

   The factors in the product could also correspond to M^4 and CP_2 degrees of freedom and this option suggested by the recent view of $M^8 - H$ duality [L34]. As a matter of fact, I proposed this kind of decomposition in the beginning of $M^8 - H$ adventure but gave it up.

3. The most recent formulation of $M^8 - H$ duality [L34] is dramatically simpler than the earlier ones. Complexified octonsions $O_c = M_c^8$ is replaced with octonions O allowing naturally a Minkowskian number theoretic norm $Re(o^2)$ making O effectively M^8. The holography = holomorphy principle at the level of H together with $M^8 - H$ duality fixes the number theoretic holography at the level of M^8 (normal space of 4-surface is associative and contains 2-D commutative subspace there is no need to define number theoretic holography using polynomials $P(o)$ in M_c^8. It seems that all nice features of the earlier proposal apply also to this proposal.

   The vanishing of 2 holomorphic functions of 4 generalized complex coordinates of H defines 4-D space-time surfaces in H [L25, L31]. These holomorphic functions form naturally a hierarchy of pairs of polynomials P_i, $i = 1, 2$, and one can assign toP_i an extension of rationals with dimension n_i, $i = 1, 2$. Could one identify $h = h_{eff}/h_0 = n$ as the product $n = n_1 n_2$? Note that n_1 and n_2 can also factorize to primes.

   Number theoretic vision forces the increase of algebraic complexity meaning the increase of h_{eff} during cosmic evolution. $h_{eff} = h_0$ would be the simplest option in the primordial phase, where things are as simple as possible.

2.1.3 Hierarchies of p-adic length scales and effective Planck constants

The number theoretic vision of TGD implies hierarchies of p-adic length scales labelled by powers of p-adic primes p. Each p-adic hierarchy is accompanied by a hierarchy of dark scales and a hierarchy of phases behaving like dark matter. p-Adic length scale hypothesis, motivated by p-adic mass calculations [K4, K2], states that primes near some powers of 2 are physically preferred p-adic primes strengthens this hypothesis.

1. For a given prime p there exists entire hierarchy of p-adic length scales $L_{p,n} = p^{(n-1)/2)} L_p$, where one has $L_p = sqrtpR$, where R equals to the radius of CP_2 apart from a numerical constant.

2. The hierarchy of Planck constants $h_eff = nh_0$, where h_0 is the minimal value of effective Planck constant defines a hierarchy of phases of ordinary matter behaving like dark matter. This hierarchy solves the missing baryon problem whereas the energy of cosmic strings explains the galactic dark matter. The dark scales are given by $L_{p,n}^{dark} = \hbar_{eff} L_{p,n}$.

3. These two hierarchies are not independent since a given extension of rationals determining $h_{eff}/h_0 = n$ as its dimension defines also a set of p-adic primes p as a ramified prime for a polynomial defining the extension. The largest p-adic prime p_{max} is in a special physical role. The phase transitions changing the extension of rationals and the value of h_{eff} are

possible and change the length scale of the monopole flux tube. Reconnections of the flux tubes define their topological dynamics and are in a central role in TGD inspired quantum chemistry and explain the basic mysteries of biocatalysis. Simple calculations show that p_{max} can be exponentially larger than n_0 [L30].

4. The ramified primes are bounded if one assumes that the coefficients of polynomials P are smaller than their degrees and imply that the number of polynomials with a smaller degree is finite for a given degree: this forces a number theoretic evolution in a very strong sense.

2.1.4 Zero energy ontology

In the TGD framework, zero energy ontology (ZEO) [L13] [K11] is the central element of quantum measurement theory and provides additional insights to the situation.

1. ZEO ontology involves as a basic concept the notion of causal diamond (CD) [L29, L34] as an interaction of future and past directed light-cones. CD is characterized by its size identifiable as the distance between its tips. The sizes of CDs form scaling hierarchies labelled by $h_{eff}/h_0 = n$ and p-adic length scales L_p. At least L_p, $L_{p,2} = \sqrt{p}L_p$, and the dark scales nL_p and $nL_{p,2}$ are fundamenal scales. The p-adic primes p correspond to the ramified primes assignable to the polynomials defining the extension and p_{max} is in a preferred position.

2. The interpretation of CD is as the perceptive field of a conscious entity: CD could correspond to the part of the Universe perceivable to corresponding conscious entityt and CD size would serve as the analog for horizon radius. The size of CD would naturally define the scale of quantum coherence and would increase during the cosmic evolution as n increases. It could be however arbitrarily long already in primordial phase if rational polynomials are allowed.

2.2 The TGD view of primordial cosmology

I have already earlier consider primordial cosmology in the TGD framework [L1] [K8].

2.2.1 Primordial cosmology and the almost constant temperature of the CMB

Primordial cosmology preceding the radiation dominated phase corresponds in the TGD framework to a "gas" like phase formed by a network of cosmic strings, which could be arbitrarily long and are always closed. Reconnection is the basic topological reaction for them. This phase has no counterpart in Einstein's theory.

A natural assumption is that there is a quantum coherence along the string. This means a hierarchies of quantum coherence scales assignable to cosmic strings and monopole flux tubes, which in the number theoretic vision of TGD would correspond to p-adic length scales and to a hierarchy of dark scales assignable to the h_{eff} a hierarchy of phases behaving like dark matter.

1. The p-adic length scales L_p could characterize the thickness of the monopole flux tubes and, as it turns out, $L_{p,2}$ could characterize the lengths of strings and flux tubes.

2. The dark length scales $nL_{p,n}$, $n = h_{eff}/h_0$ would be associated with the dark variants of the strings and monopole flux tubes. p would correspond to a ramified prime for a polynomial P defining an extension of rationals with dimension n and there is a large number of polynomials of this kind. The maximal p-adic prime for given P and n is in a physical special role and defines the maximal thickness and length of the flux tube in this case.

What about the p-adic length scales associated with the primordial phase? Assume the holography=holomorphy vision [L31, L36] so that a pair of polynomials defines the space-time surface and these polynomials define extension rationals assignable to M^4 and CP_2 degrees of freedom.

One can consider two options.

1. The simplest option is that cosmic strings correspond to $p = 1$ for which the flux tube is infinitely thin and the extension of rationals is trivial ($n = 0$). This would mean that flux tubes would have the same minimal length defined by CP_2 radius R. Primordial quantum coherence would be possible only in CP_2 scale.

2. There is also a more complex option.

   (a) The transversal scale of the cosmic string corresponds to CP_2 length scale R and is minimal. The CP_2 projection Y^2 as a complex surface can however have several sizes. One could however argue that they do not correspond to p-adic length scales and $p = 1$ corresponding to linear polynomials of CP_2 coordinates allowing only a homologically non-trivial geodesic sphere is possible.

   (b) What about M^4 degrees of freedom? Could one allow the reduction of the polynomials of 4 four complex (or hypercomplex) variables to non-irreducible polynomials when 3 complex variables are fixed to rational values (say put equal to zero). These would also allow rational roots. If all roots are rational, $n = 0$ is true. Does it make sense to identify the ramified primes as prime factors of the determinant identified as the square of the product of root differences ($b^2 - 4ac$ for a second order polynomial). If so, one could have p-adic primes $p \geq 2$ also in the primordial phase. Strings could have arbitrary long lengths also in this phase but no dark phases would be present.

   For this option a primordial quantum coherence would be possible in arbitrarily long p-adic length scales. Only the dark phases would emerge during evolution. This option conforms with the recent view of TGD.

In ZEO causal diamond (CD=cd$\times CP_2$) defines the perceptive field of conscious entity. cd is analogous to a empty cosmology as a big bang followed by big crunch.

1. What determines the size of the CD in the recent cosmology? The ratio of CP_2 radius to Planck length is in the range $10^3 - 10^4$ from p-adic mass calculations. Could the recent mean value $h_{eff} = h = n_0 h_0$ correspond to CP_2 length scale R perhaps identifiable as the length scale of M^4 projection of monopole flux tube? The value of n_0 is in the range $10^7 - 10^8$.

2. The scale defined as the geometric mean of Planck length and the length scale L defined by cosmological constant Λ defines the size scale of a large neuron around $L_m \sim 10^{-4}$ m. One can think that $_m$ is for "meso": L_m is the fundamental biological scale determined as a geometric mean of two scales: Planck length for microcosmos and Hubble radius for macroscosmos. The basic scale of biological systems would correspond to the geometric mean of horizons scale and Planck scale. The geometric mean property implies that L_m and L can be expressed as $L_n = xL_0$ and $L = x^2 L_0$ which strongly suggests that these scales are primary and secondary length scales for some prime p.

3. In the twistor lift of TGD [K9, K7] [L19, L20], the cosmological constant Λ appears as the coefficient of the 4-volume term in the dimensionally reduced Kähler action determining as its preferred extemals 6-D twistor space as 6-surface in the product of 6-D twistor spaces of M^4 and CP_2 having two-sphere S^2 as a fiber and the space-time surface $X^4 \subset H$ as the base space. The only spaces having a twistor space with Kähler structure are M^4 and CP_2 [A1] so that TGD is unique.

4. Twistor lift suggests that $L_m = xL_P$, $x \equiv L_m/L_P = \sqrt{L/l_P} \sim 10^{31}/1.65$, defines the maximal thickness of a typical monopole flux tube in the recent cosmos. The scale $x^2 L_P$ in turn could define the scaling factor giving the maximal length L of the cosmic string determining the size scale of the CD. The natural identification would be as Hubble length $\hbar/H_0$, which is determined by the cosmological constant Λ. There are two scales: do they correspond to scales assignable to ordinary matter and dark matter at the highest possible level of the magnetic body of the system?

Could one understand the value of x number theoretically? Certainly it cannot correspond to the ratio $n_0 = h/h_0 \in [10^7 - 10^8]$. Much larger values are required.

1. Number theoretical approach predicts besides dark scales also p-adic length scales. The primary p-adic length scale L_p and secondary p-adic length $L_{2,p} = \sqrt{p} L_p$ and possibly also higher p-adic length scales forming a hierarchy in powers of $\sqrt{p}$. Could x and x^2 correspond to the dark primary length scale $nL_p \propto n\sqrt{p}R$ and to the dark secondary p-adic length

scale $nL_{p,2} = npR$? p would be a ramified prime determined by the extensions of rationals determined by the value of h_{eff}.

