

# Restrictions on a geometrical language in gravity

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## Abstract

It was shown by the author (gr-qc/0207006) that screening the background of super-strong interacting gravitons creates Newtonian attraction if single gravitons are pairing and graviton pairs are destructed by collisions with a body. In such the model, Newton's constant is connected with Hubble's constant, for which the estimate is obtained:  $94.576 \text{ km} \cdot \text{s}^{-1} \cdot \text{Mpc}^{-1}$ . It is necessary to assume an atomic structure of any body to have the working model. Because of it, an existence of black holes contradicts to the equivalence principle in a frame of the model. For usual matter, the equivalence principle should be broken at distances  $\sim 10^{-11} \text{ m}$ , if the model is true.

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## 1 Introduction

An alternative explanation of cosmological redshift [1, 2] gives us a possibility to explain observed dimming of supernovae Ia [3] and the Pioneer 10 anomaly [4] as additional manifestations of the graviton background which is considered in a flat space-time. It leads to a new cosmological model based

on this approach [5]. It was also shown that pressure of correlated gravitonic pairs, which are destructed by collision with a body, may create Newtonian attraction [6, 7].

In this paper, some important features of this approach are described which give the restrictions on a geometrical language in gravity. Gravity in this model may not be geometry at short distances  $\sim 10^{-11} m$ . At such the distances quantum gravity cannot be described alone but only in some unified manner. The geometrical description of gravity should be a good idealization at big distances only by the condition of "atomic structure" of matter. This condition cannot be accepted for black holes which must interact with gravitons as aggregated objects. The equivalence principle is roughly broken for black holes, if this quantum mechanism of classical gravity is realized in the nature.

## 2 Effects due to the graviton background

In was shown in author's papers [1, 2] that a quantum interaction of photons with the graviton background would lead to redshifts of remote objects; the Hubble constant  $H$  should be equal in this model to:

$$H = \frac{1}{2\pi} D \cdot \bar{\epsilon} \cdot (\sigma T^4), \quad (1)$$

where  $\bar{\epsilon}$  is an average graviton energy,  $\sigma$  is the Stephan-Boltzmann constant,  $T$  is an effective temperature of the graviton background assumed to be Planckian, and  $D$  is some new dimensional constant. To cause the whole redshift magnitude, the interaction should be super-strong - it is necessary to have  $D \sim 10^{-27} m^2 / eV^2$ . In the model, a photon energy  $E$  should depend on a distance from a source  $r$  as

$$E(r) = E_0 \exp(-ar), \quad (2)$$

where  $E_0$  is an initial value of energy. It must be  $a = H/c$ , where  $c$  is the light velocity, to have the Hubble law for small distances.

Additional photon flux's average energy losses on a way  $dr$  due to rejection of a part of photons from a source-observer direction should be proportional to  $badr$ , where the factor  $b$  is equal to:  $b = 3/2 + 2/\pi = 2, 137$ .

Such the relaxation together with the redshift will give, in a case of flat no-expanding universe, the luminosity distance  $D_L$  [3], which is equal in our

model to:

$$D_L = a^{-1} \ln(1+z) \cdot (1+z)^{(1+b)/2} \equiv a^{-1} f_1(z; b). \quad (3)$$

Comparison of the redshift model with supernova cosmology data [3] gives us a possibility to evaluate  $H$  in our model (see Fig. 1). Instead of prompt fitting to data, we can compare  $f_1(z; b)$  with one of the best fit of them. The function  $D_L(z; H_0, \Omega_M, \Omega_\Lambda) \equiv a^{-1} f_2(z; \Omega_M, \Omega_\Lambda)$  from [3] (see Eq.2 in [3]) with  $\Omega_M = -0.5$  and  $\Omega_\Lambda = 0$ , which is unphysical in the original work, gives such the fit. One can see plots of the functions  $f_1(z; b)$ ,  $f_1(z; b)/1.09$  and  $f_2(z; \Omega_M, \Omega_\Lambda)$  on Fig. 1. The ratio  $H/H_0 = 1.09$  corresponds to the function  $f_1(z; b)/1.09$  which approximates  $f_2(z; \Omega_M, \Omega_\Lambda)$  well enough [1, 2].

