About the recent TGD based view concerning cosmology and astrophysics

November 12, 2025

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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 is 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 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 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.

In the last section a cosmic string model for the spiral galaxies predicting the branched spiral structure is considered. Also a quantum model for the galactic blackhole-like objects allowing to understand the weird properties of Sagittarius A* is discussed.

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 [?] [?]. 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 [?]. 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 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 Nottale's proposal is discussed. Nottale's model [?] 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. One fascinating application is blackholes: for instance, could one one understand the weird properties of Sagittarius A* using Bohr quantization?

In the last section a cosmic string model for the spiral galaxies predicting the branched spiral structure is considered. Also a quantum model for the galactic blackhole-like objects allowing to understand the weird properties of Sagittarius A* is discussed.

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 the inflaton fields. I have considered the TGD analog of inflation already 12 years ago [?] [?] and the recent discussion brings in the progress in the understanding that 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 the 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 [?] 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 the 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 [?, ?] for the odyssey leading to its recent dramatically simplified form [?]. 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 [?, ?] 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 submanifold 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 decreases. The recent accelerating period of expansion could correspond to this kind of phase transition. The thickening *need not* involve an exponential expansion of these space-time surfaces. This decay would lead from the cosmic string dominated phase to a radiation dominated phase and generate Einsteinian space-time and cosmology.

3. There is Quanta Magazine post (see this) telling about the evidence that dark energy is getting weaker found by DESI collaboration [?]. This would mean that the values of the cosmological constant decreases. TGD predicts the analogy of cosmological constant and also its weakening in a sequence of phase transitions reducing the value of the string tension of the monopole flux tube analogous to string tension.

4. The energy of the cosmic strings generates a 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 [?] 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 [?, ?, ?, ?, ?, ?], 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 $M^4_c \subset M^8_c$ 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 fluctuations 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 polynomials 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 the 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 [?]. 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 [?] is dramatically simpler than the earlier ones. Complexified octonsions $O_c = M^8_c$ are replaced with octonions O allowing naturally a Minkowskian number theoretic norm $Re(o^2)$ making O effectively M^8. The hologra-phy=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^8_c. 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 [?, ?]. These holomorphic functions naturally form 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 [?, ?], 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 $L^{dark}_{p,n} = \hbar_{eff} L_{p,n}$.

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 [?].

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) [?] [?] 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) [?, ?] 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 fundamental 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 entity 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 the primordial phase if rational polynomials are allowed.

2.2 The TGD view of primordial cosmology

I have already considered primordial cosmology in the TGD framework [?] [?].

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 [?, ?] 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 a conscious entity. cd is analogous to an 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 [?, ?] [?, ?], 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 [?] 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 neurons. 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 $R^2_{eff} = n_0 R^2 = n_0\sqrt{G}$, 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 a 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 $R^2_{eff} = \hbar_{eff}R^2/\hbar_0$ 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 $\rho = 3\hbar_0 H_0^2/8\pi R^2_{eff} = 3\hbar_{eff}/8\pi L^2_{p,2}$.

(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 $rho_{crit} \propto 1/nL^2_{p,2}$.

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^2_{eff} 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 $\Delta H_0/H_0 = \delta L_{p_2}/L_{p,2}$ 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 $\Delta H_0/H_0 = -2\delta n/n + \delta L_{p_2}/L_{p,2} \simeq -2/\delta n/n$. 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?

1. 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 $p_{max} = p$.

2. 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 $|\delta n| = 1$.

$$\frac{\delta T}{T} = \frac{1}{2}\frac{\delta\ \rho_{cr}}{\rho_{cr}} = 2\frac{\delta H_0}{H_0} = -2\ \frac{\delta n}{n}\ . \tag{2.1}$$

3. 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?

1. 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 $\delta\ \rho_{cr}/\rho_{cr} = 4\delta\ T/T =\ 1.3 \times 10^{-4}$.

2. 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.

3. 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.

4. 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 $n_1 \rightarrow 8n_1$ and $n_2 = n_1 \rightarrow n_1/8$ in $n \rightarrow n_1 n_2 \sim n_1^2$ 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 [?].