There are two options. In the recent universe either a) L_p or b) nL_p could correspond to a p-adic length scale assignable to neuron. For option a) nL_p would correspond to a scale in the range $10^3 - 10^4$ m. For option b) L_p would correspond to a length scale in the range $10^{-12} - 10^{-11}$ m (electron Compton length is 2.4×10^{-12} m).

Secondary p-adic length scale $L_{2,p}$ would correspond to the horizon radius $\hbar/H_0$ and $nL_{2,p}$ to the radius of dark horizon assignable to the field body of cosmos perceivable to us.

2. During the primordial phase, the size of CD could correspond to Planck length or to CP_2 radius R. One could have $l_P = R$ for $h_{eff} = h_0$. In the recent situation one would $h = n_0 h_0$ and $R_{eff}^2 = n_0 R^2 = n_0 \sqrt{G}$, perhaps identifiable as the scale of the M^4 projection of cosmic string (see below). n_0 would correspond to the dimension of extension of rationals and the p-adic prime p to a ramified prime of extension. There would be at least two CD sizes defined by $L_m = xL_P$ and $L = x^2 L_P$, where one has $x = \sqrt{p/2}$ and p is a ramified prime of the extension of rationals considered.

2.2.2 Do quantum fluctuations replace the thermal fluctuations of inflation theory?

If long length scale quantum coherence is possible in the length scale of cosmic strings, one ends up with the following questions.

1. Does gravitational quantum coherence due to long cosmic strings explain the almost constant value of the CMB temperature? One has $\rho \propto T^4$, which gives $\delta T/T \propto 4\delta\rho/\rho$.

   One can imagine two options.

   (a) If arbitrarily long cosmic strings are possible in the primordial phase (rational polynomials are allowed), quantum coherence could be present in all scales already in the primordial phase with $h_{eff} = h_0$. This option conforms with the original proposal.

   (b) If the lengths of cosmic strings are bounded in the primordial phase so that they are proportional too h_{eff}, long cosmic strings must be created later by reconnection in phase transitions increasing the value of h_{eff} allowing larger p-adic primes defining p-adic lengths scales. These phase transitions would also increase the length of cosmic strings.

2. In the inflation model, the fluctuations of CMB temperature are due to the density fluctuations $\delta\rho/\rho$. Could these density fluctuations be reduced to the fluctuations of the density in the phase formed by the cosmic strings in the primordial phase and later in the phase formed by the monopole flux tubes (magnetic bodies) characterized by the value of h_{eff}?

3. Inflationary cosmology is critical in the sense that mass density $\rho_{cr} = 3H_0^2/8\pi G$, where H_0 is the Hubble constant, is critical. In the TGD framework, this formula holds true at the level of future light-cone $M_+^4 \subset M^4 \subset H = M^4 \times CP_2$ representing empty standard cosmology rather than at space-time level as in inflation theory. Therefore exponential expansion is not needed for this formula. The quantum criticality would naturally apply to the phase formed by ordinary particles at monopole flux tubes characterized by the values h_{eff}.

4. Quantum criticality means a spectrum of the values of $h_{eff} = nh_0$. How do the fluctuations of h_{eff} imply the density fluctuations?

   The dimension of G is $[L^2]/[h]$. In TGD the only dimensional parameter is CP_2 length scale R and this suggests the formula $G = R^2/\hbar$, which generalizes to the formula $G = R^2/\hbar_{eff}$. One must have $\hbar \sim (10^7 - 10^8)\hbar_0$ to explain CP_2 radius fixed by electron mass from p-adic mass calculations.

   Again one can consider several options.

(a) R is a fundamental constant and the value of $G_{eff} = R^2/h_{eff}$ varies and is different in the dark phases and decreases with h_{eff}. This looks strange but since we cannot yet observe dark matter, one cannot exclude this option. For this option one would have for the dark matter $\rho_{cr} = 3H_0^2/4\pi G_{eff} = 3\hbar_{eff}H_0^2/4\pi R^2$. A natural assumption is that H_0 corresponds to p-adic length scale that is $H_0 \propto 1/L_{p,2}$.

(b) $G = R^2/\hbar_0$ is a fundamental constant and the effective radius squared $R_{eff}^2 = \hbar_{eff}R^2/\hbar_0$ of CP_2 varies. It could geometrically correspond to the size of the M^4 projection of the cosmic string, or more precisely the thickening of $Y^2 \subset CP_2$. CP_2 scale would correspond to the Planck scale. For this option one would have $\rho = 3\hbar_0 H_0^2/8\pi R_{eff}^2 = 3\hbar_{eff}/8\pi L_{p,2}^2$.

(c) For both options the density of dark matter would increase with $\hbar_{eff}$. One can however consider also the possibility that H_0 corresponds to the inverse of the dark p-adic length scale $H_0 \propto 1/L_p(dark)$, $L_p(dark) = nL_p$. This would give $rho_{crit} \propto 1/nL_{p,2}^2$.

Consider now what quantum criticality predicts.

1. Criticality means that one has $\rho = \rho_{cr} = 3H_0^2/8\pi G$ so that the fluctuations would correspond to fluctuations of Hubble constant and $\hbar_{eff}$: $\delta\rho/\rho = \delta\hbar_{eff}/\hbar + 2\Delta H_0/H_0$. This means fluctuations and long range correlations since quantum coherence scales are typically proportional to h_{eff} and even h_{eff}^2 as in atomic physics.

2. Depending on option, one can write the fluctuations of H_0 in terms of fluctuations of p-adic length scale $L_{p,2}$ or of dark p-adic length scale $L_{p,2}(dark) = nL_{p,2}$.

   (a) For the $L_H = L_p$ option, one has $\Delta H_0/H_0 = \delta L_{p2}/L_{p,2}$ which is extremely small in cosmic scales. This gives $\delta\rho/\rho \sim \delta\hbar_{eff}/\hbar = \delta n/n$.

   (b) For the $L_H = L_p(dark) = nL_p$ option one has $\Delta H_0/H_0 = -2\delta n/n + \delta L_{p2}/L_{p,2} \simeq -2/\delta n/n$. This gives $\delta\rho/\rho \sim \delta - \hbar_{eff}/\hbar = -\delta n/n$.

   One therefore obtains $\delta H_0/H_0 \sim \epsilon\delta n/n$, where $\epsilon = \pm 1$ depending on option. The thermal fluctuations are induced by the fluctuations of $\hbar_{eff}/h_0 = n$ and depend extremely weakly on the polynomial defining the extension of rationals with dimension n.

   For the first option the scale $L_m \sim 10^{-4}$ m would correspond too L_p and for the second option to the scale $L_p(dark) = n_0 L_p$. In the latter case one would have $L_p \in [10^{-12}, 10^{-11}]$, the p-adic length scale $L_{M_{127}} \simeq \sqrt{5}L_c = 5.4 \times 10^{-12}$ m is highly suggestive. This would correspond to $n_0 \simeq 1.85 \times 10^7$.

   What can one say about the p-adic prime p assignable to an extension as a ramified prime?

   (a) Suppose that $p = p_{max}(P_{|n})$, that is the largest ramified prime assignable to a polynomial P defining the extension of rationals with dimension n. Several extensions can have dimension n exist and several polynomials P could in principle define an extension with a given value of n and the same value of $p_{max} = p$.

   (b) For an extension with a given value of n, one can allow fluctuations defined by polynomials with different values of p_{max}. This gives a rough estimate $\delta H_0/H_0 = -(\delta n/n - dL_{p_{max}}/L_{p_{max}})$. The term $dL_{p_{max}}/L_{p_{max}} = \delta p_{max}/p_{max}$ is very small for large p-adic primes, and one would have $\delta H_0/H_0 \sim -\delta n/n$ giving $\delta H_0/H_0 \sim 1/n$ for $|\delta n| = 1$.

   $$\frac{\delta T}{T} = \frac{1}{2}\frac{\delta\rho_{cr}}{\rho_{cr}} = 2\frac{\delta H_0}{H_0} = -2\frac{\delta n}{n} \quad .$$

   (c) The temperature fluctuations of CMB would reveal the fluctuations of $n = \hbar_{eff}/h_0$ in turn inducing fluctuations of padic length scale $L_{p_{max},2}$ defining H_0.

   The fluctuations of CMB would be a number theoretic phenomenon. Does this proposal conform with the observations?

   (a) Density fluctuations are in the range $\delta T/T \in [10^{-4}, 10^{-5}]$. The nominal value of $\delta T/T$ is $10^{-4}/3$ (see this). This corresponds to $\delta\rho_{cr}/\rho_{cr} = 4\delta T/T = 1.3 \times 10^{-4}$.

(b) If the fluctuation corresponds to a single extension of rationals, or more generally, n is not a product of two or more statistically independent factors, one has $|\delta n| \geq 1$ and the $|\delta T|/T \sim (1/2)|\delta n|/n$. If one uses the estimate $n = R^2/G \in [10^7 - 10^8]$, one obtains $|\delta T|/T = (1/2)\sum_k p(|\delta|n = k)k/n$, which in the first approximation gives $|\delta T/T| = p(1)x/2$, $x \in [10^{-7}, 10^{-8}]$. The estimate is too small.

(c) If one assumes that the decomposition $h_{eff}/h_0 = n_1 n_2$, where n_i are assumed to be statistically independent, one obtains $|\delta h_{eff}|/h_{eff} = |\delta n_1|/n_1 + |\delta n_2|/n_2$. If only $|\delta n_1| = 1$ and $|\delta n_2| = 1$ contribute significantly, and one has $|\delta|T/T = p(1)/n_1 + p(2)/n_2]/2$. Assuming $n_1 = n_2 \sim \sqrt{n} \in [10^{3.5}, 10^4]$, and $p_1 = p_2 = P$ one has very naive estimate $2P/\sqrt{n}$, $n \in [10^{-3.5}, 10^{-4}]$. The order of magnitude is correct.

