Superstrongly interacting gravitons: low-energy quantum gravity and vacuum effects

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Abstract

A brief review of the consequences of the hypothesis about the existence of a background of superstrong interacting gravitons is given. Gravity is seen as a shielding effect in a sea of low-energy gravitons, and Newton's constant can be calculated as a function of the background temperature. At very small distances, the phenomenon of asymptotic freedom arises. Restrictions on the geometric language and the ban on the existence of black holes are considered. Additional deceleration of massive bodies occurs due to forehead and backhead collisions with gravitons. Scattering of photons by background gravitons leads to a redshift of distant objects, their additional darkening and the appearance of a background of scattered photons. These effects could revolutionize cosmology because they don't need dark energy, the Big Bang, etc. to explain observations.

Keywords: Superstrongly interacting gravitons, low-energy quantum gravity, quantum mechanism of cosmological redshifts, cosmology

1 Introduction

The equality of the inertial and gravitational masses of any body prompted Albert Einstein to come up with the idea of a geometric description of gravity. Supplemented by the postulate of local validity of special relativity, in which light propagates along null geodesics, it led to a theory describing forceless gravity, in which light is deflected near large bodies. General relativity takes into account the finite speed of gravity. The intensity of the interaction depends on the value of Newton's constant G, i.e. this theory is at a fundamental level no deeper than Newton's law of gravity. In both cases, the mechanism of gravity remains unknown. All the effects of the general theory of relativity are observed, which makes it a real diamond of theoretical physics.

The Friedmann-Lemaitre-Robertson-Walker metric is an exact solution of general relativity used in the modern standard cosmological model (LCDM) to describe cosmological expansion. Although its use is not possible during the early stages of expansion, it describes the redshift and the luminosity distance

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of remote galaxies, as well as the rate of expansion. To describe the observed dimming of distant objects, the discovery of dark energy was announced in 1998 [1, 2].

But there is a contradiction between general relativity and quantum mechanics, in which there is no trajectory for microparticles (the uncertainty principle of W. Heisenberg, 1927). This principle is essential to understanding electron diffraction on a crystal; at a distance scale of 10^{-10} m electrons behave like waves. In general relativity there are no restrictions on the masses of bodies, and it is expected that its use is possible up to the Planck distance scale, where some quantum effects should take place. One of the most promising candidates for the role of a theory of quantum gravity precisely on this scale and based directly on the geometric formulation of general relativity is considered to be loop quantum gravity [3]. This theory does not currently predict observable effects that would allow it to be tested, but it is under development.

I would like to describe here an alternative approach to gravity, based on the hypothesis of the existence of a background of superstrongly interacting gravitons. Gravity can then be viewed as a screening effect, which is a completely quantum phenomenon, without the need for quantization. Newton's constant can be calculated as a function of background temperature; this means that this approach is in some sense deeper than general relativity. Scattering of photons by background gravitons leads to a redshift of distant objects, their additional darkening and the appearance of a background of scattered photons. These effects can be very important for cosmology.

2 Gravity as the screening effect in the sea of gravitons

In author's papers [4, 5], a cross-section $\sigma(E,\epsilon)$ of interaction of a graviton with an energy ϵ with any body having an energy E was accepted to be equal to:

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

where D is some new dimensional constant.

To ensure an attractive force which is not equal to a repulsive one, particle correlations should differ for *in* and *out* flux. For example, single gravitons of running flux may associate in pairs. If such pairs are destructed by collisions with a body, then quantities $<\epsilon>$ will distinguish for running and scattered particles ($<\epsilon>$ is an average energy of gravitons). Graviton pairing may be caused with graviton's own gravitational attraction or gravitonic spin-spin interaction. Then a force of attraction of two bodies due to pressure of graviton pairs F_2 will be equal to:

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

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

where

$$I_2 \equiv \int_0^\infty \frac{x^5 (1 - \exp(-(\exp(2x)-1)^{-1}))^2 (\exp(2x)-1)^{-5}}{\exp(2(\exp(2x)-1)^{-1}) \exp(2(\exp(x)-1)^{-1})} dx = \tag{3}$$

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

The difference F between attractive and repulsive forces will be equal to:

$$F \equiv F_2 - F_2^{'} = \frac{1}{2} F_2 \equiv G_2 \frac{m_1 m_2}{r^2}, \tag{4}$$

where the constant G_2 is equal to:

$$G_2 \equiv \frac{4}{3} \cdot \frac{D^2 c(kT)^6}{\pi^3 \hbar^3} \cdot I_2. \tag{5}$$

