Gravity as a screening effect*

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Abstract

Objective: A model of quantum gravity unrelated to general relativity is described. The main postulate of the model is the assumption of the existence of a background of superstrongly interacting gravitons. To describe the interaction of a graviton with any particle during their collision, a new constant is introduced.
Methods: It is shown that screening of the background of single gravitons by a pair of bodies leads to approximately equal attractive and repulsive forces between the bodies. Pairing of a part of the background gravitons, provided that the pairs are destroyed as a result of a collision with a body, yields an attractive force twice as great as the repulsive force, and gravity arises as an effect of background screening.
Results: Newton's constant has been calculated in the model as a function of background temperature, which allows the value of the new constant to be estimated. This model is free from divergences, unlike quantum gravity models based on general relativity, due to the specific shape of the Planck spectrum of the graviton background. A theoretical estimate of the Hubble constant, depending on the new constant, is also obtained.
Conclusion: An important feature of the model is the necessity of an "atomic" structure of matter, which leads as a side effect to the prohibition of the existence of black holes that do not have such a structure. Small additional effects of the model, caused by the interaction of photons with gravitons, may have great significance for cosmology.

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Key words: low-energy quantum gravity, non-geometrical approach to gravity, superstrongly interacting graviton background, graviton pairing, black hole ban, cosmology without dark energy.

1 Introduction

Because of the weakness of gravitational interaction, little new information about gravity was learned between Newton's formulation of the law of universal gravitation and Einstein's theory of general relativity, which is in stark

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contrast to the history of the study of electromagnetism. Once this new theory has been established by testing its basic predictions within the solar system, the main effort is directed towards further testing of the theory, while independent experimental efforts have virtually dried up. No quantum manifestations of gravity have been identified, so attempts to construct models of quantum gravity are usually based on the general theory of relativity as a recognized standard. Since the theory of general relativity is formulated in geometric language, the construction of a quantum theory of gravity is perceived as a task of finding a quantum description of curved space-time, which leads to incredible logical and mathematical difficulties ((see reviews [1, 2]).

An introduction to the theory of non-associative geometric classical and quantum information flows in string gravity can be found in [3]. This work, written at a high mathematical level, demonstrates the level of complexity at which the fusion of different approaches to constructing a theory of quantum gravity is expected to be achieved. In the article [4] a group of authors considers the variants of the emergence of cosmology from quantum gravity. In particular, the authors rely on the existence of a singularity in the solution of general relativity describing the expansion of the Universe, as well as on the importance of deviations from homogeneity and isotropy in the era of inflation. The emission of gravitons by a black hole near its event horizon as a result of the quantum gravitational Hawking effect is discussed in paper [5]. The author of article [6] suggests that a virtual graviton can lead to the geometry of a Kerr black hole when its momentum exceeds a certain value. Moreover, such gravitons are considered by the author as point particles, which supposedly allows one to construct an ultraviolet-finite model of quantum gravity. Article [7] discusses a model of quantum gravity based on the hypothesis of the existence of some primary field to describe the structure of quarks. Quarks are considered to be vortices of an ideal fluid, evolving into toroidal flows.

This article describes an alternative approach to finding a quantum description of gravity, completely independent of general relativity [8, 9, 10]. It is based on the assumption of the existence of a low-temperature background of gravitons, the effect of which on a pair of bodies leads to their attraction due to the screening of the background. In fact, this is a very old idea, discussed by Newton's contemporaries, albeit in a different language. This idea of describing gravity as an effect caused by ab extra particles was criticized by the great physicist R. Feynman [11]. In fact, in such a simple formulation, this idea does not work: gravitons scattered by bodies create a repulsion between bodies, which balances the attraction. The attraction will exceed the repulsion if some of the gravitons form pairs that are destroyed when they collide with the bodies. Another problem is the need to introduce a new constant to describe the interaction of a graviton with any particle when they collide. In this model, this constant is introduced as a factor in the postulated expression for the cross section of the interaction of a graviton with any particle when they collide head-on. In order to obtain the measured value of the Newton constant calculated in the model, the new constant must be very large. This means that at the quantum level, gravitons in this model are superstrongly interacting. This is strikingly different from the situation in other models of quantum gravity, where Newton's constant remains a fundamental constant, and quantum effects are expected on the Planck distance scale. The possibility of calculating Newton's constant shows that this model is in some ways deeper than general relativity, but the mechanism of gravity adopted in it also leads to some discrepancies with Einstein's theory. First, the model predicts several small effects that do not occur in general relativity, but which may be very important for cosmology. Second, it prohibits the existence of black holes and limits the use of geometric language in describing gravity at short distances. The inverse square law acts as the main quantum effect of this model.