(d) The justification for the decomposition comes from the holography=holomorphy hypothesis, which implies that the two polynomials defining the space-time surface as a complex surface in generalized sense gives rise to two extensions of rationals with dimensions n_1 and n_2. These extensions can be assigned to M^4 degrees of freedom (string world sheets X^2) and to CP_2 degrees of freedom (partonic 2-surfaces Y^2). One can also consider the possibility that internal consistency requires the extensions to have the same dimension $n_1 = n_2$.

For the cold spot of CMB (see this), the temperature fluctuation of CMB is 70 μK and 4 times higher than on the average. Could one understand this number theoretically? For instance, could this could be due to $n_1 \to 8n_1$ and $n_2 = n_1 \to n_1/8$ in $n \to n_1 n_2 \sim n_1^2$ giving for $\delta n_1 = deltan_2 = 1$ the outcome $\delta n/n = 1/(8n_1) + 8/n_1 \simeq 8/n_1$ so that the fluctuation is 4 times larger.

2.2.3 About the problem of two Hubble constants

The usual formulation of the problem of two Hubble constants is that the value of the Hubble constant seems to be increasing with time. There is no convincing explanation for this. But is this the correct way to formulate the problem? In the TGD framework one can start from the following ideas discussed already earlier [K5].

(a) Would it be better to say that the measurements in short scales give slightly larger results for H_0 than those in long scales? Scale does not appear as a fundamental notion neither in general relativity nor in the standard model. The notion of fractal relies on the notion but has not found the way to fundamental physics. Suppose that the notion of scale is accepted: could one say that Hubble constant does not change with time but is length scale dependent. The number theoretic vision of TGD brings brings in two length scale hierarchies: p-adic length scales L_p and dark length scale hierarchies $L_p(dark) = nL_p$, where one has $h_{eff} = nh_0$ of effective Planck constants with n defining the dimension of an extension of rationals. These hierarchies are closely related since p corresponds to a ramified prime (most naturally the largest one) for a polynomial defining an extension with dimension n.

(b) I have already earlier considered the possibility that the measurements in our local neighborhood (short scales) give rise to a slightly larger Hubble constant? Is our galactic environment somehow special?

Consider first the length scale hierarchies.

(a) The geometric view of TGD replaces Einsteinian space-times with 4-surfaces in $H = M^4 \times CP_2$. Space-time decomposes to space-time sheets and closed monopole flux tubes connecting distant regions and radiation arrives along these. The radiation would arrive from distant regions along long closed monopole flux tubes, whose length scale is L_H. They have thickness d and length L_H. d is the geometric mean $d = sqrt(l_P L_H)$ of Planck length L_P and length L_H. d is of about 10^{-4} meters and size scale of a large neuron. It is somewhat surprising that biology and cosmology seem to meet each other.

(b) The number theoretic view of TGD is dual to the geometric view and predicts a hierarchy of primary p-adic length scales $L_p \propto \sqrt{p}$ and secondary p-adic length scales $L_{2,p} = \sqrt{p}L_p$. p-Adic length scale hypothesis states that p-adic length scales L_p correspond to primes near the power of 2: $p \simeq 2^k$. p-adic primes p correspond to so-called ramified primes for a polynomial defining some extension of rationals via its roots.

One can also identify dark p-adic length scales

$$L_p(dark) = nL_p \ ,$$

where $n = h_{eff}/h_0$ corresponds to a dimension of extension of rationals serving as a measure for evolutionary level. h_{eff} labels the phases of ordinary matter behaving like dark matter explain the missing baryonic matter (galactic dark matter corresponds to the dark energy assignable to monopole flux tubes).

(c) p-Adic length scales would characterize the size scales of the space-time sheets. The Hubble constant H_0 has dimensions of the inverse of length so that the inverse of the Hubble constant $L_H \propto 1/H_0$ characterizes the size of the horizon as a cosmic scale. One can define entire hierarchy of analogs of L_H assignable to space-time sheets of various sizes but this does not solve the problem since one has $H_0 \propto 1/L_p$ and varies very fast with the p-adic scale coming as a power of 2 if p-adic length scale hypothesis is assumed. Something else is involved.

One can also try to understand also the possible local variation of H_0 by starting from the TGD analog of inflation theory. In inflation theory temperature fluctuations of CMB are essential.

(a) The average value of h_{eff} is $\langle h_{eff}\rangle = h$ but there are fluctuations of h_{eff} and quantum biology relies on very large but very rare fluctuations of h_{eff}. Fluctuations are local and one has $\langle L_p(dark)\rangle = \langle h_{eff}/h_0\rangle L_p$. This average value can vary. In particular, this is the case for the p-adic length scale $L_{p,2}$ ($L_{p,2}(dark) = nL_{2,p}$), which defines the Hubble length L_H and H_0 for the first (second) option.

(b) Critical mass density is given by $3H_0^2/8\pi G$. The critical mass density is slightly larger in the local environment or in short scales. As already found, for the first option the fluctuations of the critical mass density are proportional to $\delta n/n$ and for the second option to $-\delta n/n$. For the first (second) option the experimentally determined Hubble constant increases when n increases (decreases). The typical fluctuation would be $\delta h_{eff}/h \sim 10^{-5}$. What is remarkable is that it is correctly predicted if the integer n decomposes to a product $n_1 = n_2$ of nearly identical integers.

For the first option, the fluctuation $\delta h_{eff}/h_{eff} = \delta n/n$ in our local environment would be positive and considerably larger than on the average, of order 10^{-2} rather than 10^{-5}. h_{eff} measures the number theoretic evolutionary level of the system, which suggests that the larger value of $\langle h_{eff}\rangle$ could reflect the higher evolutionary level of our local environment. For the second option the variation would correspond to $\delta n/n \leq 0$ implying lower level of evolution and does not look flattering from the human perspective. Does this allow us to say that this option is implausible?

The fluctuation of h_{eff} around h would mean that the quantum mechanical energy scales of various systems determined by $\langle h_{eff}\rangle = h$ vary slightly in cosmological scales. Could the reduction of the energy scales due to smaller value of h_{eff} for systems at very long distance be distinguished from the reduction caused by the redshift. Since the transition energies depend on powers of Planck constant in a state dependent manner, the redshifts for the same cosmic distance would be apparently different. Could this be tested? Could the variation of h_{eff} be visible in the transition energies associated with the cold spot.

(c) The large fluctuation in the local neighbourhood also implies a large fluctuation of the temperature of the cosmic microwave background: one should have $\Delta T/T \simeq \delta n/n \simeq \delta H_0/H_0$. Could one test this proposal?

3 Some important findings related to cosmology and astrophysics

3.1 Which came first: primordial supermassive blackhole or galaxies? Or was it something else?

The revolution initiated by the James Webb Telescope continues (see the popular article telling about the interpretation of the most reent findings proposed in the article "Which Came First: Supermassive Black Holes or Galaxies? Insights from JWST" [E4] by Joseph Silk et al published in The Astrophysical Journal Letters.

The objects identified as gigantic primordial blackholes are introduced to explain the extremely fast formation of stars for a few million years after the Big Bang. After this period the formation of stars should have slowed down and the recent galaxies and galactic blackholes would evolve very slowly.

The very existence of this kind of blackholes is in conflict with the standard general relativistic wisdom, which assumes that blackholes are formed as the final state of the development. The primordial blackholes should be formed directly from the concentrations of the primordial plasma without a formation of stars. Their presence would catalyze the rapid formation of stars and lead to formation of galaxies.

These visions can be seen as part of the desperate battle of the general relativity based cosmology in order to survive the empirical facts. In the TGD framework, space-time is replaced with a 4-surface in $H = M^4 \subset M^4 \times CP_2$: this predicts standard model symmetries and unifies gravitation and standard model. The choice of H is unique both mathematically and physically. GRT and standard model view follows at the QFT limit of TGD in long length scales.

The TGD based space-time concept leads to a new view of cosmology involving cosmic strings (not those of GUTS) as string-like objects carrying monopole magnetic fluxes [L10, L11, L17, L26, L27]. Cosmic strings are extremely thin 4-surfaces with a huge string tension carrying energy having interpretation as analog of dark energy. They provide an explanation for the galactic dark matter involving only string tension as a parameter and solving the problems of ΛCDM and MOND. TGD predicts also a hierarchy of effective Plancck constants giving rise to phases of ordinary matter behaving in many respects like dark matter: these phases explain the missing baryonic matter.

(a) Cosmic strings dominated before the radiation dominated phase and their decay to ordinary matter was the TGD counterpart of inflation. Cosmic strings were unstable against the thickening of their 1-D M^4 projection to a 3-D flux tube. The string tension of the thickened portion of the flux tubes formed a tangle and the associated dark energy transformed to ordinary matter forming a galaxy around it. Also collisions of cosmic strings generated this kind of tangles.

(b) This decay process as an analogy of inflation generated ordinary matter, galaxies and stars and generated the counterparts of the postulated primordial blackholes. During this period the formation of stars was extremely rapid and later slowed down as the findings of the JWT demonstrate.

3.2 Direct evidence for the TGD view of quasars

In a new paper in The Astrophysical Journal [E6] (see this), JILA Fellow Jason Dexter, graduate student Kirk Long, and other collaborators compared two main theoretical models for emission data for a specific quasar, 3C 273.

If the quasar were a blackhole, one would expect two emission peaks. If the galactic disk is at constant temperature, one would expected redshifted emission peak from it. The second peak would come from the matter falling to the blackhole and it would be blueshifted relative to the first peak. Only single peak was observed. Somehow the falling of the matter is prevented to the quasar is prevented. Could the quasar look like a blackhole-like object in its exterior but emit radiation and matter preventing the falling of the matter to it.

This supports the TGD view of quasars as blackhole-like objects are associated with cosmic strings thickened locally to flux tube tangles [L10, L17, L11, L26, L27]. The transformation of pieces of cosmic strings to monopole flux tube tangles would liberate the energy characterized by the string tension as ordinary matter and radiation. This process would be the TGD analog of the decay of inflaton field to matter. The gravitational attraction would lead to the formation of the accretion disk but the matter would not fall down to the quasar.