If one assumes that G_2 coincides with the Newton's constant G, then it follows from the last expression that by $T = 2.7K$ the constant D should have the value:

$$D = 0.795 \cdot 10^{-27} m^2/eV^2. \tag{6}$$

3 Asymptotic freedom at very small distances

Here, a portion of screened gravitons *for big distances between the bodies* is described by the factor $\sigma(E_2, < \epsilon_2 >)/4\pi r^2$, which should be much smaller of unity. A net force is attractive, and it is equal to $F_2/2$. For small distances, the condition $\sigma(E_2, < \epsilon_2 >) \ll 4\pi r^2$ will be broken. For example, $\sigma(E_2, < \epsilon_2 >) \sim 4\pi r^2$ for two protons and $< \epsilon_2 > \sim 10^{-3}\ eV$ at distances $r \sim 10^{-11}\ m$. This quantity is many orders larger than the Planck length.

When we compute a pressure force of graviton pairs in the limit case of super-short distances it turns out that this force almost vanishes. For this limit case, we should replace the factor $\sigma(E_2, < \epsilon_2 >)/4\pi r^2$ by $1/2$ if a separation of interacting particles has a sense. If we accept this replacement, we get for the pressure force (acting on body 1):

$$F_2 = \int_0^\infty \frac{1}{2} \cdot 4\sigma(E_1, < \epsilon_2 >) \cdot \frac{1}{3} \cdot \frac{4 f_2(2\omega, T)}{c} d\omega = \tag{7}$$

$$\frac{8}{3} \cdot \frac{D(kT)^5 E_1}{\pi^2 \hbar^3 c^3} \cdot I_5,$$

where I_5 is the new constant:

$$I_5 \equiv \int_0^\infty \frac{x^4 (1 - \exp(-(\exp(2x) - 1)^{-1}))(\exp(2x) - 1)^{-3}}{\exp((\exp(2x) - 1)^{-1}) \exp((\exp(x) - 1)^{-1})} dx = \tag{8}$$

$$4.24656 \cdot 10^{-4}.$$

Then the corresponding limit acceleration is equal to:

$$w_{lim} = G \frac{\pi}{D(kT)c^2} \cdot \frac{I_5}{I_2} = 3.691 \cdot 10^{-13}\ m/s^2. \tag{9}$$

This extremely small acceleration means that at very small distances (which are meantime many orders of magnitude larger than the Planck length) we have in this model the property which never has been recognized in any model of quantum gravity: almost full asymptotic freedom (for more details, see [6, 7]).

4 Restrictions on geometric language and the ban on the existence of black holes

In this model, the cross section $\sigma(E, \epsilon)$ of the interaction of a graviton with energy ϵ with any particle with energy E was taken equal to: $\sigma(E, \epsilon) = D \cdot E \cdot \epsilon,$, where D is a new dimensional constant (its estimate is: $D = 0.795 \cdot 10^{-27} m^2/eV^2$). We obtain the inverse square law for bodies if the condition of large distances r is satisfied: $\sigma(E, < \epsilon >) \ll 4\pi r^2$, where E is the bigger energy of a pair of bodies. This leads to an important consequence: some "atomic" structure of matter is needed [5, 8]. For microparticles, the property of asymptotic freedom arises at very small distances when this condition is violated.

But black holes have no structure, and this condition can only be satisfied at huge distances: for a solar-mass black hole, the condition would be satisfied at distances $r \gg 10^6\ AE$. On the other hand, in the model, screening of the background of superstrong interacting gravitons creates for any pair of bodies both an attractive force and a repulsive force due to the pressure of gravitons. This means that black holes that absorb any particles and do not re-emit them must have a much larger gravitational mass than the inertial one, i.e. for them, Einstein's equivalence principle will be violated. So, we have here a double ban on the existence of black holes. This could mean that the invisible supermassive objects at the centers of many galaxies, as well as other supposed black holes, are now misnamed.

5 Vacuum effects

The interaction of any single massive body or photon with background gravitons leads to small effects, which to the observer will seem like vacuum effects. All of them are outside the scope of the special theory of relativity. Some of these effects may only manifest themselves at cosmological distances or on large time scales.

