Different expectations about quantum gravity

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Abstract

The desire to quantize general relativity to unify it with quantum mechanics gave not very much up to now; some predicted effects lie very far in the Planck scale to be observed in the foreseeable future. The situation is different in the model of low-energy quantum gravity by the author where some known effects (such as the cosmological redshift) may be interpreted as results of the interaction of gravitons with photons or bodies. The Newton constant *G* may be computed in the model that makes it principally underlying for general relativity. Important features of the model and some possibilities to verify it at present are discussed here.

1 Introduction

There exist very different approaches to unify general relativity with quantum mechanics or with the standard model of particle physics (SM), but there are almost not theoretical predictions which may be verified by experiments or observations. Known predictions, if the ones are possible, concern mainly Planck-scale physics and geometry, for example, foamy space-time in loop quantum gravity. Quantum gravity effects may lead to the observable dispersion of light in vacuum, that may be verified by cosmological observations [1]. This poorness of theoretical predictions of existing models and the absence of manifestations of quantum gravity accepted by the scientific community make the situation around quantum gravity very vague: theorists are not sure in the validity of used approaches, experimentalists and observers do not know what to search to help them. Taking into account logical difficulties of existing approaches, the main sought by H. Nicolai [2] about the situation is that we have no other choice but to try to create a future consistent theory out of purely theoretical basics. It seems that one of the possible ways is to choose some symmetry group which may lead us further as it was by the creation of the SM. But the SM's symmetries were established due to big experimental efforts. From another side, as it was shown in my papers [3, 4], the SM's continuous symmetries may result from underlying discrete symmetries if the fundamental fermions are the two-component composite particles. In any case, even the appearance of the consistent model of quantum gravity talking us about Planck-scale physics cannot help to understand why micro particles prefer not to move along geodesics by small energies which are very far from the Planck scale. Perhaps, we should search and introduce some more non-evident ideas to come nearer to the unknown quantum nature of gravity.

Here I would like to describe some important features of my model of low-energy quantum gravity [5, 6] and possibilities to verify it by cosmological observations and in ground-based experiments.

2 Important features of the model of low-energy quantum gravity

Contrary to the idea that gravity is geometry, the model is based on the suggestion that gravity is a fully quantum phenomenon, while geometry is only a language to describe an average behavior of big bodies interacting with the graviton background. The geometrical language seems in this model to be restricted very far from the Planck scales of energies and distances. The main assumption of the model is the existence of the background of super-strong interacting gravitons. Its temperature T defines values of the Newton constant and of the Hubble constant, so that: $G \sim T^6$ and $H_0 \sim T^5$. The inverse-square law of classical gravity describes the main quantum effect of this model. The possibility to calculate G makes the model underlying for general relativity, too. For micro particles, single acts of interactions with gravitons of the background should lead to their stochastic motion. Perhaps, quantum mechanics gives an indirect description of this motion. It would be interesting to prove this assumption, but most likely it will be necessary for this purpose to create some updated version of quantum mechanics taking into account the existence of the graviton background. The Hubble constant is not connected here with any expansion of the universe, but only with energy losses of photons moving through the graviton background due to forehead collisions with gravitons. There exists an additional effect of decreasing the number of photons in a propagating beam due to non-forehead collisions with gravitons which allows to get along without any dark energy in interpreting cosmological observations. These two effects give the luminosity distance/redshift relation:

$$D_L(z) = c/H_0 \cdot \ln(1 + z) \cdot (1 + z)^{(1+b)/2}, \tag{1}$$

where the "constant" b belongs to the range 0 - 2.137 ($b = 2.137$ for very soft radiation, and $b \to 0$ for very hard one). This relation fits cosmological observations of remote sources very well without dark energy.

The geometrical distance/redshift relation of this model: $r(z) = ln(1 + z)\, c/H_0$, where H_0 is the Hubble constant, c is the velocity of light, leads to the volume/redshift relation:

$$V(z) = 4/3 \cdot \pi(ln(1+z) \cdot c/H_0)^3 \equiv A \cdot (ln(1+z))^3, \tag{2}$$

where $A \equiv 4/3\ \pi(c/H_0)^3 = 13627$ Gyr^3 by the theoretical value of H_0 in the model: $H_0 = 2.14 \cdot 10^{-18}\ s^{-1} = 66.875\ km \cdot s^{-1}\ Mpc^{-1}$. The derivative of this function is equal to:

$$\frac{dV}{dz} = \frac{3A}{1+z} \cdot (ln(1+z))^2. \tag{3}$$

Its graph is shown in Fig. 1. The derivative has a maximum near $z = 6.4$, and further it decreases more than 2.5 times up to $z = 100$. An observer may conclude that the universe becomes more and more empty by $z > 6.4$, if a concentration of galaxies remains really constant.

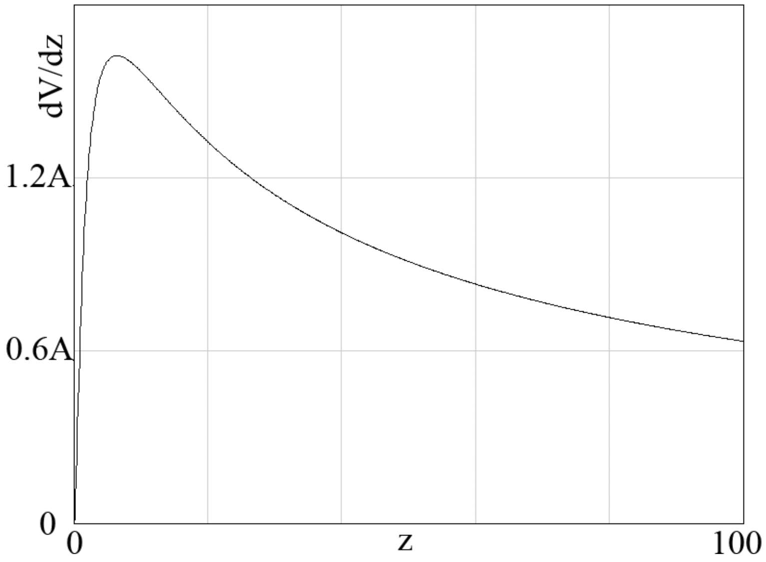

Figure 1: The graph of derivative $\frac{dV}{dz}$ for a big range of z.

