Fluctuations of Newton's constant in sub-millimeter scales as evidence for TGD

M. Pitkänen
Email: matpitka6@gmail.com.
http://tgdtheory.com/.

June 20, 2019

Abstract

Washington group has reported evidence for the variation of the effective value of Newton's constant in sub-millimeter scales. The proposed interpretation in terms of spatially oscillating variation of the effective value of G does not look convincing. In this article the interpretation as fluctuations in the value of G predicted by TGD is discussed. The fluctuations are predicted to be make themselves visible in p-adic lengths scales assignable to the density of vacuum energy. The correspondence between these relatively short p-adic length scales and the hierarchy of cosmological p-adic length scales defined by length scale dependent cosmological constant Λ suggests that gravitational physics at short and long length scales reflect each other. Biologically interesting p-adic length scales would be of special interest quantum gravitationally.

Contents

1 Introduction

Sabine Hossenfelder had a post with link to an article "*Hints of Modified Gravity in Cosmos and in the Lab?*" [E3] (see http://tinyurl.com/y6j8sntw). Here is the part of abstract that I find the most interesting.

On sub-millimeter scales we show an analysis of the data of the Washington experiment (Kapner et al. (2007) searching for modifications of Newton's Law on sub-millimeter scales and demonstrate that a spatially oscillating signal is hidden in this dataset. We show that even though this signal cannot be explained in the context of standard modified theories (viable scalar tensor and f(R) theories), it is a rather generic prediction of nonlocal gravity theories.

What is interesting from TGD point of view that the effect - if it is indeed real - appears in scale of .085 mm about 10^{-4} μm, which is the scale defined by the density of dark energy in recent universe and thus by cosmological constant. This is also size scale of large neuron.

Washington group studied gravitational torque on torque pendulum for sub-millimeter distances of masses involved [E2] (see http://tinyurl.com/y2un6686). Figure 19 of [E3] (see http://tinyurl.com/y6j8sntw) illustrates data points representing the deviation of the gravitational torque from the Newtonian prediction as a function of distance in the range .05-10 mm.

The deviation can be parameterized in terms of effective scaling $G \rightarrow kG$ of Newton's constant, which is assumed to be predictable rather than due to fluctuations and depend on the distance only

$$k = 1 + xcos(\frac{2\pi r}{\lambda} + \frac{3\pi}{4}) \ .$$

x is a numerical parameter. The highly non-trivial assumption is that Newton's potential is modified by an oscillating term, which must go to zero at large distances: its amplitude could approach to zero like $1/r$. The model predicts an anomalous gravitational torque $\Delta\tau$ proportional to $k-1$ and having the form

$$\Delta\tau = acos(\frac{2\pi r}{\lambda} + \frac{3\pi}{4}) \ ,$$

where r is the distance between the masses. The parameter $\lambda = \hbar/m$ is formally analogous to Compton length for imaginary mass m.

The finding is that the statistical significance for the best fit to the data is $(a,\lambda) = (0.004 \ \ fNm, 65 \ \ mm^{-1})$ is more than 3σ, where a is the amplitude of the deviation. The highly non-trivial problem is however that one obtains also other minima of χ^2 measuring the goodness of the fit with different values of the parameter λ.

I am not specialist but while looking at the data, I cannot avoid the feeling that the fit does not make much sense and reflects theoretical prejudices (belief in modified gravity of some kind) rather than reality. My first impression that fluctuations in the value of Newton's constant G are in question.

The value of G is indeed known to vary from experiment to experiment and the variation is too large to be explained in terms of measurement inaccuracies. The last link of this kind was to a popular article (see `http://tinyurl.com/ya2wekch`) telling about the article [E4] (see `http://tinyurl.com/yanvzxj6`) reporting measurements of Newton's constant G carried out by Chinese physicists Shan-Qing Yang, Cheng-Gang Shao, Jun Luo and colleagues at the Huazhong University of Science and Technology and other institutes in China and Russia. The outcomes of two experiments using different methods differ more than the uncertainties in the experiments, which forces to consider the possibility that G can vary.

Could it be that the value of G fluctuates, and for some reason in the length scale range around .1 mm the fluctuations are especially large meaning different values of G are large? Could some kind of criticality enhanced rather dramatically below .1 mm be involved?

