Low-energy quantum gravity: some prospects in cosmology and astrophysics

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Abstract

A model of low-energy quantum gravity by the author may have very essential cosmological and astrophysical impacts. I consider here the following aspects of the model: it does not need any form of dark energy to fit observations; a constant deceleration of massive bodies by the graviton background may be a cause of non-classical motion of bodies by very small gravitational accelerations; a full mass of black hole should be restricted from the bottom, and inertial and gravitational masses of a black hole are different.

1 Introduction

Gravity is in touch with everybody in any moment of our life, and we are sure that it is described and understood very well. But what is a mechanism of gravity? It is an open question today, because this mechanism should be quantum, but quantum gravity is only a theoretical dream - existing models have such a poor pool of new predictions that they seem to be not needed for any serious affair. From another side, quantum mechanics describes the wave properties of any micro-particle without any connection with such a general phenomenon as gravity and in the obvious contradiction with general relativity demanding a definite trajectory for any particle. One cannot exclude a possibility of an existence of some unexpected missing link between them, for example quantum mechanics might be interpreted as a formal result of a universal (i. e. gravitational) interaction of any particle with a sea of carriers of gravity, when general relativity may be an average result of such the quantum interaction in some approximation. In this case, we should search for their common origin and common roots, but not for quantization of the geometrical description. It is only a conjecture, but it may be not so far from reality.

It is known from observations, that by very small accelerations in galaxies velocities of stars essentially differ from classical expectations [1]. It would mean that the theory of general relativity is not applicable on the galactic scale of distances, then its application on bigger scales is not valid a fortiori.

I would like to describe here some consequences of my model of quantum gravity based on a new conjecture about an existence of the background of super-strong interacting gravitons [2, 3]. The model contains a fine quantum mechanism of classical gravity, a mechanism of redshift and additional relaxation of any photonic flux, and has a property of asymptotic freedom at very short distances.

2 The Hubble diagram of the model and observations

To fit observations of Supernovae 1A and GRBs in this model without dark energy, it is necessary to take into account the following three facts: 1) forehead collisions with gravitons lead to the redshift of photons, 2) non-forehead collisions with gravitons give an additional relaxation of a photon flux, caused by transmission of a momentum transversal component to some photons, 3) the correction of observations for time dilation of the standard cosmological model should be deleted for this model without time dilation. In this model, the luminosity distance is

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

where H is the Hubble constant and c is the light velocity. The theoretical value of relaxation factor b for a soft radiation is $b = 2.137$. As you can see

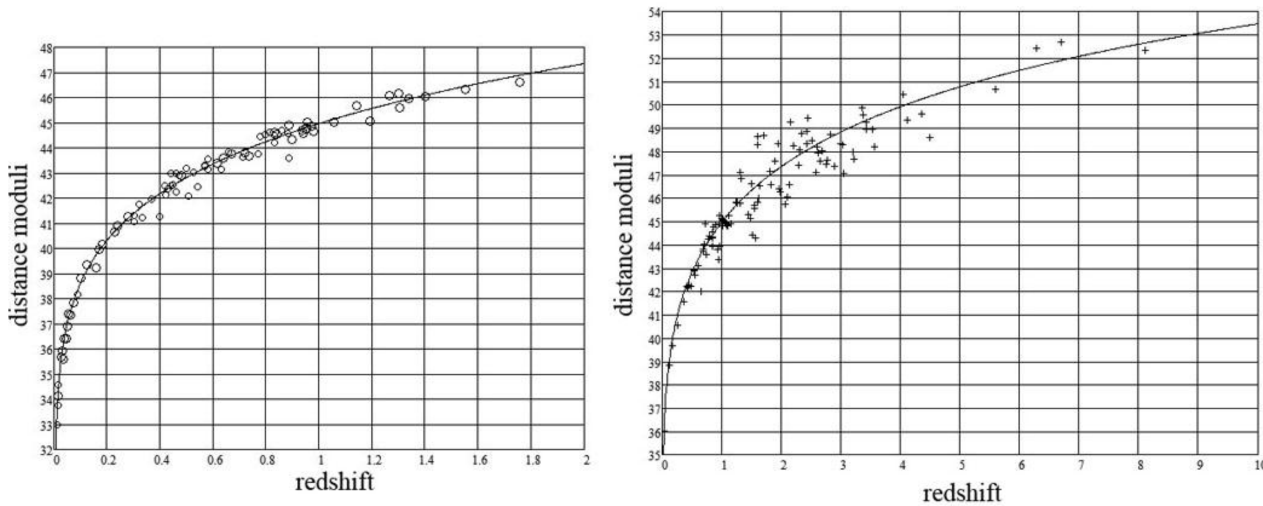

Figure 1: The theoretical Hubble diagram $\mu_0(z)$ of this model with $b = 2.137$ (solid); Supernovae 1a observational data (circles, 82 points) are taken from Table 5 of [4] and corrected for no time dilation (left panel); GRBs calibrated observational data (pluses, 109 points) from Tables 1 and 2 of [5] corrected for no time dilation (right panel).

on Fig. 1, observations after correction for no time dilation (distance moduli μ_0 found from observations and corrected for time dilation of the standard cosmological model should be reverse replaced as $\mu_0 \to \mu_0 + 2.5 \log(1+z)$) are in a very good agreement with the theoretical Hubble diagram of the model.