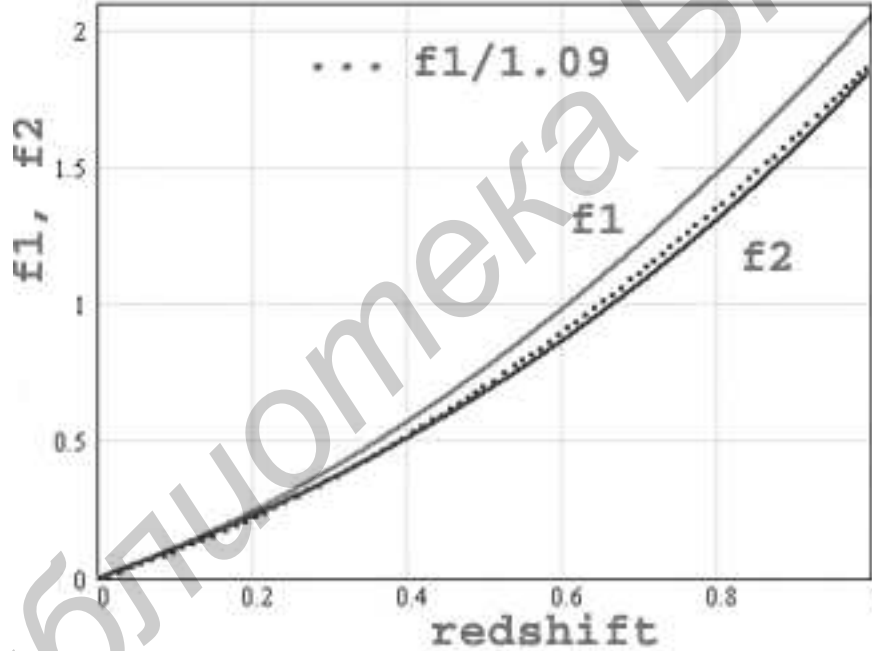


Figure 1: Comparison with supernova cosmology data. The functions  $f_1(z; b)$ ,  $f_1(z; b)/1.09$  from this model, and  $f_2(z; \Omega_M, \Omega_\Lambda)$  giving one of the best fit to supernova cosmology data [3] are shown.

But the very different functions  $f_1(z; b)$  and  $f_2(z; \Omega_M, \Omega_\Lambda)$  may not be proportional to each other on a big interval of redshifts. As one can see on Fig. 2, on the interval  $z \in (1, 2)$  their plots are intersecting; after it,

the function  $f_2$ , values of which are connected only with known supernova cosmology data for  $z < 1$ , becomes much bigger than  $f_1$ .

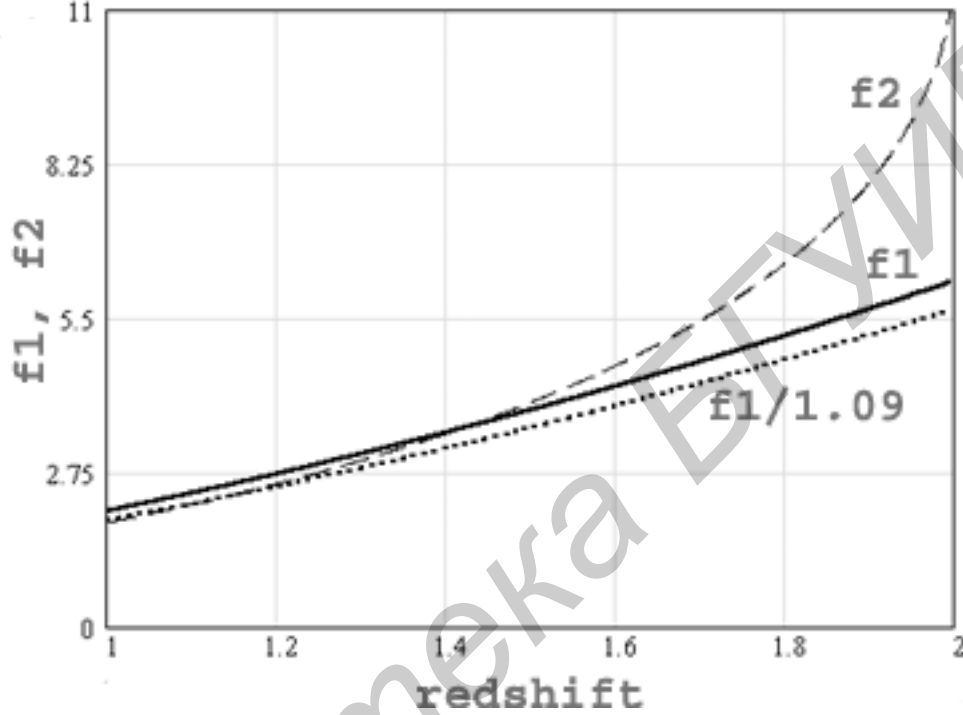


Figure 2: The same functions as on Fig. 1, but for bigger values of  $z$ .