5.1 Deceleration of massive bodies due to collisions with gravitons

The additional deceleration of massive bodies due to forehead and backhead collisions with gravitons was calculated in [9]. This deceleration w is equal to: $w = -H_0 c \cdot 4v^2/c^2 \cdot (1 - v^2/c^2)^{0.5}$, where H_0 is the Hubble constant, c is the velocity of light, v is the body's velocity relative to the background. For small velocities we have:

$$w \simeq -w_0 \cdot 4\eta^2. \tag{10}$$

In the Newtonian approach, if $\mathbf{u}$ is a more massive body's velocity relative to the background, M is its mass, and $\mathbf{V} = \mathbf{v} + \mathbf{u}$ is the velocity of the small body relative to the graviton background, we will have now the following equation of motion of the small body:

$$\ddot{\mathbf{r}} = -G\frac{M}{r^2} \cdot \frac{\mathbf{r}}{r} + \frac{4w_0}{c^2}(u \cdot \mathbf{u} - \mid \mathbf{v} + \mathbf{u} \mid \cdot (\mathbf{v} + \mathbf{u})), \tag{11}$$

where $\mathbf{r}$ is a radius-vector of the small body. Some results of numerical modeling of a motion of bodies in the central field by the influence of this additional deceleration are described in[10]. To evaluate a stability of planetary orbits in the solar system in a presence of the anomalous deceleration w, we can use the following trick: to increase w by hand to see a very small change of the orbit's radius, and to re-calculate a value of the resulting effect. In a case of the Earth-like circular orbit, i.e. by $M = M_{\odot}$, $r(0) = 1$ AU, given $u = 4 \cdot 10^5$ m/s and that three vectors $\mathbf{r},\ \mathbf{v},\ \mathbf{u}$ lie in one plane, we get by the replacement: $w \to 10^4 \cdot w$ for one classical period T: $\Delta r/r(0) = -1.08 \cdot 10^{-8}$ yr^{-1} by $\Delta t = 10^{-10} \cdot T$. It means that by the anomalous deceleration w we should have now: $\Delta r/r(0) = -1.08 \cdot 10^{-12}$ yr^{-1}. For the case when $\mathbf{u}$ is perpendicular to $\mathbf{r},\ \mathbf{v}$ we have: $\Delta r/r(0) = -7.2 \cdot 10^{-13}$ yr^{-1}. The Earth orbit will be stable enough to have not contradictions with the estimated age of it in the solar system. Results of modeling a star orbit in a galaxy in the similar way show that for $M = 10^{10} \cdot M_{\odot}$, $u = 5 \cdot 10^5$ m/s by $r(0) = 1$ kpc and $r(0) = 100$ kpc the ratio $\frac{w_0}{\ddot{r}(0)}$ is equal to 2.2 and 0.00022 respectively. By $r(0) = 1$ kpc the relative change of the distance to the center is $\Delta r/r(0) = -0.034$ during the time interval of $\simeq 30$ Gyr. By $r(0) = 1$ kpc the first unclosed external loop corresponds to 29.2 Gyr. At all scales closed orbits do not exist in the model: bodies inspiral to the center of attraction, but for the Earth-like orbits this effect is very small. When $\mathbf{u}$ is perpendicular to $\mathbf{r},\ \mathbf{v}$, another effect takes place: the motion of the body in the central field is not planar.

5.2 Scattering of photons on gravitons of the background

The Hubble constant is not connected here with any expansion of the universe, but only with energy losses of photons due to forehead collisions with gravitons of the background that causes redshifts of spectra of remote galaxies. The Hubble constant H in this model is described by the formula:

$$H = \frac{1}{2\pi} D \cdot \bar{\epsilon} \cdot (\sigma T^4), \tag{12}$$

where $\bar{\epsilon}$ is an average graviton energy, σ is the Stephan-Boltzmann constant, T is an effective temperature of the graviton background. Energy losses of photons due to forehead collisions with gravitons of the background leads to the geometrical distance/redshift relation of this model:

$$r(z) = ln(1+z) \cdot c/H_0, \tag{13}$$

where H_0 is the Hubble constant, c is the velocity of light. We may introduce the Hubble parameter $H(z)$ in the following manner:

$$dz = H(z) \cdot \frac{dr}{c}, \tag{14}$$

to imitate the local Hubble law. Taking a derivative $\frac{dr}{dz}$, we get in this model without expansion for $H(z)$:

$$H(z) = H_0 \cdot (1+z). \tag{15}$$

The Hubble parameter $H(z)$ of this model is a linear function of z, that is in a big discrepancy with ΛCDM. As it was shown, this function fits available observations of $H(z)$ very well [12, 13].