1. 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.

2. 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.

1. 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.

2. 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

$$L_p(dark) = nL_p \ , \tag{2.2}$$

   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).

3. 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.

1. 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.

2. 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.

3. 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?

2.2.4 Is dark energy needed at all?

The year 2024 in cosmology and astrophysics have been full of surprises. The last surprise came afterthe Christmas. I received links to two very interesting ScienceDaily articles from Mark McWilliams. The first article (see this) discusses dark energy. The second article (see this) discusses Hubble tension. Both articles relate to the article "Cosmological foundations revisited with Pantheon+." published by Lane ZG et al in Notices of Royal Astronomical Society [?] (see this).

On the basis of their larger than expected redshift supernovae in distant galaxies appear to be farther than they should be and this inspires the notion of dark energy explaining accelerated expansion. The argument proposes a different explanation based on giving up the Friedmannin cosmology and giving up the notion of dark energy. This argument would also resolve the Hubble tension discussed in the second popular article. The argument goes as follows.

(a) Gravitation slows down the clocks. The clocks tick faster inside large voids than at their boundaries where galaxies reside. When light passes through a large void it ages more than if it passed through the same region with an average mass density.

(b) As the light from distant supernovae arrives it spends a longer time inside the voids than in passing through galaxies. This would mean that the redshift for supernovae in distant galaxies appears to be larger so that they are apparently farther away. Apparently the expansion accelerates.

(c) This is also argued to explain the Hubble tension meaning that the cosmic expansion rate characterized by the Hubble constant, for the objects in the early Universe is smaller than for the nearby objects.

This looks to me like a nice argument and is claimed to also explain the Hubble tension. The model forces us to give up the standard Robertson-Walker cosmology. Qualitatively the proposal conforms with the notion of many-sheeted space-time predicting Russian doll cosmology defined by space-time sheets condensed on larger space-time sheets.

I have written two articles about what I call magnetic bubbles and used the term "mini big bang" [?, ?]. Supernova explosion would be one example of a mini big bang. Also planets would be created in mini big bangs.

But what about the galactic dark matter? TGD predicts an analog of dark energy as Kähler magnetic and volume energy of cosmic strings and of monopole flux tubes generated as they thicken and generate ordinary matter in the process is identifiable as galactic dark matter. No dark matter halo is predicted, only the cosmic strings and the monopole flux tube with much smaller string tension appearing in all scales, even in biology.

It should be noticed that TGD also predicts phases of ordinary matter with non-standard value of Planck constant behaving like dark matter. The transformation of ordinary matter to these kinds of phases explains the gradual disappearance of baryonic (and also leptonic) matter. These phases are absolutely essential in TGD inspired quantum biology and reside at the field bodies of the organisms with a much larger size than the organism itself and their quantum coherence induces the coherence of biomatter.

2.2.5 Dark energy weakens?

Quanta Magazine post (see this) tells about the evidence, found by DESI collaboration (see this), that dark energy is getting weaker. These findings challenge the very notion of dark energy, which is also theoretically problematic. There is the problem whether the dark energy corresponds to a modification of the gravitational part of the action obtained by replacing the curvature scalar by adding a volume term or a modification of the matter part of the action corresponding to exotic particles, quintessence, with a negative pressure.

In Big Think (see this) there is an article discussing in detail the claim about the claimed weakening of dark energy (see this). The article describes in detail the constraints on the ΛCDM model. It becomes clear that standard cosmology is a good parametrization of huge amounts of data but has a lot of problems and that the notion of dark energy is far from being elegant. The basic empirical inputs are as follows.

1. Cosmic microwave background (CMB) provides information about the basic parameters of the standard cosmology such as its age, the value of Hubble constant characterizing the expansion rate, and density matter. This information allows us to identify several anomalies. For instance, the Hubble constant seems to have two slightly different values. It would seem that Hubble constant depends on length scale but the notion of scale is lacking from the standard cosmology.

2. The finding that the radiation from supernovae of type I is weaker than expected led to the conclusion that cosmic expansion is accelerating. Cosmological constant characterizing dark energy density would at least parametrix the acceleration expansion in the general relativistic framework.