It might mean, if one assumes that the present model is true, that further investigations of supernovae Ia for bigger  $z$  will lead to some difficulties in interpretation of data in a frame of cosmological models with expansion of the universe.

The known conclusion about an accelerating expansion of the universe [3, 8] is model-dependent. As one can see here, an alternative explanation of dimming of supernovae Ia exists. This explanation does not require an existence of any dark energy or other exotic.

Any massive objects, moving relative to the background, should loss their energy too due to such a quantum interaction with gravitons. It turns out [1, 2] that massive bodies must feel a constant deceleration of the same order of magnitude as a small additional acceleration of NASA cosmic probes [4]. We get for the body acceleration  $w \equiv dv/dt$  by a non-zero velocity:

$$w = -ac^2(1 - v^2/c^2). \quad (4)$$

It is for small velocities:  $w \simeq -Hc$ .

To ensure an attractive force bigger than a repulsive one due to a presence of the graviton background, we need of graviton pairing [4]. In such the case, we get Newton's law in which Newton's constant  $G$  is equal to:

$$G = \frac{2}{3} \cdot \frac{D^2 c (kT)^6}{\pi^3 \hbar^3} \cdot I_2 \quad (5)$$

where  $I_2 = 2.3184 \cdot 10^{-6}$ .

We can establish in a frame of this model a connection between the two fundamental constants  $G$  and  $H$  :

$$H = \left( G \frac{45}{32\pi^5} \frac{\sigma T^4 I_4^2}{c^3 I_2} \right)^{1/2}, \quad (6)$$

where  $I_4 = 24.866$ . This connection gives us the following estimate of Hubble's constant:  $H = 3.026 \cdot 10^{-18} s^{-1}$ , or in the units which are more familiar for many of us:  $H = 94.576 km \cdot s^{-1} \cdot Mpc^{-1}$  (I would like to remember that there is not any age of the universe in this model). This value of  $H$  is significantly larger than we see in the majority of present astrophysical estimations [3, 9], but it is well consistent with some of them [10] and with the observed value of anomalous acceleration of Pioneer 10 [4]  $w = (8.4 \pm 1.33) \cdot 10^{-10} m/s^2$ .

### 3 Why and when gravity is geometry

The described quantum mechanism of classical gravity [6, 7] gives Newton's law with expression (5) for the constant  $G$  and the connection (6) for the constants  $G$  and  $H$  if the condition of big distances is fulfilled:

$$\sigma(E, \langle \epsilon \rangle) \ll 4\pi r^2, \quad (7)$$

where  $\sigma(E, \langle \epsilon \rangle) = D \cdot E \cdot \langle \epsilon \rangle$  is a cross-section of interaction of a graviton with an average energy  $\langle \epsilon \rangle$  with a body having an energy  $E$  (there are two different average energies in this model; for more details, see [6]).

Newton's law is a very good approximation for big bodies of the solar system. But assuming  $r = 1 AU$  and  $E = m_{\odot} c^2$ , we obtain:

$$\frac{\sigma(E_2, \langle \epsilon \rangle)}{4\pi r^2} \sim 4 \cdot 10^{12}.$$

It means that in the case of interaction of gravitons or graviton pairs with the Sun in the aggregate, the considered quantum mechanism of classical gravity could not lead to Newton's law as a good approximation. One must assume that gravitons interact with "small particles" of matter - for example, with atoms. If the Sun contains of  $N$  atoms, then  $\sigma(E, \langle \epsilon \rangle) = N\sigma(E_a, \langle \epsilon \rangle)$ , where  $E_a$  is an average energy of one atom. For rough estimation we assume here that  $E_a = E_p$ , where  $E_p$  is a proton rest energy; then it is  $N \sim 10^{57}$ , i.e.  $\sigma(E_a, \langle \epsilon \rangle)/4\pi r^2 \sim 10^{-45} \ll 1$ .

This necessity of "atomic structure" of matter for working the described quantum mechanism is natural relative to usual bodies. But would one expect that black holes have a similar structure? If any radiation cannot be emitted with a black hole, a black hole should interact with gravitons as an aggregated object. For bodies without an atomic structure, the allowances, which are proportional to  $D^3/r^4$  and are caused by decreasing a gravitonic flux due to the screening effect, will have a factor  $m_1^2 m_2$  or  $m_1 m_2^2$ . These allowances break the equivalence principle for such the bodies.