2 The case of single gravitons

The interaction cross section $\sigma(E, \epsilon)$ for head-on collisions of any particle with energy E and a graviton with energy ϵ is defined in this model as [12]:

$$\sigma(E, \epsilon) = D \cdot E \cdot \epsilon. \tag{1}$$

To go further, we need to discuss what properties the graviton background must have. Since there is no cosmological expansion in this model, a new mechanism for the appearance of the CMB is needed. The red shift due to the interaction with the graviton background is quite suitable for this role. In such a process, energy gradually passes from photons to the graviton background, which will lead to an increase in the temperature of the latter. To achieve equilibrium, a process of cooling the background is needed; mutual collisions of gravitons with each other can be such a process, since they will lead to a decrease in the average energy of gravitons after the collision [9]. The graviton background must be in thermal equilibrium with the CMB, and in detailed equilibrium, so the simplest assumption is that it has the same properties and the same temperature as the CMB. Let's accept this hypothesis by assuming that the individual gravitons of the background have spin 1. This allows us to use Planck's formula to describe the graviton background in detail. Later we will see that the new dimensional constant D must have the value: $D \sim 10^{-27} m^2/eV^2$. This large value of the new constant is due to the low temperature of the graviton background.

If background gravitons flying from infinity collide with a pair of bodies with masses m_1 and m_2 (and energies E_1 and E_2), then some of the gravitons are screened. Let $\sigma(E_1, \epsilon)$ be the cross section of interaction of body 1 with a graviton with energy $\epsilon = \hbar\omega$, where ω is the graviton frequency, $\sigma(E_2, \epsilon)$ is the same cross section for body 2. Let the spectrum of gravitons $f(\omega, T)$ be described by Planck's formula:

$$f(\omega, T) = \frac{\omega^2}{4\pi^2 c^2} \frac{\hbar\omega}{\exp(\hbar\omega/kT) - 1}. \tag{2}$$

Let $x \equiv \hbar\omega/kT$, and $\bar{n} \equiv 1/(\exp(x) - 1)$ is an average number of gravitons in a flat wave with a frequency ω (on one mode of two distinguishing with a projection of particle spin). In the absence of body 2, the entire modulus of the graviton pressure force acting on body 1 would be equal to:

$$4\sigma(E_1, <\epsilon>) \cdot \frac{1}{3} \cdot \frac{4f(\omega, T)}{c}, \tag{3}$$

where the factor 4 in front of $\sigma(E_1, <\epsilon>)$ is introduced to take into account all possible directions of graviton motion, $<\epsilon>$ is another average energy of gravitons with frequency ω, taking into account the probability that in the implementation of a plane wave the number of gravitons can be equal to zero, and that not all gravitons fly toward the body.

Body 2, located at a distance r from body 1, will screen a portion of the gravitons incident on body 1, which for large distances between bodies (i.e. under the condition of big distances: $\sigma(E_2, <\epsilon>) \ll 4\pi r^2$) is equal to:

$$\frac{\sigma(E_2, <\epsilon>)}{4\pi r^2.} \tag{4}$$

Given all frequencies ω, the force of attraction between bodies 1 and 2 will be:

$$F_1 = \int_0^\infty \frac{\sigma(E_2, <\epsilon>)}{4\pi r^2} \cdot 4\sigma(E_1, <\epsilon>) \cdot \frac{1}{3} \cdot \frac{4f(\omega, T)}{c} d\omega. \tag{5}$$

Let $P(n, x)$ be the probability that in the realization of a plane wave the number of gravitons is n, for example $P(0, x) = \exp(-\bar{n})$.

The quantity $<\epsilon>$ must contain the factor $(1 - P(0, x))$, i.e. it must be:

$$<\epsilon> \sim \hbar\omega(1 - P(0, x)), \tag{6}$$

which allows us to discard the realizations of a plane wave with zero number of gravitons.