3. Baryonic acoustic oscillations (BAO) provide information about the large scale structure of the Universe and BAO led in the recent study to the conclusion that dark energy is weakening. BAO has also led to the conclusion that the density of baryonic matter is decreasing: as if baryons were disappearing. Are these two phenomena different aspects of the same phenomenon?

In TGD, the new view of space-times as 4-D surfaces in $H = M^4 \times CP_2$, predicts the analogy of cosmological constant as well as its weakening. Only an analogy is in question and the optimistic expectation is that this analogy gives rise to GRT type description at the QFT limit of TGD when many-sheeted space-time is replaced with a single slightly deformed region of empty Minkowski space.

1. String tension characterizes the energy density of a magnetic monopole flux tube, a 3-D surface in $H = M^4 \times CP_2$. String tension contains a volume part (direct analog of Λ) and Kähler magnetic part and it is a matter of taste whether one identifies the entire string tension or only the volume contribution as counterpart of Λ. In the primordial cosmology [?], cosmic string sheets have 2-D M^4 projection and 2-D CP_2 projection.

2. Cosmic strings are unstable against the thickening of their 2-D M^4 projection, which means that the energy density is gradually reduced in a sequence of phase transitions as thickenings of the cosmic string so that they become monopole flux tubes and give rise to galaxies and stars. The energy of cosmic strings is transformed to ordinary particles. This process is the TGD analog of inflation. No inflaton fields are required.

3. The string tension is gradually reduced in these phase transitions and in this sense one could say that dark energy is weakened. For instance, for hadronic strings it is rather small as compared to the original value of string tension during the primordial phase dominated by cosmic strings, at the molecular level the string tension of cosmic strings is really small.

4. The primordial string dominated phase was followed by a transition to the radiation dominated cosmology and emergence of Einsteinian space-time with 4-D M^4 projection so that general relativity and quantum field theory became good approximations explaining a lot of physics. Quantum field theory approximation cannot however explain the structures appearing in all scales and here monopole flux tubes are necessary.

5. TGD also predicts a hierarchy of effective Planck constants labelling phases of the ordinary matter behaving like dark matter in many respects. These phases would be quantum coherent in arbitrarily long scales. They would reside at the magnetic bodies consisting of monopole flux tubes and define a number theoretic complexity hierarchy highly relevant in quantum biology. The transformation of ordinary matter to this kind of dark matter would explain the observed apparent disappearance of baryons during cosmic evolution. In primordial cosmology cosmic strings as 4-D objects with 2-D M^4 projection would dominate: during this period one cannot speak of Einsteinian space-time as space-time surfaces with 4-D M^4 projection.

One can try to translate these analogies to a more detailed quantitative view of dark energy and dark matter.

1. The energy of the cosmic string contains two contributions: volume contribution and Kähler magnetic contribution. Their sum defines the galactic dark matter (see this), whose portion is about 26 percent of cosmic energy density, and it is concentrated at cosmic strings. Ordinary matter, about 5 percent of energy density emerges in the thickening of these cosmic strings as they form local tangles. The liberated energy transforms to ordinary matter. This is the TGD counterpart of inflation and cosmic strings carry the counterpart of matter assigned with the vacuum expectations of inflation fields.

2. What about the dark energy forming 85 percent of cosmic energy density? Does dark energy correspond to the energy associated with Minkowski space-time sheets as the energy associated with the volume action with Käher magnetic part being negligible. Could the volume contribution dominate or are the contributions of the same size scale? The cosmological constant would have a spectrum being inversely proportional to the p-adic length scale characterizing these space-time sheets. The value of the cosmological constant would not depend on time but on the scale of the space-time sheet and would decrease as a function of the scale. This might explain the latest findings if they are true.

3. One can ask whether only magnetic flux tubes and sheets are present at the fundamental level and whether cosmological constant corresponds to the energy assignable to large enough monopole flux tubes. Already flux tubes of the thickness of neuron size of about 10^{-4} m correspond to the extremely small value of cosmological constant deduced from cosmology. Also hadronic string tension corresponds to a particular value of cosmological constant.