For bodies with an atomic structure, a force of interaction is added up from small forces of interaction of their "atoms":

$$F \sim N_1 N_2 m_a^2 / r^2 = m_1 m_2 / r^2,$$

where  $N_1$  and  $N_2$  are numbers of atoms for bodies 1 and 2. The allowances to full forces due to the screening effect will be proportional to the quantity:  $N_1 N_2 m_a^3 / r^4$ , which can be expressed via the full masses of bodies as  $m_1^2 m_2 / r^4 N_1$  or  $m_1 m_2^2 / r^4 N_2$ . By big numbers  $N_1$  and  $N_2$  the allowances will be small. Let us denote as  $\Delta F$  an allowance to the force  $F$ . Then we get by  $E = E_\odot$ ,  $r = 1 \text{ AU}$  that the ratio  $\frac{\Delta F}{F} \sim 10^{-46}$ .

One can replace  $E_p$  with a rest energy of very big atom - the geometrical approach will left a very good language to describe the solar system. We see that for bodies with an atomic structure the considered mechanism leads to very small deviations from the equivalence principle, if the condition (7) is fulfilled for microparticles, which prompt interact with gravitons.

For small distances we shall have:

$$\sigma(E, \langle \epsilon \rangle) \sim 4\pi r^2. \quad (8)$$

It takes place by  $E_a = E_p$ ,  $\langle \epsilon \rangle \sim 10^{-3} \text{ eV}$  for  $r \sim 10^{-11} \text{ m}$ . This quantity is many order larger than the Planck length. The equivalence principle should be broken at such distances.

Under the condition (8), big digressions from Newton's law will be caused with two factors: 1) a screening portion of a running flux of gravitons is not small and it should be taken into account by computation of the repulsive force; 2) a value of this portion cannot be defined by the expression  $\sigma(E, \epsilon >)/4\pi r^2$ .

One might expect that a screening portion may tend to a fixing value at super-short distances. But, of course, at such distances the interaction will be super-strong and our naive approach would be not valid.

## 4 Conclusion

Observations of last years give us strong evidences for supermassive black holes in galactic nuclei. Of course, a central dark mass in galactic nucleus may not be a black hole; it is most likely to the one by its properties from all known objects. We must remember that we know only that these objects are supermassive and compact - and we, further, suggest that they are black holes. It was supposed by the author [5] that such black holes may be collectors of virtual massive gravitons and "germs" of galaxies in a frame of this approach. But the analysis of [6, 7] shows that black holes should interact with gravitons as aggregated objects and, therefore, their existence must break the equivalence principle. We have a dilemma here: to accept their existence and breaking the equivalence principle or to find other candidates on a role of observable supermassive and compact objects in the approach. For example, virtual massive gravitons might be collected in some kind of Bose condensate.

A main conclusion of my mentioned works is that, if a redshift has the non-Dopplerian nature, an interaction of a graviton with any particle should be super-strong. This circumstance would lead to a new manner to construct a quantum description of gravity and to unify known interactions.

## References

- [1] M.A.Ivanov, General Relativity and Gravitation, **33**, 479 (2001); Erratum: **35**, 939 (2003); [astro-ph/0005084 v2].
- [2] M.A.Ivanov, [gr-qc/0009043]; Proc. of the Int. Symp. "Frontiers of Fundamental Physics 4" (9-13 Dec 2000, Hyderabad,

- India), Eds B.G. Sidharth and M.V. Altaisky, Kluwer Academic/Plenum Publishers, August 2001; Proc. of the 4th Edoardo Amaldi Conference on Gravitational Waves (Perth, Western Australia, 8-13 July 2001) *Class. Quantum Grav.* **19**, 1351 (2002).
- [3] A.G. Riess et al. *AJ* **116**, 1009 (1998).
- [4] J.D.Anderson et al. *Phys. Rev. Lett.*, 1998, v.81, p. 2858; *Phys. Rev.* **D65** (2002) 082004. [gr-qc/0104064 v4]
- [5] M.A.Ivanov. Model of graviton-dusty universe. [gr-qc/0107047]
- [6] M.A.Ivanov. Screening the graviton background, graviton pairing, and Newtonian gravity. [gr-qc/0207006]
- [7] M.A.Ivanov. A fine quantum mechanism of classical gravity. Contribution to the TENTH MARCEL GROSSMANN MEETING on General Relativity (MG10), 20-26 July 2003, Rio de Janeiro, Brazil. [gr-qc/0307093]
- [8] S.Perlmutter et al. *ApJ* **517**, 565 (1999).
- [9] W. L. Freedman et al. *ApJ*, **553** (2001) 47.
- [10] J.A. Willick, Puneet Batra. *ApJ*, **548** (2001) 564.