3.3 Evidence for cosmic strings from weak lensing

The cosmic plot is finally starting to unravel! For almost twenty years I have been trying to communicate a TGD-based theory for the galactic dark matter but in vain. Now empiria has come to rescue.

There is now evidence for dark matter filaments from the detection of weak-lensing caused by them (see the popular article and the article "Weak-lensing detection of intracluster filaments in the Coma cluster" by HyeongHan et al in Nature Astronomy [E3]. This kind of dark filaments are a basic prediction of TGD and their classical energy corresponds to dark energy [L10, L11, L17, L26, L27].

Before radiation-dominated cosmology, the matter in the TGD Universe consists of extremely massive objects, cosmic strings. In TGD the spacetimes correspond to 4-surfaces $M^4 \subset M^4 \times CP_2$ and cosmic strings are string-like 3-surfaces. The monopole flux associated with these string-like objects stabilizes them against splitting. They are typically more or less perpendicular to the galaxies they have generated in a local decay process. Cosmic string create a gravitational field in the plane of the galaxy behaving like 1 over transversal distance.

The string tension alone explains the constant velocity spectrum of the distant stars and the model avoids the problems of the ΛCDM and MOND. However, cosmic strings are unstable against decaying into ordinary matter by thickening, which reduces the string tension, and in this process galaxies are formed. In particular, the collisions of the cosmic strings trigger decay to ordinary matter as the TGD counterpart of inflation.

The extremely fast star formation in the very early universe, recently observed by JWT, is a mystery for which an explanation is proposed in terms of giant black holes which, contrary to standard wisdom, were born before the galaxies and formed directly from plasma rather than as the end result of evolution (see this). The above picture explains the star formation in terms of the production of matter in the decay of cosmic string to monopole flux tubes. The above picture picture explains the rapid star formation in terms of the production of matter in the decay of cosmic string to monopole flux tubes.

3.4 The connection of missing baryon number problem with the TGD view of evolution

The following argument relates the missing baryon problem to the TGD view of the evolution and also clarifies how the galactic dark matter differs from the dark matter as $h_{eff} \geq h$ phases (see this).

What is the problem of missing baryonic matter?

(a) 1/7 of the matter of the Universe is dark matter in the sense of galactic dark matter. The identification of the dark matter is still a mystery. The proponenets of ΛCDM have decided dark matter to be some exotic particles forming halos around galaxies. MOND people have decided that Newtonian gravity is modified for weak fields.

(b) Besides this 30 per cent of the ordinary matter, baryons, seems to be missing. This is known as the missing baryon problem (see this).

The prosaic explanation for the puzzle is that with the available technology we are not able to detect the missing part of ordinary matter and it has been argued that the missing baryonic matter can be assigned with long filamentary structures. This explanation might be correct.

What could one say about the missing baryonic matter in this framework? I have considered this question in more detail earlier [L5] [K1], and the following general comment explains why ordinary baryons should transform to dark ones during the cosmic evolution.

(a) In the TGD Universe, the radiation dominated phase was preceded by cosmic string dominance [L1, L35] [K8]. Cosmic strings would have decayed to ordinary matter like inflaton fields and this would have led to the radiation dominated Universe.

(b) The galactic dark matter could be actually dark energy assignable with long cosmic strings with a gigantic string tension. Monopole flux would make them stable. This dark energy would decay to ordinary matter since the cosmic strings are unstable against thickening and the generation of flux tube tangles giving rise to ordinary galaxies and also stars and planets [L10, L17, L11, L26, L27].

   This process would be the TGD counterpart of inflation (see this): inflaton fields would be replaced by cosmic strings. This view predicts the flat velocity spectra of galaxies using only string tension as a parameter and makes a long list of predictions allowing us to understand the anomalies of ΛCDM (see) and MOND (see).

(c) TGD predicts also matter behaving like dark matter. This analog of dark matter is identifiable as $h_{eff} \geq h$ phases of the ordinary matter. I have used to talk about dark matter but this matter need not be galactic dark matter, which could be mostly dark energy for cosmic strings. The $h_{eff} \geq h$ phases phases can have arbitrarily long quantum coherence scales and in TGD view of quantum biology they play a fundamental role in living matter as controllers of the ordinary matter. In TGD inspired biology dark protons identified as this kind of phase at monopole flux tubes play an essential role.

What could one say about the missing baryonic matter in this framework?

(a) Could the missing baryonic matter correspond to $h_{eff} \geq h$ phases of the ordinary matter? Same would of course apply to other elementary particles and only fact that baryons dominate the mass density motivates the attribute "baryonic". The intuitive view is that the density of dark protons is much smaller than the number of ordinary protons. Could this be true only in the regions containing high density of ordinary matter. The fraction of ordinary protons be much larger than that of dark protons only in the regions where the visible matter is concentrated.

(b) Why would ordinary nucleons transform to dark nucleons? Evolution means the increase of complexity. In the TGD Universe this means the increase of h_{eff}, which corresponds to a dimension of algebraic extension of rationals characterizing polynomials which at the fundamental level characterize space-time regions. Number theoretic evolution would transform the ordinary matter to dark matter as $h_{eff} \geq h$ phases residing at the monopole flux tubes. Could 30 per cent of ordinary matter have transformed to dark matter in this sense?

3.5 Are blackholes really what we believe them to be?

James Webb produces surprises at a steady rate and at the same time is challenging the standard view of cosmology and astrophysics. Just when I had written an article about the most recent findings, which challenged the basic assumption of these fields including those of general relativity and thought that I could rest for a few days, I learned from a new finding in FB. The title of the popular Youtube video (see this) was "James Webb Telescope Just Captured FIRST, Ever REAL Image Of Inside A Black Hole!" There is also a popular article describing a detection of light from behind the blackhole-like object (briefly BH) (see `https://cosmosmagazine.com/space/first-light-detected-from-behind-a-black-hole/`. One day after writing these lines, I learned that this kind of phenomenon had been observed already earlier 2 years ago by Connors et al: the finding is published in Astrophysics Journal [E2] (see this).

3.5.1 The findings

Gravitational lensing is the method used to gain information about these objects and it is good to start with a brief summary of what is involved. One can distinguish between different kinds of lensings: strong lensing, weak lensing, and microlensing.

(a) In the strong lensing (see this), the lense is between the observer and the source of light so that the effect is maximized. For high enough mass of the lense, lensing causes multiple images, arcs or Einstein rings. The lensing object can be a galaxy, a galaxy cluster or a supermassive blackhole. Point-like objects one can have multiple images and for extended emissions rings and arcs are possible.

The galactic blackhole, SgrA*, at the center of the Milky Way at distance of 27,000 light-years was imaged in 2022 by the Event Horizon Telescope (EHT) Collaboration (see this) using strong gravitational lensing and radio telescope network in a planetary scale. The blackhole was seen as a dark region at the center of the image. The same collaboration observed the blackhole in the M87 galaxy at a distance of 54 million light years already in 2019.

(b) In the weak lensing (see this), the lense is not between the observer and the source so that the effect is not maximized. Statistical methods can be however used to deduce information about the source of radiation or to deduce the existence of a lensing object. The lensing effect magnifies the image of (convergence effect) and stretches the image of the object (shear effect). For instance, weak lensing led quite recently to a detection of linear objects, which in the TGD framework could correspond to cosmic strings [L35] which are the basic objects in TGD based cosmology and model for galaxies, stars and planets.

(c) In microlensing (see this) the gravitational lense is small such as planets moving between the observer and star serving as the light source. In this case the situation is dynamic. The lensing can create two images for point-like objects but these need not be distinguishable so that the lense serves as a magnifying glass. The effect also allows the detection of lense-like objects even if they consist of dark matter.

3.5.2 GRT based interpretation of the findings

The recent results of JWT the findings of JWT are about a supermassive blackhole located 800 million light years away. Consider first the GRT based interpretation of the findings.

(a) What was observed by the strong lensing effect was interpreted as follows. The matter falling into the blackhole was heated and generated an X-ray corona. This X-ray radiation was reflected back from a region surrounding the blackhole. The reflection could be based on the same effect as the long wavelength electromagnetic radiation from the ionosphere acting as a conductor. This requires that the surface of the object is electrically charged, and TGD indeed predicts this for all massive objects and this electric charge implies quantum coherence in astrophysical scales at the electric flux tubes [L22], which would be essential for the evolution of life at Earth.

(b) After this the radiation, which was reflected behind the blackhole should have ended up in the blackhole and stayed there but it did not! Somehow it got through the blackhole and was detected. It would seem that the blackhole was not completely black. This is not all the behavior of a civilized blackhole respecting the laws of physics as we understand them. Even well-behaving stars and planets would not allow the radiation to propagate through them. How did the reflected X ray radiation manage to get through the blackhole? Or is the GRT picture somehow wrong?

3.5.3 Could the TGD view of blackholes explain the findings?

Consider first the GRT inspired interpretation. Could the TGD view of BHs come to rescue?

(a) In TGD, monopole flux tube tangles generated by the thickening of cosmic strings (4-D string-like objects in $H = M^4 \times CP_2$) and producing ordinary matter as the dark energy of the cosmic strings is liberated [L35] are the building bricks of astrophysical objects including galaxies, stars and planets. I have called these objects flux tube spaghettis.

Einsteinian blackholes, identified as singularities with a huge mass located at a single point, are in the TGD framework replaced with topologically extremely complex but mathematically and physically non-singular flux tube spaghettis, which are maximally dense in the sense that the flux tube spaghetti fills the entire volume [L11]. The closed flux tubes would have thickness given by the proton Compton length. From the perspective of the classical gravitation, these blackholes-like objects behave locally like Einsteinian blackholes outside the horizon but in the interior they differ from the ordinary stars only in that the flux tube spaghetti is maximally dense.

(b) The assumption, which is natural also in the TGD based view of primordial cosmology replacing the inflation theory, is that there is quantum coherence in the length scale of the flux tubes, which behave like elementary particles even when the value of h_{eff} is $h_{eff} = nh_0 = h$ or even smaller. What does this say is that the size of the space-time surface quite generally defines the quantum coherence length. The TGD inspired model for BHs suggests $h_{eff} = h$ inside the ordinary blackholes. The flux tubes would contain sequences of nucleons (neutrons) and would have a thickness of proton Compton length. For larger values of h_{eff}, the thickness would increase with h_{eff} and the proposal is that also stellar cores are volume filling black-hole like objects [L11].