The additional effect of decreasing a number of photons in a propagating beam due to non-forehead collisions with gravitons can explain the discovered in 1998 additional dimming of remote sources [1, 2]. These two effects give the luminosity distance/redshift relation of the model:

$$D_L(z) = c/H_0 \cdot \ln(1+z) \cdot (1+z)^{(1+b)/2}, \tag{16}$$

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 one). This relation fits cosmological observations of remote sources very well without dark energy [12]. To fit this model, observations should be corrected for no time dilation as: $\mu(z) \to \mu(z) + 2.5 \cdot \lg(1+z)$, where $\lg x \equiv \log_{10} x$, and the distance modulus: $\mu(z) \equiv 5lgD_L(z)(Mpc) + 25$. In [13], I have used 31 binned points of the JLA compilation from Tables F.1 and F.2 of [14] (diagonal elements of the correlation matrix in Table F.2 are dispersions of distance moduli). Varying the value of b, we find the best fitting value of this parameter: $b = 2.365$ with $\chi^2 = 30.71$. It means that the best fitting has 43.03% C.L. This value of b is 1.107 times greater than the theoretical one. For the Hubble constant we have in this case: $< H_0 > \pm\sigma_0 = (69.54 \pm 1.58)\frac{km}{s \cdot Mpc}$. Results of the best fitting are shown in Fig. 1.

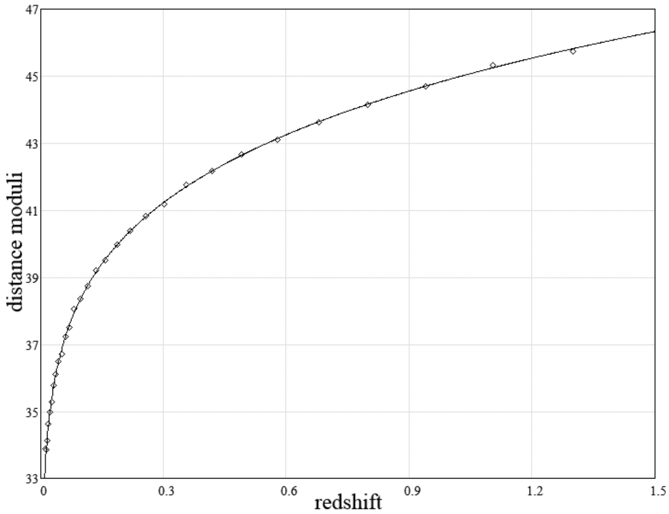

Figure 1: The theoretical Hubble diagram $\mu_0(z)$ of this model with $b = 2.365$ (solid); Supernovae 1a observational data (31 binned points of the JLA compilation) are taken from Tables F.1 and F.2 of [14] and corrected for no time dilation.

After non-forehead collisions, scattered photons should create the light-from-nowhere effect which has not an analog in the standard cosmological model. The ratio $\delta(z)$ of the scattered flux to the remainder reaching the observer is equal to [15]:

$$\delta(z) = (1+z)^b - 1. \tag{17}$$

By $b = 2.137$ we have, for example: $\delta(0.4) = 1.05$, i.e. this effect is big enough to explain a tentative detection of a diffuse cosmic optical background [20].

In this model, the functions $r(z)$ and $D_L(z)$ are found for radiation consisting of photons with energies $\hbar\omega \gg < \epsilon >$, where $< \epsilon >$ is the average graviton energy. But for $\hbar\omega \ll < \epsilon >$, e.g. for the radio band, the situation is more complicated [18]. In this case, only a small part of the background gravitons will transfer their momentum to photons in head-on collisions, and this momentum will often be of the same order as the photons' own momentum. This should lead to a large broadening of the emission spectrum towards the red, and its redshift as a whole will be much smaller than expected for high-energy radiation. From another side, all gravitons with energies $\epsilon > \hbar\omega$ are able to get the photon momentum in such the collisions that should additionally attenuate the radiation flux. This means that the known redshift z and the constant parameter b are not enough to describe the situation; this issue remains open. This feature of the model may be important for measurements of the redshifted 21-cm radiation, which are now of great interest [19].