At this point, it is necessary to introduce some new assumptions in order to find other factors in $<\epsilon>$. Below I will show that the large distance condition is valid only for some very small particles of matter, and not for large bodies. If the realization of a plane wave running from infinity to a small particle contains one graviton, then we cannot assume that the graviton must hit the body exactly in order to interact with it with some probability. This would violate the uncertainty principle of W. Heisenberg. We must admit that the trajectory of the graviton is known to us. The same applies to gravitons scattered by one of the bodies at a large distance between the bodies. What is the probability that a single graviton will hit this particular particle? If we denote this probability as P_1, then for a wave with n gravitons their chances of hitting a particle should be equal to $n \cdot P_1$. Given the probabilities of n values for a Poisson event stream, the additional factor in $<\epsilon>$ should be equal to $\bar{n} \cdot P_1$. I assume here that

$$P_1 = P(1, x), \tag{7}$$

where $P(1, x) = \bar{n}\exp(-\bar{n})$; (below it is assumed for pairing gravitons: $P_1 = P(1, 2x)$ - see Section 4).

In this case, for $<\epsilon>$ we have the following expression:

$$<\epsilon> = \hbar\omega(1 - P(0, x))\bar{n}^2 \exp(-\bar{n}). \tag{8}$$

Then for the force of attraction F_1 we obtain:

$$F_1 = \frac{4}{3}\frac{D^2 E_1 E_2}{\pi r^2 c} \int_0^\infty \frac{\hbar^3\omega^5}{4\pi^2 c^2}(1 - P(0, x))^2 \bar{n}^5 \exp(-2\bar{n}) d\omega = \tag{9}$$

$$\frac{1}{3} \cdot \frac{D^2 c (kT)^6 m_1 m_2}{\pi^3 \hbar^3 r^2} \cdot I_1,$$

where

$$I_1 \equiv \int_0^\infty x^5(1-\exp(-(\exp(x)-1)^{-1}))^2(\exp(x)-1)^{-5}\exp(-2(\exp(x)-1)^{-1})dx = 5.636 \cdot 10^{-3}. \tag{10}$$

If $F_1 \equiv G_1 \cdot m_1 m_2/r^2$, then the constant G_1 is equal to:

$$G_1 \equiv \frac{1}{3} \cdot \frac{D^2 c(kT)^6}{\pi^3 \hbar^3} \cdot I_1. \tag{11}$$

At $T = 2.7K$:

$$G_1 = 1215.4 \cdot G, \tag{12}$$

which is three orders of magnitude greater than Newton's constant G.

But if gravitons are elastically scattered by body 1 and then fly apart in random directions, forming an isotropic flow of secondary gravitons, then our reasoning can be reversed: the same portion (4) of scattered gravitons will create a repulsive force $F_1^{'}$ acting on body 2 and equal to

$$F_1^{'} = F_1. \tag{13}$$

Thus, for bodies that elastically scatter gravitons, screening of the flow of single gravitons does not provide Newtonian attraction.

3 Graviton pairing

In order to provide an attractive force that is not equal to the repulsive one, the graviton correlations must differ for the *in* and *out* flows [10]. For example, single gravitons of the incoming flow can combine into pairs. If such pairs are destroyed upon collision with a body, then the values of $< \epsilon >$ will differ for the incoming and scattered particles. Such pairs can be formed in head-on collisions of photons with gravitons. If a photon collides with a spin-1 graviton with a much lower energy ϵ, a photon with lower energy and a virtual massive graviton with zero momentum, energy 2ϵ, and spin 1 are formed. Due to conservation laws, this virtual graviton can decay into three spin-1 gravitons that must move along the direction of the initial graviton. In this case, two of them with a total energy ϵ and the same helicity must fly in one direction, and the third in the opposite direction. If the energies of gravitons of the pair are equal, a system of two identical gravitons emitted at the same time in one direction is obtained, which can be considered a paired graviton with spin 2. If the helicities of the gravitons in the pair were different, a paired graviton with spin 0 would result. Perhaps, the spin-spin interaction excludes the latter option. If a paired spin-2 graviton collides with a photon, a photon with lower energy and a virtual massive graviton with the same spin may be formed. In the simplest case, it will decay into two spin-1 gravitons with different helicities, flying off in opposite directions along the direction of motion of the initial graviton.

To find the average number of pairs $\bar{n}_2$ in a wave with frequency ω for the state of thermodynamic equilibrium, we can replace $\hbar \to 2\hbar$ when deriving Planck's formula. Then the average number of pairs will be:

$$\bar{n}_2 = \frac{1}{\exp(2x) - 1}, \tag{14}$$

and the energy of one pair will be $2\hbar\omega$.