Besides this, the protons at the flux tubes can behave like dark matter (not the galactic dark matter, which in the TGD framework would be dark energy associated with the cosmic strings) in the sense that they can have very large value of effective Planck constant $h_{eff} = nh_0$, where h_0 is the minimal value of h_{eff} [L35]. This phase would solve the missing baryon problem and play a crucial role in quantum biology. In the macroscopic quantum phase photons could be dark and propagate without dissipation and part of them could get through the BH.

(c) How could the X-rays manage to get through the supermassive black hole? The simplest option is that the quantum coherence in the length scale of the flux tube containing only neutrons allows photons to propagate along it even when one has $h_{eff} = h$. The photons that get stuck to the flux tube loops would propagate several times around the flux tube loop before getting out from the blackhole in the direction of the observer. In this way, an incoming radiation pulse would give rise to a sequence of pulses.

I have considered several applications of this mechanism.

(a) I have proposed that the gravitational echoes detected in the formation of blackholes via the fusion of two blackholes could be due to this kind of stickind inside a loop [L4]. This would generate a sequence of echoes of the primary radiation burst.

(b) The Sun has been found to generate gamma rays in an energy range in which this should not be possible in standard physics [L12]. The explanation could be that cosmic gamma rays with a very high energy get temporarily stuck at the monopole flux tubes of the Sun so that Sun would not be the primary source of the high energy gamma radiation.

(c) The propagation of photons could be possible also inside the Earth along, possibly dark, monopole flux tubes, at which the dissipation is small. The TGD based model for Cambrian explosion [L9, L18, L24] proposes that photosynthesizing life evolved in the interior of Earth and bursted to the surface of Earth in the Cambrian explosion about 450 million years ago. The basic objection is that photosynthesis is not possible in the underground oceans: solar photons cannot find their way to these regions. The photons could however propagate as dark photons along the flux tubes. The second option is that the Earth's core [L21, L23] provides the dark photons, which would be in the same energy range as solar photons. The mechanism of propagation would be the same for both options.

3.5.4 A more precise view of monopole flux tubes

One can also consider other options to explain the findings: also these would be based on the propagation of photons along a monopole flux tube. First one must however develop a more detailed view of the monopole flux tubes.

(a) Monopole flux tubes must be always closed. This is due to the conservation of monopole flux and the fact that boundary conditions do not allow cutting of flux tubes yielding opposite magnetic charges at the ends created in this way.

There are also good reasons to argue that at least gravitons propagate from source A to the receiver B along pairs (a,b) of parallel flux tubes with opposite fluxes. The pairs (a,b) are naturally formed by reconnection of closed U-shaped flux tubes emating from A and B. The reconnection and its reversal are proposed to the basic mechanism of biocatalysis. The flux tube pair (a,b) is always a part of a closed flux tube loop. In the simplest situation the member a (b) of the loop would turn backwards inside A (B) and return back as b (a).

(b) Also wormhole magnetic fields are possible. The members a and b of the tube pairs could also reside at parallel space-time sheets with distance about CP_2 size R scales of order 10^4 Planck lengths. The flux would move between the space-time sheets through wormhole contacts. Wormhole contact would like a magnetic dipole of size R. I have christened these structures as wormhole magnetic fields [K10] and elementary particles would be simplest configurations of this kind.

(c) Since the flux tubes carrying opposite magnetic fields are extremely near to each other and since the space-time sheets cannot be resolved from each other, wormhole magnetic fields do not create any observable effects and have nothing to do with the observable magnetic fields.

The flux tube pairs, in particular wormhole magnetic fields, can however mediate basic interactions by serving as channels for the propagation of associated elementary bosons. The distribution and direction of the flux tube pairs emanating from the surface of the source A must reflect the classical fields at the surface of A.

(d) One can however argue that since one also has macroscopic magnetic fields even in cosmic scales (this is one of the mysteries of cosmology) that unpaired flux tubes are necessary.

Could the magnetic fields of astrophysical objects correspond to unpaired flux tubes as single-sheeted objects? They would be closed but would not correspond to wormhole magnetic fields. A configuration consisting of unpaired monopole flux tubes could have a well-defined orientation, say parallel to the magnetic axis of BH. Monopole flux tubes would explain the existence of magnetic fields in cosmic scales not possible in the Maxwellian world and also the stability of the magnetic field of Earth [L3].

The unpaired monopole flux tubes could form a network connecting various astrophysical objects, in particular stars, and light and gravitons could propagate also along them and would not be weakened with distance. This would give rise to effects not possible in the standard astrophysics. This could for instance explain why JWST has detected signals from "too distant" objects. Also the gravitational hum could be explained as a diffraction effect in a lattice-like network formed by the stars [L33].

3.5.5 Alternative explanations for the findings

Consider now an alternative explanation for the findings challenging our views of blackhole-like objects. This explanation does not exclude the explanation already discussed but leads to stronger predictions and would also explain why it is possible at all to see objects at such large distances.

(a) If the light travels around the BH along unpaired monopole flux tubes like water flow around a spherical obstacle, the photons inside flux tubes are not "eaten" by the

BH-like object. Magnetic fields and incompressible flow with constant density indeed obey the basic local equation stating that there are no magnetic charges. Note however that the flux tubes could also go through the BH since the photons propagating inside the monopole flux tubes are shielded against interactions with the surrounding matter inside BH.

(b) The radiation from astrophysical object A would only reach observers B connected to it by unpaired monopole flux tubes or pairs of them. If the analogy with the simplest hydrodynamic flow around an obstacle makes sense, the effect would be observed only by observers in the direction of the monopole flux tubes defining the network and would be large since no attenuation is involved. The observers in the direction of the jets associated with the BH would satisfy this condition. One can of course consider more complex options in which several flux tubes emerge from the BH and connect it to astrophysical objects.

In the TGD framework, one must of course take the interpretation of the findings inspired by general relativity with a grain of salt. The object called supermassive blackhole-like could be something very different from a standard blackhole. If it is a thickened portion of a cosmic string, it emit particles instead of absorbing them in an explosion-like thickening of cosmic string transforming dark energy to matter and radiation (this would be TGD counterpart for the decay of inflation fields to matter [L26, L27, L35]. The matter bursting into the environment from a BH-like object would tend to fall back and could cause the observed phenomena in a way discussed above. Furthermore, the X-rays identified as the reflected X-rays could correspond to this kind of X-rays reflected back from the BH. I am not a specialist enough to immediately choose between these two options.

4 The planet that should not exist

The popular article in Futurism (see this) tells about a strange finding challenging the beliefs of the formation mechanism of planets. In the study published in Science, researchers out of Pennsylvania State described a surprising discovery: a Neptune-sized planet that's 13 times the mass of Earth, which is orbiting a tiny ultracool star that's with mass by a factor 1/9 smaller than the mass of the Sun.

According to the abstract of the article [E5] (see this) planets form in protoplanetary disks of gas and dust around young stars that are undergoing their own formation process. The amount of material in the disk determines how big the planets can grow. Stefansson et al. observed a nearby low-mass star using near-infrared spectroscopy. They detected Doppler shifts due to an orbiting exoplanet of at least 13 Earth masses, which is almost the mass of Neptune. Theoretical models do not predict the formation of such a massive planet around a low-mass star (see the Perspective by Masset). The authors used simulations to show that its presence could be explained if the protoplanetary disk were 10 times more massive than expected for the host star. To sum up, Neptune sized planets (mass is $17.1 M_E$ and radius $3.88 R_E$) should not exist around stars with mass $M_E/9$.

The analysis of these findings led to a considerably more detailed view of the formation of planets and also formation of stars.

4.1 TGD view of formation of planets

The TDG based proposal for the formation of planets assumes that planets have condensed from spherical shells of dark matter produced by "mini big bangs" as explosions of the star [L26, L27]. These dark mass shells with a large value of h_{eff} would transform to ordinary matter around a seed giving rise to the core of the planet and the dark matter from the spherical shell would transform to ordinary matter and condense around this core. The seed region need not contribute much to the mass of the planet.

(a) The basic difference with respect to the standard model would be that the disk is replaced with a spherical shell of dark matter. The open question is whether the mass of the shell condensing to form the planet can have a mass $\geq 13M_E$ for a star with mass as small as $M_{Sun}/9$. The mass mass ΔM of the mass shell should have been of the order $10^{-4}M_{star}$ and gives $\Delta R/R_{Sun} \sim 10^{-4}/3$. The radius of the star is not very sensitive to its mass so that $R_{star} = R_{Sun}$ is a reasonable estimate. Assuming $R_{star} \sim R_{Sun}$ and using $M_{Sun} = .333 \times 10^{-6}M_E$ and $R_{Sun} \sim 100R_E$, one obtains the estimate $\Delta R \sim 75$ km.

(b) For the Earth-Sun system the thickness of the layer would satisfy $\Delta R/R_{Sun} \sim 1.1\times10^{-4}$ and give $\Delta R \sim .64$ km.

(c) There are several theories about the origin of Moon. One of the theories states that Moon resulted from the debris coming from a collision of Mars sized object with Earth (see this). TGD suggests that Moon was created by the same mechanism as a planets, that is by an explosion creating a spherical layer, which condensed to form a Moon. The condition $4\Delta R/R_E \simeq M_{Moon}M_E$ gives $\Delta R \simeq 22$ km.

4.2 How could stars form in the TGD Universe?

Also the mechanism for the formation of stars would be different in the TGD framework and is inspired by the predicted quantum coherence in astrophysical scales and the general view of TGD inspired view of what happens in state function reductions, which also leads to a theory of consciousness and life as universal phenomena present in all scales, even astrophysical.

(a) According to the standard model, stars condense from the interstellar gas, possibly from a material of a spherical or a disk-like structure. In the TGD framework this cannot apply to the first generation stars. Rather, the mass of the first stars could have come from the transformation of the analog of dark energy to ordinary matter as the energy of a cosmic string transforms to matter in a process analogous to the decay of the inflaton field. The string tension of the resulting monopole flux tube is much smaller and the process can repeat itself. This mechanism could play some roles later.

