Essay

Plausible Solution to the Hubble Constant Discrepancy

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Abstract

This comment was inspired about year after writing the above proposal by an interesting popular article about a possible explanation of Hubble constant discrepancy. The article told about a proposal of Lucas Lombriser discussed in the article *Consistency of the local Hubble constant with the cosmic microwave background* for an explanation of this discrepancy. The proposal is that the local region around our galaxy having size of order few hundred Mly - this is the scale of the large voids forming a honeycomb like structure containing galaxies at their boundaries - has average density of the matter 1/2 of that elsewhere. TGD suggests explanation of this finding in terms of p-adic length scale hypothesis favouring powers of 2 and predicted existence of two kinds of magnetic flux tubes: the monopole flux tubes carrying non-vanishing Kähler magnetic flux and crucial in the model of astrophysical objects as flux tube structures and flux tubes with vanishing induced Kähler field suggested to mediate gravitational interaction in very long scales. The large void around galaxy would correspond to flux tubes with string tension reduced by factor 1/2 from that in typical case.

1 Introduction

This comment was inspired about year after writing the above proposal by an interesting popular article about a possible explanation of Hubble constant discrepancy (`http://tinyurl.com/yd783ow6`). The article told about a proposal of Lucas Lombriser discussed in the article *Consistency of the local Hubble constant with the cosmic microwave background* [1] (`http://tinyurl.com/ycd4aenh`) for an explanation of this discrepancy. The proposal is that the local region around our galaxy having size of order few hundred Mly - this is the scale of the large voids forming a honeycomb like structure containing galaxies at their boundaries - has average density of the matter 1/2 of that elsewhere.

TGD suggests explanation of this finding in terms of p-adic length scale hypothesis favouring powers of 2 and predicted existence of two kinds of magnetic flux tubes: the monopole flux tubes carrying non-vanishing Kähler magnetic flux and crucial in the model of astrophysical objects as flux tube structures and flux tubes with vanishing induced Kähler field suggested to mediate gravitational interaction in very long scales [13]. The large void around galaxy would correspond to flux tubes with string tension reduced by factor 1/2 from that in typical case. This void would be one step ahead in cosmological evolution proceeding by phase transitions reducing the string tension of monopole flux tubes by factor 1/2 at least.

2 The new view about the origin of discrepancy

Consider first the discrepancy. The determination of Hubble constant characterizing the expansion rate of the Universe can be deduced from cosmic microwave background (CMB). This corresponds to long length scales and gives value $H_{cosmo} = 67.4$ km/s/Mpc. Hubble constant can be also deduced from local measurements using so called standard candles in the scales of large voids. This gives Hubble constant $H_{loc} = 75.7$ km/s/Mpc, which is by about 10 percent higher.

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2.1 Is the discrepancy due to reduction of mass density in the local environment of galaxy

The argument of the article is rather simple.

1. It is a well-known fact that Universe decomposes into giant voids with size scale of 10^8 light years. The postulated local region would have this size and mass density would be reduced by factor 1/2.

   Suppose that standard candles used to determine Hubble constant belong to this void so that density is lower than average density. This would mean that the Hubble constant H_{loc} for local measurements of Hubble constant using standar candles would be higher than H_{cosmo} from measurements of CMB.

2. Consider the geometry side of Einstein's equations. Hubble constant squared is given by

$$H^2 = (\frac{dlog(a)}{dt})^2 = \frac{1}{g_{aa} \times a^2} \quad .$$

   Here one has $dt^2 = g_{aa}da^2$. t is proper time for a comoving observer and a is the scale factor in the spatial part of Robertson-Walker metric. The reduction of H^2 is caused by the increase of g_{aa} as the density decreases. At the limit of empty cosmology (future light-one) $g_{aa} = 1$. Hubble constant is largest at this limit for given a, which in TGD framework corresponds to light-cone proper time coordinate.

3. The matter side of Einstein's equations gives

$$H^2 = \frac{8\pi G}{3}\rho_m + \frac{\Lambda}{3} .$$

   The first contribution corresponds to matter and second dark energy, which dominates.

4. It turns out that be reducing ρ_m by factor 1/2, the value of H_{loc} is reduced by about 10 percent so that H_{loc} agrees with H_{cosmo}.