2.2.6 Are standard candles so standard after all?

Sabine Hossenfelder told about findings suggesting that the notion of dark energy might not be needed after all (see this). The analysis of 100 supernovae known as standard candles by Perlmutter, Schmidt and Reese led to the Nobel prize 2011. The recent study by Son et al involving more than 3000 supernovae that should be standard candles however suggested that the Nobel prize was premature.

The article titled *Strong Progenitor Age-bias in Supernova Cosmology. II. Alignment with DESI BAO and Signs of a Non-Accelerating Universe* [?] (see this) concludes on basis of empirical data that the expansion, although it has been accelerating, is not accelerating anymore and might be even decelerating. The conclusion would be that there is no need for dark energy or at least that the cosmological constant is decreasing now.

Perlmutter, Schmidt and Reese studied supernovae of type Ia SNe known as standard candles assumed to have a peak luminosity, which does not depend on their age or the galaxy in which they belong. These supernovae typically have as progenitors which dwarfs, which are dead stars. These stars do not shine anymore. Since they can be regarded as the final states of stellar evolution, one can argue that their explosions yield the same peak luminosity so that they can serve as standard candles allowing a reliable determination of their distance from the redshift. If this were not the case, one should have a reliable model for the luminosity to deduce the distance.

The analysis of Son et al has, however, led to a conclusion that the luminosity of the standard candle correlates with the age of their progenitor. The younger the progenitor, the lower the peak luminosity. This conclusion is at 5.5 σ level. Therefore the distances estimated on the basis of standard candle assumption using redshift are too large. The actual distances would be smaller and no acceleration would be needed in the recent cosmology. Already the earlier findings by DESI suggested that acceleration has been decreasing which could be understood as a decrease of the cosmological constant Λ. If these findings are true they mean that the ΛCDM model is in grave difficulties. Even stellar models might be in difficulties if the properties of a white dwarf depend on the galactic environment they reside in.

The abstract of the article of Son et al gives a more technical summary.

Supernova (SN) cosmology is based on the key assumption that the luminosity standardization process of Type Ia SNe remains invariant with progenitor age. However, direct and extensive age measurements of SN host galaxies reveal a significant (5.5σ) *correlation between standardized SN* *magnitude and progenitor age, which is expected to introduce a serious systematic bias with redshift in SN cosmology. This systematic bias is largely uncorrected by the commonly used mass-step correction, as progenitor age and host galaxy mass evolve very differently with redshift.*

After correcting for this age-bias as a function of redshift, the SN dataset aligns more closely with the w0waCDM model recently suggested by the DESI BAO project from a combined analysis using only BAO and CMB data. This result is further supported by an evolution-free test that uses only SNe from young, coeval host galaxies across the full redshift range. When the three cosmological probes (SNe, BAO, CMB) are combined, we find a significantly stronger ($> 9\sigma$) tension with the ΛCDM model than that reported in the DESI papers, suggesting a time-varying dark energy equation of state in a currently non-accelerating universe.

What could be the interpretation of this finding in the TGD framework.

Consider first the TGD based view of cosmology.

1. In the TGD Universe cosmological constant-like parameter appears as a multiplier of the volume term of the action containing also Kähler action if the twistor lift of TGD, fixing the choice of $H = M^4 \times CP_2$ is accepted. Λ is inversely proportional to the square of the p-adic length scale characterizing the size scale of the space-time sheet and is proposed to satisfy the p-adic length scales hypothesis favor primes near powers of 2. An entire hierarchy of cosmological constants is predicted [?].

   If the observations determine the value of the cosmological constant reflect the p-adic size scale of the observable Universe at the moment when the radiation was emitted. Since this p-adic size scale correlates with the cosmic age, the observed cosmological constant should decrease with cosmic time. This could explain DESI observations.

2. Primordial cosmology is dominated by cosmic strings, unstable against thickening to monopole flux tubes. Flux tubes are characterized by thickness and length [?]. The scale defined by the cosmological constant emerging naturally in the twistor lift of TGD [?] corresponds to the p-adic length assignable to the length of the cosmic string.