(b) The emerging matter could be mostly ordinary matter but can transform to a phase, which has a large effective Planck constant $h_{eff} > h$. These phases of ordinary matter would explain the missing baryonic mass [L5] and would have a key role in biology. Evolution as a gradual increase of h_{eff} serving as a measure of algebraic complexity conforms with this view.

   The galactic dark matter in turn would correspond to the dark energy assignable to the string tension of very long cosmic strings orthogonal to the galactic plane and creating a transversal $1/\rho$ gravitational field explaining the flat velocity spectrum of distant stars.

(c) This model for the generation of stars should explain the fact that there are star generations: stars die as supernovae and are regenerated later. Zero energy ontology (ZEO) [L13] provides a possible solution to the problem. The end of the life of the star as supernova could correspond to "big" state function reduction (BSFR) (the TGD counterpart of the ordinary state function reduction) in astrophysical scale changing the arrow of time. This process would be highly analogous to a biological death involving a decay process identifiable as supernova explosion.

   After a supernova explosion the star would live a life with an opposite arrow of geometric time and reincarnate in the original time direction as a star which would partially consist of the decay products of the earlier star(s). The evolutionary age of the star increases steadily in this sequence of lives forth and back in geometric time although the cosmological age increases much slower. JWST has indeed discovered stars and galaxies older than the universe [L32].

The model should also explain how the core of the daughter star is generated.

(a) The TGD based model is motivated by the problem caused by the fact that stellar fusion cannot produce elements heavier than iron plus the fact that the model for their production in supernova explosions has problems. Also the observed abundances of lighter elements are problematic. "Cold fusion", which is usually admitted as a real phenomenon, is the third problem [L2, L5, L16].

(b) The TGD based model assumes that the dark "cold fusion" of dark nucleons produces nuclei with much smaller binding energy than that of normal nuclei and can occur at low temperatures. The potential energy wall preventing the occurrence of fusion is much lower if it scales as the inverse size scale of the dark nuclei. This predicts the formation of dark nucleon sequences which can transform to ordinary nuclei by the reduction of the value of h_{eff} and liberate in this process almost all ordinary nuclear binding energy. This process would lead to the generation of the core of the protostar and when the temperature is high enough, ordinary nuclear fusion reactions begin.

(c) In this framework elements heavier than Fe would be formed outside stellar interiors during the period leading to the formation of the protostar. Also the formation of the cores of planets could involve this process but would not lead to the ignition temperature at which ordinary nuclear fusion begins. The seeds for the formation of stars could correspond to tangles of thickening cosmic strings producing ordinary matter as the energy of the string is liberated.

The Youtube posting "The James Webb Space Telescope Has Just Made an Incredible Discovery about Our Sun! Birth of Sun"!" (see this) tells about Herbit Haro object HH211 located at a distance 1000 light years about which JWQST has provides a picture (I hope that the sensationalistic tone of the title does not irritate too much: it seems that we must learn to tolerate this style).

Herbig Haro luminous objects are associated with very young stars, protostars. Typically they involve a pair of opposite jets containing streams of matter flowing with a very high speed of several hundred km/s. The jets interact with the surrounding matter and generate luminous regions. HH211 was the object studied by JWT. The jets were found to contain CO, SiO, H_2.

Herbig Haro objects provide information about the very early states of star formation. As a matter of fact, the protostar stage still remains rather mysterious since the study of these objects is very challenging already because their distances are so large. The standard wisdom is that stars are born, evolve and explode as supernovae and that the remnants of supernovae provide the material for future stars so that the portion of heavy elements in their nuclei should gradually increase. The finding that the abundances of elements seem to depend only weakly on cosmic time seems to be in conflict with these findings and forces us to ask whether the vision about the protostars should be modified. Also JWT found that the galaxies in the very young Universe can look like the Milky Way and could have element abundances of recent galaxies which challenges this belief.

The association of the jets to Herbig Haro objects conforms with the idea that cosmic strings or monopole flux tubes formed from them are involved with the formation of a star. One can consider two options for how the star formation proceeds in the TGD Universe.

(a) The seed for the star formation comes from the transformation of dark energy associated with the cosmic string or monopole flux tube to ordinary matter (it could also correspond to a large h_{eff} phase and behave like dark matter and. explain the missing baryonic matter). By the conservation of the magnetic flux the magnetic energy density per unit length of the monopole flux tube behaves like $1/S$ and decreases rapidly with its transversal area. The volume energy density increases like area but its growth is compensated by the phase transition reducing the value of the analog of cosmological constant Λ so that on the average this contribution behaves as a function of the p-adic length scale. In the same way as magnetic energy per unit length. The energy liberated from the process is however rather small except for almost cosmic strings and this process might apply only to the formation of first generation stars.

(b) The second option is that the process is analogous to "cold fusion" interpreted in the TGD framework as dark fusion [L5, L2, L16]) in which ordinary matter, say protons and perhaps even heavier nuclei, are transformed to dark protons at the monopole flux tubes having much larger Compton length (proportional to h_{eff}) that ordinary protons or nuclei. If the nuclear binding energy scales like $1/h_{eff}$ for dark nuclei nuclear potential wall, is rather low and the dark fusion can take place at rather low temperatures. The dark nuclei would then transform to ordinary nuclei and liberate almost all of their ordinary nuclear binding energy, which would lead to a heating which would eventually ignite the ordinary nuclear fusion at the stellar core. Heavier nuclei could be formed already at this stage rather than in supernova explosions. This kind of process could occur also at the planetary level and produce heavier elements outside the stellar cores.

This process in general requires energy feed to increase the value of h_{eff}. In living matter the Pollack effect would transform ordinary protons to dark protons. The energy could come from solar radiation or from the formation of molecules, whose binding energy would be used to increase h_{eff} [L22]. This process could lead to the formation of molecules observed also in the jets from HH211. Of course, also the gravitational binding energy liberated as the matter condenses around the seed liberates and could be used to generate dark nuclei. This would also raise the temperature helping to initiate dark fusion. The presence of the dark fusion and the generation of heavy elements already at this stage distinguishes between this view and the standard picture.

The flux tube needed in the process would correspond to a long thickened monopole flux tube parallel to the rotation axis of the emerging star. Stars would be connected to networks by these flux tubes forming quantum coherent structures [L33]. This would explain the correlations between very distant stars difficult to understand in the standard astrophysics. The jets of the Herbig Haro object parallel to the rotation axis would reveal the presence of these flux tubes. The translational motion of matter along a helical flux tube would generate angular momentum. They would make possible the transfer of the surplus angular momentum, which would otherwise make the protostar unstable. By angular momentum conservation, the gain of the angular momentum by the protostar could involve generation of opposite angular momentum assignable to the dark monopole flux tubes.

4.3 Are the abundances of elements independent of cosmic time?

The model predicts that effects of reprocessing, which are central in the standard model, would be weak and the abundances produced by the nuclear fusion itself inside the star should depend only weakly on cosmic time! The TGD Universe would be an expanding steady state Universe!

ZEO strengthens this prediction. The sequence of reincarnations leads to an asymptotic state: the abundances of the nuclei in the interstellar space should not depend on time: this was actually one of the first "almost-predictions" of the TGD inspired model of nuclei as string-like entities [K6]. Standard model makes different prediction: the abundances of the heavier nuclei should gradually increase as the nuclei are repeatedly re-processed in stars and blown out to interstellar space in a supernova explosion. What is the situation in real life?

Amazingly, there is empirical support for this highly non-trivial prediction of TGD [E7]. The 25 measured elemental abundances (elements up to $Sn(50,70)$ (tin) and $Pb(82,124)$ (lead)) of a 12 billion years old galaxy turned out to be very nearly the same as those for the Sun. For instance, oxygen abundance was 1/3 of that from that estimated for the Sun. Standard model would predict that the abundances should be .01-.1 from that for the Sun as measured for stars in our galaxy. The conjecture was that there must be some unknown law guaranteeing that the distribution of stars of various masses is time independent. The alternative conclusion would be that heavier elements are created mostly in the interstellar gas and dust.

The findings of JWST, in particular the discovery of stars and galaxies which seem to be older than the Universe, conforms with this picture.

5 Are planets and stars quantum gravitational harmonic oscillators?

I learned (thanks to Mark McWilliams and Grigol Asatiani) about a proposal that blackhole like stars, gravatars, could develop Russian doll-like nested structures, nestars (see this). Gravastar is a star proposed to replace blackhole. It has a thin layer of matter at the horizon and de-Sitter metric in the interior. Nestar would consist of nested gravastars.

This finding raised the question whether the layered structures of planets could be understood in the TGD framework and inspired what I call quantum gravitational harmonic oscillator model of star.

The second input came from the observation of a planet which is too massive as compared to its mother star to exist [E5] (see this). Could the TGD based model for the formation of planets [L26, L27] be consistent with this finding? Quite surprisingly, the detailed considerations led to more detailed ideas about the evolution of stars explaining the old but forgotten paradoxical finding that the abundances of elements do not seem to depend on cosmic time as predicted by the standard model of star formation in which the decay products of supernovae are reprocessed. JWST has in fact confirmed this finding.

5.1 Could planets and stars have a layered structure in the TGD Universe?

The proposal is interesting from the TGD point of view because TGD raises the question whether stars, and astrophysical objects, in general could have a layered structure.

(a) One of the early "predictions" of TGD for stars coming from the study of what spherically symmetric metrics could look like, was that it corresponds to a spherical shell, possibly a hierarchical layered structure in which matter is condensed on shells. p-Adic length scale hierarchy suggests shells with radii coming as powers of $2^{1/2}$.

(b) Nottale's model [E1] for planetary systems suggests Bohr orbitals for planets with gravitational Plack constant $\hbar_{gr} = GMm/\beta_0$. The value of the velocity parameter $\beta_0 = v_0/c \leq 1$ is from the model of Nottale about 2^{-11} for the inner planets and 1/5 times smaller for the outer planets. This might reflect the fact that originally the planets or what preceded them consisted of gravitationally dark matter or that the Sun itself consisted of gravitationally dark matter and perhaps still does so.