2.2 Could one understand the finding in TGD framework?

It seems that Hubble constant depends on scale. This would be natural in TGD Universe since TGD predicts p-adic hierarchy of scales coming as half octaves. One can say that many-sheeted space-time gives rise to fractal cosmology or Russian doll cosmology.

Cosmological parameters would depend on scale. For instance, cosmological constant would come naturally as octave of basic values and approach to zero in long length scales. Usually it is constant and this leads to the well-known problem since its value would be huge by estimates in very short length scales. Also its sign comes out wrong in super string theories whereas twistor lift of TGD predicts its sign correctly.

I have already earlier tried to understand the discrepancy in TGD framework in terms of many-sheeted space-time [3, **?**] suggesting that Hubble constant depends on space-time sheet - first attempts were first applications of TGD inspired cosmology for decades ago - but have not found a really satisfactory model. The new finding involving factor 1/2 characteristic for p-adic length scale hierarchy however raises hopes about progress at the level of details.

1. TGD predicts fractal cosmology as a kind of Russian doll cosmology in which the value of Hubble constant depends on the size scale of space-time sheet. p-Adic length scale hypothesis states that the scale comes in octaves. One could therefore argue that the reduction of mass density by factor 1/2 in the local void is natural. One can however find objections.

2. The mass density scales as $1/a^3$ and one could argue that the scaling could be like $2^{-3/2}$ if p-adic length scale increas by factor 2. Here one can argue that in TGD framework matter is at magnetic flux tubes and the density therefore scales down by factor 1/2 meaning reduction of string tension by this factor.

3. One can argue that also the cosmological term in mass density would naturally scale down by 1/2 as p-adic length scales is scaled up by 2. If this happened the Hubble constant would be reduced by factor $1/2^{1/2}$ roughly since dark energy dominates. This does not happen.

   Should one assign dark energy parameter Ω to a space-time sheet having scale considerably larger than that those carrying the galactic matter? Should one regarded large void as a local sub-cosmology topologically condensed on much larger cosmology characterized by Ω? But why not use Ω associated with the sub-cosmology? Could it be that the Ω of sub-cosmology is included in ρ_m?

Could the following explanation work? TGD predicts two kinds of magnetic flux tubes: monopole flux tubes, which ordinary cosmologies and Maxwellian electrodynamics do not allow and ordinary flux tubes representing counterparts of Maxwellian magnetic fields. Monopole flux tubes need not currents to generate their magnetic fields and this solves several mysteries related to magnetism: for instance, one can understand why Earth's magnetic field has not decayed long time ago by the dissipation of the currents creating it. Also the existences of magnetic fields in cosmic scales impossible in standard cosmology finds explanations.

1. First kind of flux tubes carry only volume energy since the induced Kähler form vanishes for them and Kähler action is vanishing. There are however induced electroweak gauge fields present at them. I have tentatively identified the flux tubes mediating gravitational interaction with these as these flux tubes.

   Could Ω correspond to cosmological constant assignable to gravitational flux tubes involving only volume energy and be same also in the local void? This because they mediate very long range and non-screened gravitational interaction and correspond to very long length scales.

2. Second kind of flux tubes carry non-vanishing monopole flux associated with the Kähler form and the energy density is sum of volume term and Kähler term. These flux tubes would be carriers of dark energy generating gravitational field orthogonal to the flux tubes explaining the flat velocity spectrum for distant stars around galaxies. These flux tubes be present in all scales would play central role in TGD based model of galaxies, stars, planets, quantum biology, molecular and atomic physics, nuclear physics and hadron physics.

   These flux tubes suffer phase transitions increasing their thickness by factor 2 and reducing the energy density by factor 1/2. This decreases gradually the value of energy density associated with them.

   Could the density ρ_m of matter correspond to the density of matter containing contributions from monopole flux tubes and their decay products: ρ_m would therefore contain also the contribution from both magnetic and volume energy of flux tubes. Could it have been scaled down in a phase transition reducing locally the value of string tension for these flux tubes. Our local void would be one step further in the cosmic evolution by reductions and have experience one more expansions of flux tube thickness by half octave than matter elsewhere.

To sum up, this model would rely on the prediction that there are two kinds of flux tubes and that the cosmic evolution proceeds by phase transitions increasing p-adic length scale by half octave reducing the energy density by factor 1/2 at flux tubes. The local void would be one step further in cosmic evolution as compared to a typical void.

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