5.3 Lorentz symmetry violation due to interactions of photons with the graviton background

The small average time delay of photons due to multiple interactions with gravitons of the background has place in this model. At enormous distances, this violates the basic postulate of the special theory of relativity about the constancy of the speed of light. The two variants of evaluation of the lifetime of a virtual photon are considered: 1) on a basis of the uncertainties relation (it is a common place in physics of particles) and 2) using a conjecture about constancy of the proper lifetime of a virtual photon. It is shown that in the first case the violation of Lorentz symmetry is insignificant: the ratio of the average delay time of photons to their propagation time is approximately 10^{-28}; in the second (with a new free model parameter), the delay is proportional to the difference $\sqrt{E_{01}} - \sqrt{E_{02}}$, where $E_{01},\ E_{02}$ are the initial photon energies, and more energetic photons should come later, as in the first case [20].

To compute the average time delay of photons in the model [4, 5], it is necessary to find a number of collisions with gravitons of the graviton background on a small way dr and to evaluate a delay due to one act of interaction. Let us consider at first the background of single gravitons. Given the expression for H in the model, we can write for the number of collisions with gravitons having an energy $\epsilon = \hbar\omega$:

$$dN(\epsilon) = \frac{|dE(\epsilon)|}{\epsilon} = E(r) \cdot \frac{dr}{c} \frac{1}{2\pi} D f(\omega, T) d\omega, \tag{18}$$

where $f(\omega, T)$ is described by the Plank formula. In the forehead collision, a photon loses the momentum ϵ/c and obtains the energy ϵ; it means that for a virtual photon we will have:

$$\frac{v}{c} = \frac{E - \epsilon}{E + \epsilon};\ 1 - \frac{v}{c} = \frac{2\epsilon}{E + \epsilon};\ \ 1 - \frac{v^2}{c^2} = \frac{4\epsilon E}{(E + \epsilon)^2}. \tag{19}$$

5.3.1 Evaluation of the lifetime of a virtual photon on a basis of the uncertainties relation

The uncertainty of energy for a virtual photon is equal to $\Delta E = 2\epsilon$. If we evaluate the lifetime using the uncertainties relation: $\Delta E \cdot \Delta\tau \geq \hbar/2$, we get

$\Delta\tau \geq \hbar/4\epsilon$. So as during the same time $\Delta\tau$ real photons overpass the way $c\Delta\tau$, and virtual ones overpass only the way $v\Delta\tau$, we have:

$$c\Delta t = c\Delta\tau - v\Delta\tau,$$

where Δt is the time delay, and the last one will be equal to:

$$\Delta t(\epsilon) = \Delta\tau(1 - \frac{v}{c}) \geq \hbar/2 \cdot \frac{1}{E+\epsilon}. \tag{20}$$

The full time delay due to gravitons with an energy ϵ is: $dt(\epsilon) = \Delta t(\epsilon)dN(\epsilon)$. Taking into account all frequencies, we find the full time delay on the way dr:

$$dt \geq \int_0^\infty \frac{\hbar}{2}\frac{E}{E+\epsilon} \cdot \frac{dr}{c}\frac{1}{2\pi}Df(\omega,T)d\omega. \tag{21}$$

The one will be maximal for $E \to \infty$, and it is easy to evaluate it:

$$dt_\infty \geq \frac{\hbar}{4\pi}\frac{dr}{c} \cdot D\sigma T^4. \tag{22}$$

On the way r the time delay is:

$$t_\infty(r) \geq \frac{\hbar}{4\pi}\frac{r}{c} \cdot D\sigma T^4. \tag{23}$$

In this model: $r(z) = c/H \cdot \ln(1+z)$; let us introduce a constant $\rho \equiv \hbar/4\pi \cdot D\sigma T^4/H = 37.2 \cdot 10^{-12}s$, then

$$t_\infty(z) \geq \rho \ln(1+z). \tag{24}$$

We see that for $z \simeq 2$ the maximal time delay is equal to $\sim 40\ ps$, i.e. the one is negligible.

In the rest frame of a virtual photon, a single parameter, which may be juxtaposed with an energy uncertainty, is mc^2. Accepting $\Delta E = mc^2$ in this frame, we'll get:

$$t(z) \geq \rho/2 \cdot \ln(1+z) \tag{25}$$

with the same ρ; now this estimate doesn't depend on E.