2 Could fluctuations in the value of G explain the findings?

Twistor lift of TGD [K3, K4, K2, K5] predicts that cosmological constant is length scale dependent and that Newton's constant G has a spectrum reflecting the spectrum of effective Planck constant $h_{eff} = nh_0$ ($h = 6h_0$ is a good guess [L1]): dark matter would correspond to $h_{eff} = nh_0$ phases of ordinary matter.

p-Adic length scale hypothesis allows to assign to cosmological constant Λ two length scales: the cosmological p-adic scale defined by Λ itself and the short p-adic length scale determined by the density of dark energy so that physics is cosmological scales and physics in microscopic scales reflect each other.

This encourages the idea that one might understand the experimental findings in terms of fluctuations of G induced by quantum fluctuations of h_{eff} at quantum criticality.

1. TGD suggests a spectrum for the values of G. The starting points is the expression for the effective Planck constant ass $h_{eff} = n \times h_0$. In adelic physics the value of n is identified as the number of sheets for the space-time surface as covering space and would correspond to the order of Galois group of extension of rationals inducing the extensions of p-adic number fields appearing in the adele [L2, L3].

2. An additional hypothesis is that space-time surface can be regarded as covering of both M^4 and CP_2 with numbers of sheets equal to n_1 and n_2: $n = n_1 n_2$. The number of sheets over M^4 would be n_1 so that CP_2 coordinates would be n_1-valued functions of M^4 coordinates. The number of sheets over CP_2 would be n_2 and one would have effective n_2 copies of n_1 valued regions in M^4.

   The gravitational Planck constant $\hbar_{gr} = GMm/v_0$ originally introduced by Nottale [E1] is proposed to correspond to $\hbar_{eff} = \hbar_{gr} = n_1 n_2 \hbar_0$. The real Planck length $l_P(real)$ would correspond to $l_P(real) = R$, the CP_2 size scale identified as geodesic length, and Newton's constant would correspond to

$$G = \frac{R^2}{\hbar_1} = \frac{R^2}{n_1\hbar_0} \quad .$$

One would have $n_1 \sim 6 \times 10^7$ from $l_P^2/R^2 \sim 10^7$.

3. The value of n_1 can fluctuate and induce fluctuations of G. The fluctuations could be even large. One can even ask whether the fountain effect of superfluidity involves a large value of n_1 responsible for macroscopic quantum coherence and due to the increase of the value of $\hbar eff$ caused the increase of n_1 in turn reducing the value of G [K1].

   Could the fluctuations of n_1 explain the findings about the value of G deduced from Washington experiment? The appearance of several values for parameter λ might signal about fluctuations of G rather than modification of the radial dependence of gravitational potential.

Why the fluctuations in the value of G would be so large in sub-millimeter length scales?

1. Cosmological constant $\Lambda \simeq 1.1 \times 10^{-52}$ m^{-2} has dimension of $1/L^2$, L length scale. The density of dark energy $\rho_{vac} = \Lambda/8\pi G$ has dimensions of $\hbar/L^4$. One can assign to Λ very long p-adic length scale $L(k_1) = 2^{k_1/2}R$ ($p_1 \simeq 2^{k_1}$), and to $\rho_{vac}/\hbar$ rather short p-adic length scale $L(k_2) = 2^{k_2/2}R$. One has

$$\frac{\rho_{vac}}{\hbar} = \frac{x_2}{L(k_2)^4} = \frac{x_1}{8\pi}\frac{1}{l_P^2 L(k_1)^2} \quad ,$$

   where x_1 and x_2 are numerical constants not far from unity. This would give

$$L(k_2) = (8\pi\frac{x_2}{x_1})^{1/4}(L(k_1)l_P)^{1/2} \quad .$$

   $L(k_2)$ would be proportional the geometric mean of $L(k_1)$ and l_P. This implies

$$2^{2k_2} = \frac{x_2}{x_1} \times 8\pi \times (\frac{l_P}{R})^2 \times 2^{k_1} \quad .$$

   Very roughly, $k_1 \sim 2k_2 - 28$ would hold true for $x_2/x_1 \sim 1$. It turns out that k_2 corresponds to a p-adic length scale about 10^{-4} meters, which happens to be the size of large neuron suggesting that quantum gravitation is indeed highly relevant to biology but in manner different from that speculated by Penrose.