If expression (14) is true, then it follows from the law of conservation of energy that composite gravitons must be distributed over only two modes. Since

$$\lim_{x \to 0} \frac{\bar{n}_2}{\bar{n}} = 1/2, \tag{15}$$

then for $x \to 0$ we have $2\bar{n}_2 = \bar{n}$, i.e. all gravitons are paired at low frequencies. The average energy on each mode of paired gravitons is $2\hbar\omega\bar{n}_2$, and on each mode of single gravitons - $\hbar\omega\bar{n}$. These energies are equal on $x \to 0$, therefore the numbers of modes are also equal if the background is in thermodynamic equilibrium with the surrounding bodies.

The spectrum of composite gravitons is proportional to the Planck spectrum; it has the form:

$$f_2(2\omega, T)d\omega = \frac{\omega^2}{4\pi^2 c^2} \cdot \frac{2\hbar\omega}{\exp(2x) - 1} d\omega \equiv \frac{(2\omega)^2}{32\pi^2 c^2} \cdot \frac{2\hbar\omega}{\exp(2x) - 1} d(2\omega). \tag{16}$$

This means that the absolute luminosity for the subsystem of composite gravitons is:

$$\int_0^\infty f_2(2\omega, T)d(2\omega) = \frac{1}{8}\sigma T^4, \tag{17}$$

where σ is the Stefan-Boltzmann constant; i.e., the equivalent temperature of this subsystem is

$$T_2 \equiv (1/8)^{1/4} T = \frac{2^{1/4}}{2} T = 0.5946T. \tag{18}$$

4 The case of paired gravitons

The model assumes that when a graviton pair with spin 2 collides with a massive object, the graviton transfers all of its momentum and a small fraction of the energy corresponding to the transferred momentum. The resulting virtual graviton with zero momentum decays into a pair of gravitons with equal energies, spin 1, and different helicity, flying off in opposite directions. We neglect small energy losses at this stage. If the incident pairs of gravitons provide an attractive force F_2 for two bodies, then the repulsive force caused by the re-emission of gravitons of destroyed pairs will be equal to $F_2^{'} = F_2/2$. This follows from the fact that the cross section for *single additional scattered* gravitons of the destroyed pairs will be two times smaller than for the pairs themselves (the leading factor $2\hbar\omega$ for pairs should be replaced by $\hbar\omega$ for single gravitons). For pairs, here we introduce the cross-section $\sigma(E_2, < \epsilon_2 >)$, where $< \epsilon_2 >$ is the average energy of a pair, taking into account the probability that in the realization of a plane wave the number of graviton pairs can be equal to zero, and that not all graviton pairs collide with the body ($< \epsilon_2 >$ is an analogue of $< \epsilon >$). Replacing $\bar{n} \to \bar{n}_2, \hbar\omega \to 2\hbar\omega$, and $P(n,x) \to P(n,2x)$, where $P(0,2x) = \exp(-\bar{n}_2)$, we obtain for graviton pairs [10]:

$$< \epsilon_2 > \sim 2\hbar\omega(1 - P(0.2x))\bar{n}_2^2 \exp(-\bar{n}_2). \tag{19}$$

This expression does not take into account the fact that in addition to pairs, there may be single gravitons in the implementation of a plane wave. In order to reject cases when instead of a pair a single graviton hits the body (the contribution of such gravitons to attraction and repulsion is the same), we add a factor $P(0,x)$ to $< \epsilon_2 >$:

$$< \epsilon_2 >= 2\hbar\omega(1 - P(0,2x))\bar{n}_2^2 \exp(-\bar{n}_2) \cdot P(0,x). \tag{20}$$

Then the force of attraction of two bodies due to the pressure of graviton pairs F_2 - in complete analogy with (5) - will be equal to:

$$F_2 = \int_0^\infty \frac{\sigma(E_2, < \epsilon_2 >)}{4\pi r^2} \cdot 4\sigma(E_1, < \epsilon_2 >) \cdot \frac{1}{3} \cdot \frac{4f_2(2\omega, T)}{c} d\omega = \tag{21}$$

$$\frac{8}{3} \cdot \frac{D^2 c(kT)^6 m_1 m_2}{\pi^3 \hbar^3 r^2} \cdot I_2,$$

where

$$I_2 \equiv \int_0^\infty \frac{x^5(1 - \exp(-(\exp(2x) - 1)^{-1}))^2 (\exp(2x) - 1)^{-5}}{(2(\exp(2x) - 1)^{-1}) \exp(2(\exp(x) - 1)^{-1})} dx = \tag{22}$$

$$2.3184 \cdot 10^{-6}.$$

The difference F between the forces of attraction and repulsion will be equal to:

$$F \equiv F_2 - F_2^{'} = \frac{1}{2} F_2 \equiv G_2 \frac{m_1 m_2}{r^2}, \tag{23}$$

where the constant G_2 is equal to:

$$G_2 \equiv \frac{4}{3} \cdot \frac{D^2 c(kT)^6}{\pi^3 \hbar^3} \cdot I_2. \tag{24}$$