5.3.2 The case of constancy of the proper lifetime of a virtual photon

Taking into account that for a virtual photon after a collision $(E^{'}/c)^2 - p^{'2} > 0$, we may consider another possibility of lifetime estimation, for example, $\Delta\tau_0 = const$, where $\Delta\tau_0$ is the proper lifetime of a virtual photon (it should be considered as a new parameter of the model). Now it is necessary to transit to the reference frame of observer:

$$\Delta\tau = \Delta\tau_0/(1 - \frac{v^2}{c^2})^{1/2} = \Delta\tau_0 \cdot \frac{E+\epsilon}{2\sqrt{\epsilon E}}, \tag{26}$$

accordingly:

$$\Delta t(\epsilon) = \Delta\tau(1 - \frac{v}{c}) = \Delta\tau_0 \cdot \sqrt{\epsilon/E}. \tag{27}$$

Then the full time delay due to gravitons with an energy ϵ is:

$$dt(\epsilon) = \Delta t(\epsilon) dN(\epsilon) = \Delta\tau_0 \cdot \sqrt{\epsilon E} \cdot \frac{dr}{c} \frac{1}{2\pi} D f(\omega, T) d\omega, \tag{28}$$

and integrating it, we get:

$$dt = \Delta\tau_0 \cdot \sqrt{E(r)} \cdot \frac{dr}{c} \frac{1}{2\pi} D \int_0^\infty \sqrt{\epsilon} f(\omega, T) d\omega. \tag{29}$$

The integral in this expression is equal to:

$$\int_0^\infty \sqrt{\epsilon} f(\omega, T) d\omega \equiv \frac{1}{4\pi^2 c^2} \cdot \frac{(kT)^{9/2}}{\hbar^3} \cdot I_6, \tag{30}$$

where a new constant I_6 is the following integral:

$$I_6 \equiv \int_0^\infty \frac{x^{7/2} dx}{\exp x - 1} = 12.2681. \tag{31}$$

In this model, the energy of a photon decreases as: $E(r) = E_0 \exp(-Hr/c)$. The full delay on the way r now is:

$$t(r) = \Delta\tau_0 \cdot \frac{D}{8\pi^3 c^2} \cdot \frac{(kT)^{9/2}}{\hbar^3} \cdot I_6 \int_0^r \sqrt{E(r')} \cdot \frac{dr'}{c} = \tag{32}$$

$$= \Delta\tau_0 \cdot \frac{D}{8\pi^3 c^2} \cdot \frac{(kT)^{9/2}}{\hbar^3} \cdot I_6 \cdot \frac{2}{H} \cdot (\sqrt{E_0} - \sqrt{E(r)}).$$

Let us introduce a new constant ϵ_0 for which:

$$\frac{1}{\sqrt{\epsilon_0}} \equiv \frac{D}{8\pi^3 c^2} \cdot \frac{(kT)^{9/2}}{\hbar^3} \cdot I_6 \cdot \frac{2}{H},$$

so $\epsilon_0 = 2.391 \cdot 10^{-4}\ eV$, then

$$t(r) = \frac{\Delta\tau_0}{\sqrt{\epsilon_0}} \cdot (\sqrt{E_0} - \sqrt{E(r)}) = \Delta\tau_0 \sqrt{\frac{E_0}{\epsilon_0}} \cdot (1 - \exp(-Hr/2c)), \tag{33}$$

where E_0 is an initial photon energy. This delay as a function of redshift is:

$$t(z) = \Delta\tau_0 \sqrt{\frac{E_0}{\epsilon_0}} \cdot \frac{\sqrt{1+z} - 1}{\sqrt{1+z}}. \tag{34}$$

In this case, the time-lag between photons emitted in one moment from the same source with different initial energies E_{01} and E_{02} will be proportional to the difference $\sqrt{E_{01}} - \sqrt{E_{02}}$, and more energetic photons should arrive later, also as in the first case. To find $\Delta\tau_0$, we must compare the computed value of time-lag with future observations. An analysis of time-resolved emissions from the gamma-ray burst GRB 081126 [21] showed that the optical peak occurred (8.4 ± 3.9) *s later* than the second gamma peak; perhaps, it means that this delay is connected with the mechanism of burst.