2. p-Adic fractality suggests that cosmological constant is not actually constant or even time varying but depends on p-adic length scales so that the values are indeed extremely large as one approaches CP_2 scale and get very small as one approaches cosmological scales. This would solve the cosmological constant problem. The dependence would be $\Lambda(k) \propto 1/L(k)^2$, where $L(k)$ is the p-adic length scale characterizing the size of the space-time sheet. There would be a sequence of phase transition reducing Λ and these phase transition would involve quantum criticality and long length scale fluctuations possibly assignable to those of h_{eff} and thus of n_2 and G.

   If one assumes that k_2 corresponds to preferred p-adic lengths scales assignable to elementary particles, nuclei, atomic physics and biology, one obtains a prediction that the corresponding p-adic length scales correspond to cosmologically important length scales via $k_1 \sim 2k_2$. One could study cosmology by studying gravitation in laboratory scales!

   In these scales quantum phase transitions changing cosmological constant could make themselves visible via microscopic physics. Phase transitions involve long length scale fluctuations characteristic for criticality. In TGD these quantum fluctuations correspond to fluctuations of h_{eff} since Compton lengths scale like h_{eff}. The fluctuations of n_1 in $n = \hbar_{eff}/\hbar = n_1 n_2$ would induce fluctuations of G.

3. Especially interesting are the p-adic length scales which are biologically important. The number theoretical miracle is that there are as many as 4 very closely located Gaussian Mersenne primes $M_{G,n} = (1+i)^m - 1$ in the range of cell membrane thickness and size of cell nucleus corresponding to $k = 151, 157, 163, 167$. The corresponding p-adic length scales $L(k) = 2^{(k-151)/2}L(151)$, $L(151) \simeq 10$ nm could be also gravitationally especially interesting. The hierarchical coiling of DNA might relate to the hierarchy of Gaussian Mersennes and phase transitions changing cosmological constant and the density of magnetic and volume energies assignable to the magnetic flux tubes playing key role in TGD inspired biology. These phase transitions would scale the thickness of the flux tubes determined by p-adic lengths scale.

   It should be relatively easy to check whether the p-adic length scale hierarchy up to biological length scales has scaled variant in astrophysical and cosmological scales.

REFERENCES

Cosmology and Astro-Physics

[E1] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity. Available at: http://arxiv.org/abs/astro-ph/0310036, 2003.

[E2] Kapner DJ et al. Tests of the Gravitational Inverse-Square Law below the Dark-Energy Length Scale. *Phys Rev Lett.*Available at*: https://arxiv.org/abs/hep-ph/0611184*, 98(021101), 2007.

[E3] Perivolaropoulos L and Kazantzidis L. Hints of Modified Gravity in Cosmos and in the Lab? Available at:https://arxiv.org/pdf/1904.09462.pdf, 2019.

[E4] Sao CG et al Yang SQ. Measurements of the gravitational constant using two independent methods. *Nature.* Available at:https://www.nature.com/articles/s41586-018-0431-5, 560:582–588, 2018.

Books related to TGD

[K1] Pitkänen M. Criticality and dark matter. In *Hyper-finite Factors and Dark Matter Hierarchy.* Online book. Available at: http://www.tgdtheory.fi/tgdhtml/neuplanck.html#qcritdark, 2014.

[K2] Pitkänen M. About twistor lift of TGD? In *Towards M-Matrix.* Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdquantum.html#hgrtwistor, 2016.

[K3] Pitkänen M. The classical part of the twistor story. In *Towards M-Matrix.* Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdquantum.html#twistorstory, 2016.

[K4] Pitkänen M. Some questions related to the twistor lift of TGD. In *Towards M-Matrix.* Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdquantum.html#twistquestions, 2017.

[K5] Pitkänen M. The Recent View about Twistorialization in TGD Framework. In *Towards M-Matrix.* Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdquantum.html#smatrix, 2018.

Articles about TGD

[L1] Pitkänen M. Hydrinos again. Available at: http://tgdtheory.fi/public_html/articles/Millsagain.pdf, 2016.

[L2] Pitkänen M. Philosophy of Adelic Physics. Available at: http://tgdtheory.fi/public_html/articles/adelephysics.pdf, 2017.

[L3] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.