Both G_1 and G_2 are proportional to T^6.

If we assume that $G_2 = G$, then from (24) it follows that at $T = 2.7K$ the constant D should have the value:

$$D = 0.795 \cdot 10^{-27} m^2/eV^2. \tag{25}$$

The average energy of the background graviton is equal to:

$$\bar{\epsilon} \equiv \int_0^\infty \hbar\omega \cdot \frac{f(\omega, T)}{\sigma T^4} d\omega = \frac{15}{\pi^4} I_4 kT, \tag{26}$$

where

$$I_4 \equiv \int_0^\infty \frac{x^4 dx}{\exp(x) - 1} = 24.866,$$

which gives at $T = 2.7K$: $\bar{\epsilon} = 8.98 \cdot 10^{-4} eV$.

The Hubble constant H_0 was calculated in [12]:

$$H_0 = \frac{1}{2\pi} D \cdot \bar{\epsilon} \cdot (\sigma T^4) = \frac{15 D k \sigma T^5}{2\pi^5} I_4. \tag{27}$$

We can use (24) and (27) to establish a relationship between the two fundamental constants G and H_0 in this model, provided that $G_2 = G$. For D we have:

$$D = \frac{2\pi^5 H_0}{15 k \sigma T^5 I_4}; \tag{28}$$

then

$$G = G_2 = \frac{4}{3} \cdot \frac{D^2 c (kT)^6}{\pi^3 \hbar^3} \cdot I_2 = \frac{64\pi^5}{45} \cdot \frac{H_0^2 c^3 I_2}{\sigma T^4 I_4^2}. \tag{29}$$

Since the value of G is known much better than the value of H_0, we express H_0 in terms of G :

$$H_0 = (G \frac{45}{64\pi^5} \frac{\sigma T^4 I_4^2}{c^3 I_2})^{1/2} = 2.14 \cdot 10^{-18} s^{-1}, \tag{30}$$

or in units that are more familiar to many of us: $H_0 = 66.875\ km \cdot s^{-1} \cdot Mpc^{-1}$.

This value of H_0 agrees well with most modern astrophysical estimates of this constant [13, 14, 15], but it is smaller than some of them [16, 17] (see also [18]). This difference in the measured values of the Hubble constant is known as the H_0 tension. It may be related to the difference in the luminosity distances at low redshifts in the standard cosmological model and the one under consideration.

5 The necessity of the atomic structure of matter and the ban on black holes

We obtained a rational value of H_0 by taking $G_2 = G$ and assuming that the large distance condition is satisfied:

$$\sigma(E, <\epsilon>) \ll 4\pi r^2. \tag{31}$$

Since it is known from experience that for large bodies of the solar system Newton's law is a very good approximation, one might expect that condition (31) is satisfied, for example, for the Sun-Earth pair. But assuming that $r = 1\ AU$ and $E = m_{\odot} c^2$, we get, taking for a rough estimate $<\epsilon> \rightarrow \bar{\epsilon}$:

$$\frac{\sigma(E, <\epsilon>)}{4\pi r^2} \sim 4 \cdot 10^{12}.$$

This means that in the case of interaction of gravitons or pairs of gravitons with the Sun as a whole, the quantum mechanism of classical gravity under consideration could not lead to Newton's law as a good approximation [9]. This "contradiction" with experience is eliminated if we assume that gravitons interact with "small particles" of matter - for example, with atoms. If the Sun contains N atoms, then $\sigma(E, <\epsilon>) = N\sigma(E_a, <\epsilon>)$, where E_a is the average energy of one atom. For a rough estimate, we assume here that $E_a = E_p$, where E_p is the rest energy of a proton; then we have $N \sim 10^{57}$, i.e. $\sigma(E_a, <\epsilon>)/4\pi r^2 \sim 10^{-45} \ll 1$. This necessity of the "atomic structure" of matter for the operation of the described quantum mechanism is natural relative to ordinary bodies. For bodies with an atomic structure, the interaction force consists of small interaction forces 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 the numbers of atoms for bodies 1 and 2.