5.3.3 An influence of graviton pairing

Graviton pairing of existing gravitons of the background is a necessary stage to ensure the Newtonian attraction in this model. As it has been shown in [5], the spectrum of pairs is the Planckian one, too, but with the smaller temperature $T_2 \equiv 2^{-3/4}T$; this spectrum may be written as: $f(\omega_2, T_2)d\omega_2$, where $\omega_2 \equiv 2\omega$. Then residual single gravitons will have the new spectrum: $f(\omega, T)d\omega - f(\omega_2, T_2)d\omega_2$, and we should also take into account an additional contribution of pairs into the time delay.

We shall have now:

$$dN(\epsilon) = E(r) \cdot \frac{dr}{c} \frac{1}{2\pi} D(f(\omega, T)d\omega - f(\omega_2, T_2)d\omega_2), \tag{35}$$

and for pairs with energies 2ϵ :

$$dN(2\epsilon) = \frac{|dE(2\epsilon)|}{2\epsilon} = E(r) \cdot \frac{dr}{c} \frac{1}{2\pi} Df(\omega_2, T_2)d\omega_2. \tag{36}$$

After a collision of a photon with a pair, a virtual photon will have a velocity $v_2 : v_2/c = (E - 2\epsilon)/(E + 2\epsilon)$, and a mass m_2: $m_2c^2 = 2\sqrt{2\epsilon E}$.

For the case of subsection 5.3.1, after collisions with pairs: $\Delta E = 4\epsilon$, $\Delta\tau \geq \hbar/8\epsilon$, and we get:

$$\Delta t(2\epsilon) \geq \hbar/2 \cdot \frac{1}{E + 2\epsilon}. \tag{37}$$

Then due to single gravitons and pairs:

$$dt_2(\epsilon) = dt'(\epsilon) + dt(2\epsilon) \geq dt(\epsilon) - \hbar/2 \cdot \frac{\epsilon E}{(E + \epsilon)(E + 2\epsilon)} \cdot \frac{dr}{c} \frac{1}{2\pi} Df(\omega_2, T_2)d\omega_2, \tag{38}$$

where $dt'(\epsilon)$ is a reduced contribution of single gravitons, $dt(\epsilon)$ is its full contribution corresponding to formula (21). We see that if one takes into account graviton pairing, the estimate of delay became smaller. So as

$$\epsilon E/(E + \epsilon)(E + 2\epsilon) \rightarrow 0$$

by $\epsilon/E \rightarrow 0$, we have for the maximal delay in this case: $t_{2\infty}(r) \rightarrow t_\infty(r)$, i.e. the maximal delay is the same as in subsection 5.3.1.

Repeating the above procedure for the case of subsection 5.3.2, we shall get:

$$t_2(r) = [1 + (1 - 1/\sqrt{2}) \cdot (T_2/T)^{9/2}] \cdot t(r) \simeq 1.028 \cdot t(r), \tag{39}$$

where $t_2(r)$ takes into account graviton pairing, and $t(r)$ is described by formula (33). In this case, the full delay is bigger on about 2.8% than for single gravitons.

6 Virtual massive gravitons as dark matter particles

Unlike models of expanding universe, in this model a problem of utilization of energy, lost by radiation of remote objects, exists (see [8]). A virtual graviton forms under collision of a photon with a graviton of the graviton background. It should be massive if an initial graviton transfers its total momentum to a photon;

it follows from the energy conservation law that its energy $\epsilon^{'}$ must be equal to 2ϵ if ϵ is an initial graviton energy. By force of the uncertainty relation, one has for a virtual graviton lifetime $\tau : \tau \leq \frac{\hbar}{\epsilon'}$, i.e. for $\epsilon^{'} \sim 10^{-3}eV$ it is $\tau \leq 10^{-12}s$. By force of conservation laws for energy, momentum and angular momentum, the virtual graviton may decay into no less than three real gravitons. In a case of decay into three gravitons, their energies should be equal to $\epsilon, \epsilon^{''}, \epsilon'''$, with $\epsilon^{''} + \epsilon''' = \epsilon$. So, after this decay, two new gravitons with $\epsilon^{''}, \epsilon''' < \epsilon$ inflow into the graviton background. It is a source of refilling the graviton background. Collisions of gravitons with massive bodies, leading to their deceleration [13], should provide the bulk of this replenishment.