5.2 Nottale's model for solar and planetary interiors as gravitational harmonic oscillators

The Nottale model is especially interesting and one can look at what happens inside the Sun and planets, where the mass density is in a good approximation constant and gravitational potential is harmonic oscillator potential. Could particles be concentrated around the orbitals predicted by the Bohr model of harmonic oscillator with radii proportional to $n^{1/2}$, $n = 1, 2, 3, ...$ The lowest state would correspond to S-wave concentrated around origin, which is not realized as Bohr orbit. The wave function has nodes and would give rise to spherical layers of matter.

One can perform the simple calculations to deduce the energy values and the radii of Bohr orbits in the gravitatational harmonic oscillator potential by using the Bohr orbit model.

(a) The gravitational potential energy for a particle with mass m associated with a spherical object with a constant density would be $GmM(r)/r = GMmr^2/R^3$, where M is the mass of the Sun and R is the radius of the object. This is harmonic oscillator potential.

(b) The oscillator frequency is

$$\omega = (\frac{r_s}{R})^{1/2}/R \ ,$$

where $r_S = 2GM$ is the Schwartschild radius of the object, about 3 km for the Sun and 1 cm for Earth.

(c) The orbital radii for Bohr orbits are proportional to $n^{1/2}$ inside the star. By the Equivalence Principle, the radius does not depend on particle mass. One obtains

$$r_n = n^{1/2}(2\beta_0)^{-1/2}(\frac{r_s}{R})^{1/4} \times R \ .$$

One must of course remember that in the recent Sun, Earth and other planets ordinary matter is probably not gravitationally dark: only the particles associated with the U-shaped monopole flux tubes mediating gravitational interaction could be gravitationally dark and would play an important role in biology.

The situation could have been different when the planets formed. I have proposed a formation mechanism by an explosive generation of gravitationally dark magnetic bubbles ("mini big bangs"), which then condensed to planets [L26, L27]. This would explain why the value of β_0 for the Earth interior is the same as for the system formed by the interior planets and Sun and Mars. The simple calculations to be carried out suggest that for the outer planets only the core region emerged in this way and the gravitational condensation gave rise to the layer above it. The core should have the properties of Mars in order that it could correspond to S-wave state.

The model of stars and planets as quantum gravitational harmonic oscillators turns out to be surprisingly successful. It turns out that the radius of the core of Earth corresponds to the Bohr radius for the first orbital, which suggests that the core of Earth, and more generally of the inner planets and Mars corresponds to an S-wave ground state. For the Sun the $n = 1$ S-wave orbital is 1.5 times the solar radius. The model applies also to the outer planets. Also the rings of giant planets can be understood at a rough quantitative level.

5.3 Application of the oscillator model to solar system

In this section the above simple model is applied to the solar system. Recall that the basic formula is

$$\frac{r_1}{R} = (2\beta_0)^{-1/2}(\frac{r_s}{R})^{1/4} \ .$$

where R refers to the radius of the object.

5.3.1 Oscillator models for the Sun and Earth

Consider first the model for the Sun assuming that the value of $\beta_0 = 2^{-11}$ holds true for Sun and inner planets. One can of course argue that the value of β_0 need not be the same for pairs formed by particles inside Sun and Sun.

(a) For the Sun one has $\frac{r_s}{R} = 4.3 \times 10^{-6}$. For $\beta_0 = 2^{-11}$ holding true for the inner planets one obtains $r_1 = 1.45R$ so that the solar interior would correspond to a ground state S-wave with smaller than the maximal radius. For $\beta_0 = 10^{-3}$ would give the maximal radius $r^1 \simeq R$.

(b) $\beta_0 = 1$ would give $r_1 = .032R$, which is considerably smaller than the radius of the solar core about $.2R$. $\beta_0 = 0.026$ would give $r_1 = .2R$. r_{25} would be near to the solar radius. The set of the nodes of a harmonic oscillator wave function would be rather dense: at the surface of the Sun the distance between the nodes would be .1R. Note that the convective zone extends to .7R.

What about the Earth?

(a) One has $r_S = 1$ cm and $R = 6,378$ km. At the surface of Earth $\beta_0 = 1$ is the favoured value and would give $r_1 =\simeq 50.5$ km. The radius of the inner inner core is between 300 km and 400 km. $n = 36$ would correspond to 300 km and $n = 64$ to 400 km. β_0 scales like $(r_1/R_E)^2$. At the surface of Earth one would have $n = (R_E/r_1)^2 \sim 15996$ and the distance between two nodes would be $R_E/2n \simeq .197$ km.

$\beta_0 \simeq 1$ should hold true above the surface of the Earth, which suggests that it characterizes the gravitational magnetic body of Earth. Gravitational magnetic bodies of the Sun and the Earth could combine to form a single entity.

(b) One can write $\beta_0(r_1)$ as

$$\beta_0(r_1) = (\frac{50.5}{r_1})^2 \quad .$$

(c) The value $\beta_0 = 2^{-11}$ for the inner planets would give $r_1 = .36R_E \simeq 2285$ km. This is equal to the radius $R_{Core} = .36R_E$ of the Earth's core (see this). Therefore the Earth's liquid core could correspond to the ground state S-wave for the gravitational harmonic oscillator and the mantle has gravitationally condensed above the core from the material coming from the environment.

$n = 2$ orbit would correspond to the radius $.5R_E$, rather neat to the radius of Mars. The thickness of the mantle is about 45 per cent of the radius of Earth so that the crust of thickness 15-20 km might be associated with the $n < 8$ orbits. $n = 7$ would correspond to $.95R_E$ and to a depth of about 319 km. $n = 8$ would correspond to $1.018R_E$, which corresponds to 116 km above the Earth: the lower boundary of the ionosphere is at 80 km.

5.3.2 The radii of first Bohr orbits for planets modelled as gravitational harmonic oscillators

The above observations raise the question whether the value of β_0 for Sun and inner/outer planets is such that both the entire Sun or its core and the cores of at least some rocky planets correspond to the ground state S-waves for the value of the gravitational Planck constant assigned with the planet. The allowed $n \geq 1$ states could correspond to layers above the core.

Note that the Bohr orbital in plane corresponds to a wave function for Schrödinger equation localized to an orbital located near the orbital plane and that there are several orbitals for a given value of n. This state could have been the primordial dark matter state and the recent state could carry some information about this state.

The condition $r_1 \leq R_P$ requires

$$\frac{r_{S,P}}{R_P} \leq 4\beta_0^2(Sun, P) \quad .$$

Using M_E and R_E as units, this condition reads for inner planets as

$$\frac{r_{S,P}}{R_P} \leq 1$$

and for outer planets as

$$\frac{r_{S,P}}{R_P} \leq K^2 \quad ,$$

where one has $K = 1$ or $K = 1/5$ depending on what option is assumed.

(a) The first option giving $K = 1$ assumes that the principal quantum numbers n are of the form $n = 5k$, $k = 1, 2, ..$ for the outer planets. This is possible although it looks somewhat un-natural.

(b) The second option, proposed originally by Nottale [E1], is $\beta_0(outer) = K\beta_0(inner)$, $K = 1/5$.

Recall that the prediction for the radius of the first Bohr orbital is $\frac{r_1}{R_P} = (2\beta_0)^{-1/2}(\frac{r_s}{R_P})^{1/4}$. It is interesting to see whether the condition holds true (see this).

1. Rocky planets

Consider first the rocky planets, which include inner planets and Mars. For Mercury the ratio $\frac{r_1}{R}_M$ is $(R_E/R_{Mars})(M_{Mars}/M_E)^{1/4}(r_1(E)/R_E) \simeq .388$. For Venus and Earth with nearly equal masses, which suggests that Venus has also a core of nearly the same radius, which corresponds to $r_1 \sim .36R$.

For Mars, which is also a rocky outer planet, the condition for the $K = 1/5$ option gives the value of $\frac{r_1}{R}$ for Mars by a scaling the value .36 for the Earth by the factor $(1/K)^{1/2} \times (R_E/R_{Mars})(M_{Mars}/M_E)^{1/4} \simeq .931$ so that one $r_1 = .33R_{Mars}$. The situation for the mantle region would be very similar to that for the Earth. Note that the values of $r_1(P)/r_P$ are rather near to each other, which suggests that all are formed by the condensation of the mantle on top of the core.

Planet	$\frac{M_P}{M_E}$	$\frac{R_P}{R_E}$	$\frac{r_1}{R_P}$
Mercury	0.0553	0.383	.39
Venus	0.815	0.949	.35
Earth	1	1	0.36
Mars	0.107	0.532	.54

Table 1: Masses M_P and radii R_P for the inner planets and mass using mass M_E and radius R_E of Earth as units. The last column gives the ratio $\frac{r_1}{R_P}$ of the $n = 1$ Bohr orbit to the radius of planet

What is truly remarkable and raises hope that the proposed model has something to do with reality, that in the case of Earth r_1 is identifiable as the core radius.

The only rocky planets having moons are Earth and Mars.

(a) For Earth, the harmonic oscillator orbit with a radius nearest to R_E corresponds to $n = 8$. The radius is $1.0188R_E$. The distance of the orbit from the Earth surface is 118.5 km, which corresponds to the thickness of the ionosphere. $n = 9$ corresponds to 512.2 km.

The distance of the Moon is $60R_E$. For the harmonic oscillator model this would correspond to a rather large value $n = 2778$. The Bohr radius for gravitational Coulomb orbit is $a_{gr} = 20$ km and the orbit of the Moon would correspond to $n = \sqrt{R_E/a_{gr}}$ giving $n = 138$. The interpretation as Coulomb orbit looks of course physically natural. Also Saturnus, Uranus, and Neptune have moons with large orbital radius and would naturally correspond to Coulombic moons (see this).

(b) For Mars the oscillator orbit nearest to its radius has $n = 4$ and $1.08R_M$ and corresponds to a rather large distance of 943 km from the surface. Could this mean that Mars does not have the counterpart of the ionosphere, which seems to be essential for life in the TGD framework [L22]? Earth and Mars look clearly very different from each other.