There exists an additional deceleration w of massive bodies moving through the graviton background:

$$w = -w_0 \cdot 4\eta^2 \cdot (1-\eta^2)^{0.5}, \tag{4}$$

where $\eta \equiv v/c$, v is a body velocity, m is its mass, $w_0 \equiv H_0 c = 6.419\ 10^{-10}\ m/s^2$, if we use the theoretical value of H_0 in the model. This anomalous deceleration leads to the absence of exactly closed orbits and to the non-planar motion of massive bodies in the central field by some conditions [7].

In the model, the attractive force between bodies results from the pressure of external gravitons and of the ones scattered by bodies. It means that the existence of black holes should lead in a frame of it to the violation of the equivalence principle because inertial and gravitational masses of black holes cannot be equal if black holes do not scatter gravitons, too.

3 Some possibilities to verify the model

The Newton constant G has been measured up to now with the relative standard uncertainty only $\sim 10^{-4}$ (about the long story of these measurements, see [8]). In the model, the Newton constant arises as an average value of the stochastic variable characterizing the interaction of a couple of bodies with a huge number of gravitons. Uncertainties of G and T are connected as:

$$\frac{\Delta G}{G} = 6 \frac{\Delta T}{T}.$$

If fluctuations of the temperature of the graviton background have the same order of magnitude as the ones of the CMB temperature, then $\Delta G/G \leq 6\ 10^{-4}$. It is important that measured values of G may depend on the orientation of two bodies relatively of remote stars. Further attempts to measure G taking into account these circumstances may be interesting for the verification.

In this model, the luminosity distance is a multivalued function of the redshift due to different values of the factor b for soft and hard radiation. It opens another way to verify the model by cosmological observations comparing the Hubble diagrams of sources with different spectra. But to realize it we should have the possibility to calibrate the luminosity, for example, of remote GRBs independently of the Hubble diagram of supernovae Ia.

The Hubble parameter $H(z)$ of this model is a linear function of z: $H(z) = H_0 \cdot (1 + z)$ (as well as in the $R_h = ct$ cosmological model [9]), that is in a big discrepancy with ΛCDM. As it was shown, this function fits available observations of $H(z)$ very well [6, 9], and further investigations of this problem are important.

The most important cosmological consequence of the model is the local quantum nature of redshifts of remote objects. At present, advanced *LIGO* technologies may be partly used to verify this redshift mechanism in a ground-based laser experiment [6]. One should compare spectra of laser radiation before and after passing some big distance in a high-vacuum tube. If one constructs a future version of the *LIGO* detector with some additional equipment, the verification of the redshift mechanism may be performed in parallel with the main task or during a calibration stage of the detector. The positive expected result of such the experiment would mean also that the universe does not expand.

4 Conclusion

It seems that to open minds for the broader perception of possible manifestations of quantum gravity and ways to its future theory, we should doubt in some commonly accepted things. The very bright example is the claimed existence of dark energy that is unnecessary in the considered model. If redshifts of remote objects have the local quantum nature, the expansion of the universe becomes not necessary, and some observable effects may be interpreted as the long-awaited exhibition of quantum gravity but in the absolutely unexpected scale of energies $\sim 10^{-3}$ eV. This scale may move us much closer to the understanding of the existing chasm between general relativity and quantum mechanics. And, perhaps, it can give us chances to construct if not a bridge between them, then a new common base for both.

References

[1] Amelino-Camelia, G., and Smolin, L. Prospects for constraining quantum gravity dispersion with near term observations [arXiv:0906.3731v3 [astro-ph.HE]].

[2] Nicolai, H. Gravity's quantum side. [https://cerncourier.com/a/gravitys-quantum-side/].

[3] Ivanov, M.A. The system of equations describing 4 generations with the symmetry group $SU(3)_C \times SU(2)_L \times U(1)$ (in Russian). Deposited in VINITY 19.12.1988 as VINITI No 8842-B88; in English: [https://vixra.org/pdf/2006.0185v2.pdf].

[4] Ivanov, M.A. Primary postulates of the standard model as consequences of the composite nature of the fundamental fermions. *Nuovo Cimento* 1992, *105A,* 77; [hep-th/0207210].

[5] Ivanov, M.A. Gravitons as super-strong interacting particles, and low-energy quantum gravity. In the book "Focus on Quantum Gravity Research", Ed. D.C. Moore, Nova Science, NY - 2006 - pp. 89-120; [hep-th/0506189].

[6] Ivanov, M.A. Selected papers on low-energy quantum gravity. [http://ivanovma.narod.ru/selected-papers-Ivanov2018.pdf].

[7] Ivanov, M.A. Low-energy quantum gravity and cosmology without dark energy. Advances in Astrophysics, 2019, Vol. 4, No. 1, pp 1-6.

[8] Wu, Junfei et al. Progress in Precise Measurements of the Gravitational Constant. *Annalen Phys. 531* (2019) 5, 1900013.

[9] Melia, F., and Yennapureddy, M.K. Model selection using cosmic chronometers with Gaussian Processes. *JCAP* 02, 034 (2018); [arXiv:1802.02255v2 [astro-ph.CO]].