From another side, a self-interaction of gravitons of the background should also lead to the formation of virtual massive gravitons with energies less than ϵ_{min} where ϵ_{min} is a minimal energy of gravitons of an interacting pare. If gravitons with energies $\epsilon^{''}, \epsilon'''$ experience a series of collisions with gravitons of the background, their lifetime should increase. In every such a cycle collision-decay, an average energy of "redundant" gravitons will double decrease, and its lifetime will double or more increase. Only for ~ 93 cycles, a lifetime will have increased from $10^{-12}s$ to as minimum 1 Gyr. Such virtual massive gravitons, with the lifetime increasing from one collision to another, would be ideal dark matter particles. The ones will not interact with matter in any manner except usual gravitation. The ultracold gas of such gravitons will condense under the influence of gravitational attraction. In addition, even in the absence of the initial inhomogeneity in such the gas, it will easily arise. It is a way of cooling the graviton background.

The model of the composite fundamental fermions by the author [17] has all symmetries of the standard model of elementary particles on global level. Possibly virtual gravitons with very low masses are quite acceptable for the role of components of such the fermions.

7 How to verify the main conjecture of this approach

The main conjecture of this approach about the quantum nature of redshifts may be verified in a ground-based laser experiment. To do it, one should compare spectra of laser radiation before and after passing some distance l in a high-vacuum tube [12]. The temperature T of the graviton background coincides in the model with the one of CMB. Assuming $T = 2.7K$, we have for the average graviton energy: $\bar{\epsilon} = 8.98 \cdot 10^{-4}$ eV. Because of the quantum nature of redshift, the satellite of main laser line of frequency ν would appear after passing the tube with a redshift of 10^{-3} eV/h, and its position should be fixed. It will be caused by the fact that on a very small way in the tube only a small part of photons may collide with gravitons of the background. The rest of them will have unchanged energies. The center-of-mass of laser radiation spectrum should be shifted proportionally to a photon path. Due to the quantum nature of shifting process, the ratio of satellite's intensity to main line's intensity should have the order: $\sim \frac{h\nu}{\bar{\epsilon}} \frac{H_0}{c} l$. Given a very low signal photon number frequency, one could use a single photon counter to measure the intensity of the satellite line after a narrow-band filter with filter's transmittance k. If q is a quantum output of a photomultiplier cathode, f_n is a frequency of its noise pulses, and n is a desired signal-to-noise ratio, then an evaluated time duration t of data acquisition would be equal to:

$$t = \frac{(\bar{\epsilon} c n)^2 f_n}{(H_0 q k P l)^2}, \tag{40}$$

where P is a laser power. Assuming for example: $n = 10$, $f_n = 10^3$ s^{-1}, $q = 0.3$, $k = 0.1$, $P = 200$ W, $l = 300$ km, we have the estimate: $t \approx 3 \cdot 10^3$ s. Such the value of l may be achieved if one forces a laser beam to whipsaw many times between mirrors in the vacuum tube with the length of a few kilometers.

8 Conclusion

In this approach, the main quantum effect of gravity is the inverse square law, postulated by Isaac Newton to explain the motion of bodies in the solar system. It is this effect that guarantees the irreversibility of time: when time is reversed, attraction should be replaced by repulsion thanks to the described mechanism of gravity. Here we can calculate the Newton and Hubble constants as functions of background temperature using the new dimensional constant D. A very large value of D makes gravity at the quantum level super strong. Of course, the question arises: where in high-energy physics could such a superstrong interaction be hidden? Perhaps the existence of three generations of fundamental fermions may be due to their complex nature; then their components can be connected by this interaction. On the other hand, background gravitons should create a region of very high turbulence near any microparticle, which gives us hope to explore in more detail using this approach the currently unknown nature of quantum uncertainty in the microworld, described by quantum mechanics.

The scattering of photons by background gravitons leads to three effects [15], two of which are observed, but currently have a different interpretation based on the generally accepted cosmological paradigm. The cost of this interpretation is very high: cosmological expansion must be accepted to explain the redshift of distant objects, and their additional dimming requires the invention of dark energy to accelerate this expansion.When New Horizons observations [20] of the third effect (light from nowhere effect) will be confirmed, this triad can become a very important argument for changing the existing paradigm. If in the case of Big Bang cosmology we have to trust the main hypothesis without a chance to prove it, then the local quantum nature of the cosmological redshifts in this approach can be tested in the described laser experiment.

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