The universe is not expanding in it; of course, this fact is much more important than full absence of dark energy. Due to the origin of redshifts in the model, the special theory of relativity may not be an exact model on any scale of distances, but deviations from it should be proportional to the characteristic redshift in a considered empty area, i.e. the ones are negligible for any laboratory experiment.

3 A non-classical motion of bodies by very small gravitational accelerations

Due to only forehead collisions with gravitons, the deceleration of massive bodies in this model is equal to:

$$w = -Hc(1 - V^2/c^2), \tag{2}$$

where V is a body's velocity relative to the graviton background [2, 3]. This deceleration may be connected with the Pioneer anomaly [6]. For small velocities: $w \simeq -Hc$. This deceleration is universal, and in a bound system of two bodies with very different masses, if we consider a motion of a smaller body relative to its more massive partner with a velocity $\mathbf{v}$, it is necessary to take into account the force of inertia. In the Newtonian approach, if $\mathbf{u}$ is a more massive body's velocity relative to the background, M is its mass, and $\mathbf{v} + \mathbf{u}$ is such the velocity of the small body, we will have the following equation of motion of the small body:

$$\ddot{\mathbf{r}} = -G\frac{M}{r^2} \cdot \frac{\mathbf{r}}{r} + w(\frac{\mathbf{u}}{u} - \frac{\mathbf{v} + \mathbf{u}}{\mid \mathbf{v} + \mathbf{u} \mid}), \tag{3}$$

where $\mathbf{r}$ is a radius-vector of the small body, G is Newton's constant. Using the theoretical value of H in this model: $H = 2.14 \cdot 10^{-18}\ s^{-1}$, we have: $w \simeq 6.42 \cdot 10^{-10}\ m/s^2$. It is necessary to investigate this equation for the case of a star moving relative to a galactic center, to understand how this modification is connected with the problem of dark matter.

There is also another important cause of mimicking dark matter in the model: due to destruction of graviton pairs on their way through a central part of galaxy, the gravitational attraction to the center should be stronger on a periphery.

4 A situation with black holes in the model

Since 1916 when K. Schwarzschild found a solution of Einstein's equations for a point mass a lot of papers and books appears about black holes; physicists trust that these objects exist and, as many people think, are observed in cosmos, for example that supermassive black holes are in the centers of most galaxies. By absence of a mechanism of gravity in general relativity, there are not essential constraints on formation of black holes from usual matter.

But in the considered model such the mechanism exists, and it leads to some interesting consequences. One of them is the following: inertial and gravitational masses of a black hole are different. In the model, screening the background of super-strong interacting gravitons creates for any pair of bodies both attraction and repulsion forces due to pressure of gravitons, and each of them is approximately 1000 times bigger than a force of Newtonian attraction. For single gravitons, these forces are approximately equal. But an attraction force due to pressure of graviton pairs is twice exceeding a corresponding repulsion force if graviton pairs are destructed by collisions with a normal body (this quantum mechanism of classical gravity is obviously asymmetric relative to the time inversion, i.e. namely the inverse square law of gravitational attraction prevents such the inversion - to invert time means to distort our world). If black holes absorb any particles and do not re-emit them, it means that such the objects would attract other bodies with a much bigger force than it is expected. So a gravitational mass of a black hole in this model should be approximately 1000 times bigger than its inertial mass, i.e. Einstein's equivalence principle would be violated for them. If they exist in nature, black holes should run to the dynamical center of a galaxy with a huge acceleration due to the difference of gravitational and inertial masses.

The property of asymptotic freedom of this model at very short distances leads to the other unexpected consequence: if a black hole arises due to a collapse of a matter with some characteristic mass of particles, its full mass should be restricted from the bottom. In a case of collapsing usual baryonic matter, a rough estimate for this minimal mass m_0 is: $m_0 \sim 10^7 M_\odot$.

There is another possibility to interpret an appearance of super-massive compact objects in the model. Virtual massive gravitons arising in graviton-graviton collisions, with a lifetime increasing from one collision to another, would duly serve dark matter particles. Having very small initial velocities relative to the graviton background, the ones will not interact with matter in any manner excepting gravitation. An ultra-cold gas of such gravitons will condense under the influence of gravitational attraction into super compact massive objects. In such the picture, these objects would turn out "germs" of galaxies.

5 Conclusion

To go beyond the theory of general relativity and to search for the quantum nature of gravity, we should have some new facts on which we would bear. Some astrophysical observations - recent and old enough - may be interpreted in a frame of this model as fingerprints of very tiny effects of low-energy quantum gravity (with the scale of $10^{-3}\ eV$), among them: the redshift of spectra of remote objects; the additional dimming of them; an existence of CMB; galaxy number counts observations. Perhaps, the non-standard motion of stars in galaxies may be included in this list. The standard cosmological model of our time gives its own explanations to all of them - and maybe it hides from us their real origin.

References

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