Mars has two moons: Phobos and Deimos. The radii for them are $2.76R_M$ and $6.91R_M$. In the harmonic oscillator model they would correspond in a good approximation to $n = 26$ and $n = 164$. The identification as Coulomb orbits would require much larger values of n of order 9.744×10^4 and 1.5418×10^5 and does not look natural.

2. Giant planets

The outer planets are gas giants apart from Mars and apart from Neptune, which is an ice giant.

1. The radii for $n = 1$ harmonic oscillator orbits The following table gives the ratios $r_1/R =$

$(1/2\beta_0)^{1/2}(r_s(p)/R_P)^{1/4}$ for the first oscillator orbit. One can estimate the ratio $r_1(P)/R_P$ by scaling its value $r_1/R_E = .36$ for Earth. One has $r_r/R_P = K^{1/2}X \times .36$ where the scaling factor is $X = [(M_P/M_E) \times (R_E/R_P)]^{1/4}K^{1/2}$ and K is the scaling factor in $\beta_0 = 2^{-11}/K$. The model of Nottale indeed allows two options: either $K = 5$ or 1. The corrected calculations give for $K = 1/5$ $r_1/r_P \geq 1$ whereas $K = 1$ gives $r_1/R_P \leq 1$.

Planet	$\frac{M_P}{M_E}$	$\frac{R_P}{R_E}$	$\frac{r_1}{R_P}$
Jupiter	317.8	11.21	0.84
Saturn	95.2	9.45	0.64
Uranus	14.5	4.01	0.50
Neptune	17.1	3.88	0.52

Table 2: Masses M_P and radii R_P for outer planets using mass and radius of the Earth as units. The last column gives the ratio $\frac{r_1}{R_P}$ of the $n = 1$ Bohr orbit to the radius of planet assuming $K = 1$.

For $K = 5$ the values of r_1 for the giant planets are systematically somewhat larger than the orbital radius. The reason is that the value r_1 is proportional to $\sqrt{K}$. The second reason for this is that the large value of the mass of the planet increases like R_P^3 and makes $\hbar_{gr} \propto \frac{r_s}{R_P}$ large. Jupiter allows only $n = 1$ orbital as interior orbital and $n = 2$ orbital corresponds to radius $1.2R_J$. Saturn allows also $n = 2$ orbital as an interior orbital and $n = 3$ orbital has $r_3 = 1.1R_S$. Uranus allows $n = 4$ orbital corresponds to the radius of Uranus. One must of course take these rough estimates with a caution: only simple estimates are in question.

The simplest model is obtained if $\beta \simeq 2^{-11}$ holds true also for the outer planets. The predictions for the radii of the cores or both inner and outer planets are in principle testable. The prediction $r_{Core} = r_1 < R_P$ can be also tested for exoplanets.

2. Do giant planets have a shell structure for a gravitational harmonic oscillator in some sense?

The above observations give $\frac{r_1}{R_P} \leq 1$ for the outer planets if one has $\beta_0 = 2^{-11}$. Giant planets would containg at least one orbit inside the planet. There are suggestions that giant planets could have a rocky core containing metals for which there is evidence (see this) with smaller mass.

(a) A natural mechanism for the formation of the giant planet would be gravitational condensation of the matter from the environment around the core region, which according to TGD based proposal [L26] would have been generated in an explosion of Sun throwing out a mass shell of dark matter in TGD sense, which then condensed to planets (in Kuiper belt this did not happen).

(b) The region outside the core would correspond in the first approximation to harmonic oscillator orbitals determined by the average density with radii given as $r_n = n^{1/2}R_{core}(P)$.

One can develop a more detailed model as follows.

(a) One can apply Newton's law for circular Bohr orbits and quantization condition for angular momentum in the gravitational potential $V(R) = GmM(R)/R$, where M(R) is

$$M(R) = M(core) + M(layer) \times [(R/R_P)^3 - (R_{core}/R_P)^3) \ .$$

Slightly below R(core) the force is harmonic force the interior R increases, the gravitational potential approaches to harmonic oscillator potential determined by M_P. For outer planets the average density is considerably smaller than the density of the core.

(b) The first condition is

$$\frac{v^2}{R} = -\frac{dV(R)}{dR} = -\frac{d(GM(R)/R)}{dR} = \frac{GM(R)}{R^2} - G\frac{dM/dR)}{R} \ ,$$

where one has

$$\frac{dM}{dR} = \frac{3R^2}{R_P^3} \ .$$

One obtains

$$v(R)^2 = \frac{1}{2} \times \frac{r_S(core)}{R} - 3r_S(layer) \times (\frac{R}{R_P})^3) \ .$$

(c) The second condition corresponds to the quantization of the angular momentum

$$vR = \frac{GM(core)}{\beta_0} \ .$$

gives for R the condition

$$\frac{R}{R_E} = \frac{r_S(core)/R_E}{\beta_0 v(R)} \ .$$

Mars is the natural choice for the core. From these data the radii of the Bohr orbits can be calculated. Near the boundary of the core the radii would go like $n^{1/2}R_{Mars}$. For large enough radii one would obtain harmonic oscillator potential.

Jupiter serves as a representative example. One has $M_J = 317.8M_E$ and $R_J = 11.2R_E \simeq 22.4R_{Mars}$. The core has radius $.64R_J$. The density of Jupiter is fraction .22 of the density of Earth. Most of the mass of Jupiter would be generated by the gravitational condensation of gas from the atmosphere. At least the dark matter at the gravitational magnetic body would be at the harmonic oscillator orbitals.

3. Could one understand the rings of giant planets in terms of the oscillator model?

One can consider two alternative models for the rings of giant planets. One could try to model the rings in terms of Bohr orbits with a small principal quantum number n for a harmonic oscillator potential or using a Coulomb potential for the gravitational analog of hydrogen atom assuming the same gravitational Planck constant as for the harmonic oscillator model ($\beta_0 \simeq 2^{-11}$). In this case the Bohr radius $a_{gr} = \beta_0^{-2}r_S/2 \simeq 2^{10}r_S$ is much smaller than the planet radius so that the scale of the rings does not emerge naturally.

The assignment of the rings of the giant planets with the harmonic oscillator orbitals seems to make sense at the order of magnitude level at least (see this,this, this and this).

(a) For Jupiter the halo ring has average radius at $1.5R_J$ would be assigned with $n = 3$ orbit with radius $1.45R_J$. The main ring has average radius of $1.75R_J$ could correspond to $n = 4$ ring with radius $1.7R_J$.

(b) Saturn would allow $n = 3$ orbit very close to the surface with radius $1.11R_S$: the smallest rings extend from $1.16R_S$ and could correspond to this orbit.

(c) For Uranus the lowest ring has radius $1.48R_U$ with could correspond to $n = 9$ with radius $1.23R_U$ ($n = 4$ corresponds to the radius of Uranus).

(d) For Neptune $n = 4$ orbital corresponds to $1.04R_N$. The $n = 12$ orbital could correspond to the lowest ring in this case.

4. Dwarf planets, Pluto, and some moons

One can also estimate the values of r_1 for some dwarf planets 3 known to be promising places for the evolution of organic life and the Moon and some moons of Jupter and Saturn. Table 3 gives the values of β_0 for some dwarf planets.

5. Blackhole-like object as a gravitational harmonic oscillator?

Object	M/M_E	R/R_E	$\frac{r_1}{R}$
Pluto	.00218	0.1818	.27
Eris	.0028	.182	.28
Ceres	1.57×10^{-4}	.2725	.17
Moon	.0123	.074	.17

Table 3: Masses M and radii R for Pluto, some dwarf planets and Moon using mass M_E and radius R_E of the Earth as units. The last column gives the ratio $\frac{r_1}{R}$ of the $n = 1$ Bohr orbit to the radius of the planet. The values $\beta_0 = 2^{-11}/5$ for outer planets and $\beta_0 = 2^{-11}$ for the Moon are used. In the case of Earth it this radius is identifiable as the core radius.

As described, in the TGD Universe blackhole-like objects are identified as monopole flux tube spaghettis and differ from the ordinary stars only in that for $h_{eff} = h$, the entire volume is filled by monopole flux tubes for which thickness is minimal and corresponds to a nucleon Compton length. For $h_{eff} > h$ also the flux tubes ordinary stars or star cores could fill the entire volume.

Just for fun, one can ask what the model of a gravitational harmonic oscillator gives in the case of Schwarzschild blackholes. The formula, $r_n = \sqrt{n}r_1$, $r_1/R = (r_s/sqrt2\beta_0)/times(r_s/R)^{1/4}$, gives for $R = r_s$ $r_1/r_s = 1/\sqrt{2\beta_0}$. $\beta_0 \leq 1/2$ gives $r_1/r_s \geq 1$ so that there would be no other states than the possible S-wave state ($n = 0$). $beta_0 = 1/2$ gives $r_1 = r_s$ and one would have just mass at $n = 0$ S-wave state and $n = 1$ orbital. For $\beta_0 = 1$ (the minimal value), one has $r_1/r_s = 1/\sqrt{2}$ and $r_2 = r_s$ would correspond to the horizon. There would be an interior orbit with $n = 1$ and the S-wave state could correspond to $n = 0$.

The model can be criticized for the fact that the harmonic oscillator property follows from the assumption of a constant mass density. This criticism applies also in the model for stars. The constant density assumption could be true in the sense that the mass difference $M(n+1) - M(n)$ at orbitals r_{n+1} and r_n for $n \geq 1$ is proportional to the volume difference $V_{n+1} - V_n$ proportional to $r_{n+1}^3 - r_n^3 = (n+1)^3 - n^3 = 3n^2 + 3n + 1$. This would give $M = m_0 + m(n_{max} + 1)^3$ leaving only the ratio of the parameters m_0 and m free. This could be fixed by assigning to the S-wave state a radius and constant density. This condition would give an estimate for the number of particles, say neutrons, associated with the oscillator Bohr orbits. If a more realistic description in terms of wave functions, this condition would fix the total amount of matter at various orbitals associated with a given value of n.

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