   The flux tube thickness corresponding to the cosmological constant for standard cosmology is estimated to be about 10^{-4} meters. Also thinner and thicker flux tubes are possible and one cannot exclude space-time regions, which are small deformations of pieces of M^4 with a non-vanishing cosmological constant. Long cosmic strings explain galactic dark matter as energy of a cosmic string or a bundle of them transversal to the galactic plane.

3. Instead of gravitational condensation, the formation mechanism for the galaxies and stars in the TGD Universe is the thickening of the cosmic string leading to a liberation of its energy and the formation of flux tube tangles. This process would have been initiated by the topologically unavoidable collisions of cosmic strings.

   This mechanism is analogous to inflation [?, ?, ?, ?, ?] but quantum coherence in astrophysical scales due the arbitrarily large values of gravitational and electric Planck constants [?, ?] makes exponential expansion un-necessary.

TGD also suggests a radical modification of stellar physics and stellar evolution [?] based on new physics predicted by TGD [?]. This new view leads to a new view of how standard candles fail to be so standard.

1. TGD also allows to consider a radically new view of the Sun itself [?] based on the TGD based generalization of the standard model predicting a hierarchy of fractally scaled variants of the standard model [?]. The surface layers in which a phase transition transforming M_{89} hadrons to ordinary hadrons would produce solar wind and solar energy, rather than the fusion in the stellar core.

2. There would be the analog of metabolic energy feed as M_{89} hadrons from the galactic nucleus to the surface of the Sun. Interestingly, the spin axis of the galactic blackhole points towards the Earth.

3. In the Universe of the standard model, star ages as nuclear fusion burns the nuclear fuel in the core. In the TGD Universe, the fuel would be M_{89} hadrons decaying to ordinary

nuclei, producing solar wind and radiation, and forming a layer at the surface of the star rather than in its core. The heavier nuclei in the layer would sink to lower depths just as in the case of Earth. This suggests that the thickness of the layer of ordinary nuclei at the surface of the star increases with its age.

4. What could prevent the gravitational collapse of the star? Do the ordinary nuclei at the surface generate the pressure opposing gravitational force? There is indeed evidence for a solid phase in the surface of the Sun [?]. In the white dwarfs of the standard model, the fusion has ceased in the standard model and they produce only thermal radiation as they cool to eventually collapse to form a supernova. Also in the TGD framework, gravitational collapse leading to a supernova explosion occurs when the feed of M_{89} hadrons from the galactic nucleus has stopped and the star becomes a white dwarf.

5. The star with too low metabolic energy feed from the galactic blackhole starves and dies. Could stars die also at the young age, just as we do? If so, there would be a spectrum of white dwarfs and standard candles characterized by their life spans.

6. Why would the liberated energy, or at least the peak luminosity, be lower in the supernova explosion of the white dwarfs in galaxies of the earlier Universe? Could the reason be that they have not had enough time to collect ordinary matter at their surface serving in a role analogous to fat forming lipid layers of cells before the M_{89} hadron feed ceased? The biological analogy suggests that "cold fusion" as dark fusion at the surface layers could act like fat and produce energy and perhaps even solar wind and radiation energy when the M_{89} hadron feed has ceased.

   What is important, that the very selection of the white dwarf in early cosmology would select a star that died at a young age! In old galaxies the still existing white dwarfs would have reached a higher age!

7. Why should the metabolic energy feed relate to the activity of the galaxies? Dead galaxies do not give rise to a formation of stars. Is the reason that the metabolic energy source in f the galactic blackhole has depleted? Or have the long monopole flux tube pairs feeding M_{89} hadrons split by reconnections to short closed fluxed tubes? This mechanism could also explain solar spots and the solar cycle and also the changes of the orientation of the Earth's magnetic field. Could the failure of metabolic energy feed also explain the death of a star?

This view would conform with the gradually emerging vision that life, death and consciousness are present in all scales and that the basic phenomena of biology could have counterparts even in stellar and galactic physics.