But can we expect that black holes have a similar structure? If no radiation can be emitted by a black hole, then the black hole must interact with gravitons as an aggregated object, i.e. condition (31) for a black hole with the mass of the Sun is not satisfied even at distances of $\sim 10^6$ AU. In addition, black holes that absorb any particles and do not re-emit them must have a much greater gravitational mass than the inertial mass, i.e., Einstein's equivalence principle will be violated for them [19]. Here we have a double prohibition on the existence of black holes. This may mean that the invisible supermassive objects in the centers of many galaxies, as well as other supposed black holes, have some other nature.

For small distances we have:

$$\sigma(E, <\epsilon>) \sim 4\pi r^2. \tag{32}$$

This occurs for $E_a = E_p$, $<\epsilon>\sim 10^{-3}$ eV at a distance of the order of $r \sim 10^{-11}$ m. This value is many orders of magnitude greater than the Planck length. At very small distances in this model we have a property that has never been recognized in any model of quantum gravity: almost complete asymptotic freedom (see [20, 21] for more details).

6 Additional effects in the background of gravitons

Anomalous deceleration w of a massive body with non-zero velocity v relative to the isotropic background due to head-on and back-on collisions with gravitons should take place in this model [22];

$$w = -w_0 \cdot 4\eta^2 \cdot (1-\eta^2)^{0.5}, \tag{33}$$

where $w_0 \equiv H_0 c = 6.419 \cdot 10^{-10}$ m/s^2, if we use the theoretical value of H_0 in the model, $\eta \equiv v/c$, c is the speed of light. The Earth's orbit will be stable enough under the influence of this deceleration so as not to contradict its supposed age in the solar system.

The Hubble constant here is not related to any expansion of the Universe, but only to the loss of photon energy due to head-on collisions with gravitons. The additional effect of reducing the number of photons in a propagating light beam due to non-head-on collisions with gravitons [19] can explain the additional darkening of distant sources discovered in 1998 [23, 24]. These two effects give the luminosity distance/redshift relationship of the model:

$$D_L(z) = c/H_0 \cdot \ln(1+z) \cdot (1+z)^{(1+b)/2}, \tag{34}$$

where the "constant" b belongs to the range 0 - 2.137 ($b = \frac{3}{2} + \frac{2}{\pi} \simeq 2.137$ for very soft radiation, and $b \to 0$ for very hard radiation). This relation agrees very well with cosmological observations of distant sources without dark energy [10, 25]. Photons scattered in non-frontal collisions with gravitons will be deflected from the initial direction of propagation. These photons will be registered by a distant observer as coming from nowhere, forming an additional optical background [26].

7 Conclusion

The gigantic intellectual efforts to construct a quantum theory of the metric field based on the general theory of relativity have not been successful so far. From the point of view of the approach under consideration, this can be explained by the fact that gravity is not geometry even at small distances $\sim 10^{-11}$ m. It follows from the present work that the geometric description of gravity must be a good idealization at large distances under the condition of "atomic structure" of matter. This condition cannot be accepted only for black holes, which must interact with gravitons as aggregated objects. In addition, the equivalence principle is grossly violated for black holes, if the described quantum mechanism of classical gravity is realized in nature.

In this model, the attracting bodies are not the original sources of gravitons. In this sense, the future theory must be non-local in order to describe gravitons flying in from infinity. This model does not have the divergences characteristic of quantum field theories, due to the fact that the spectrum of graviton energies tends to zero at low and high frequencies.

The described quantum mechanism of classical gravity is obviously asymmetric with respect to time inversion [8]. With time inversion, individual gravitons will collide with bodies, forming pairs. This will result in the replacement of attraction of bodies with repulsion. Penrose discussed a hidden physical law determining the direction of the arrow of time [27]; it will be unexpected if the implementation of Newton's law in nature determines this direction.

Small effects caused by the interaction of photons with the graviton background may be of significant importance for cosmology, since they provide an alternative explanation for already observed effects based on the local quantum nature of the redshift. Confirmation of this interpretation of the redshift would mean, in turn, that we can rely on the observed effects of quantum gravity in further developments of the theory.

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The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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