The graviton field as the source of mass and gravitational force in the modernized Le Sage's model

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The formula for the gravitational force inside a spherical body is derived, as well as for the Newtonian force of attraction between bodies from the standpoint of the gravitons' model. The parameters of the graviton field are estimated, including its energy density, energy flux and the cross section of interaction with matter. The equation is derived, from which it follows that the body mass is proportional to the power of radiation energy of the body from those of gravitons that interacted with the matter and gave their momentum to the body. The conclusion is made based on the theory of infinite nesting of matter that gravitons are generated at all matter levels by the densest objects such as nucleons and neutron stars.

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1. Introduction

In Fatio-Le Sage's model, gravitation arises as a consequence of the mechanical action on the bodies from the fluxes of number of tiny particles, falling on the body from all sides [1-2]. In Ritz ballistic theory, these particles do not only fall on the body, but also are re-emitted by the charges of the bodies' substance, which explains the constancy of the speed of light due to the constant speed of the particles emitted by the charges and substantiates the electromagnetic and gravitational forces [3].

In the modern quantum field theory, such particles are called gravitons. They must fill the whole space and have sufficient energy density and high penetrating ability to cause gravitational effects even inside large space bodies. An important advantage of the model with gravitons is that this model allows us to give a clear interpretation of the emergence of gravitational force and gravitational acceleration near massive bodies. Most of other theories, including the general theory of relativity [4], the covariant theory of gravitation [5] and other tensor-metric theories describe gravitation mathematically rather than provide the mechanism of its action.

Let us assume that the space is filled with the graviton field similar to a gas of relativistically moving particles, weakly interacting with each other due to the great speed and their small sizes. At each point in space we can find such a reference frame in which the fluxes of gravitons are isotropic. To do this, we should move to the system of the center of gravitons' momenta. In this case, the action of gravitons from all sides will be mutually balanced, the reference frame of the observer becomes inertial and the extended special theory of relativity (ESTR) will hold in it [6]. In ESTR all relations of the special theory of relativity (STR) are derived. ESTR differs from STR by the fact that the postulate of constancy of the speed of light in STR is replaced in ESTR by the postulate of the existence of an isotropic reference frame, in which the speed of light is the same in all directions. Thus the constancy of the speed of light in inertial reference frames is derived as one of the consequences.

If the reference frame of the observer is associated with a sufficiently massive body, it becomes non-inertial. This is reflected in the fact that the graviton field near the body becomes non-uniform and the gradients of graviton fluxes appear in it. As a consequence, the gravitational forces emerge, which are acting on the test bodies from the uncompensated graviton fluxes. For the purpose of clarity, we will make further estimates of all the basic quantities, characterizing the graviton field and its interaction with matter.

2. The field strength inside a uniform ball

In order to simplify, the graviton fluxes can be characterized by cubic distribution in the form of mixed derivative for a graviton flux directed in one way:

$$D_0 = \frac{dN_0}{dt dA}, \tag{1}$$

where the fluence rate D_0 indicates the number of gravitons, that during time dt fell on the area dA of one of the cube faces, limiting the volume under consideration, which is perpendicular to the flux.

Distribution (1) replaces the actual distribution of graviton fluxes in the space with the idealized cubic distribution, when only six graviton fluxes fall on this cubic volume, perpendicularly to the faces of the cube.

In the modernized Le Sage's model [7], we assume an exponential change of the graviton flux by the matter, which depends on the flux itself, on the length of the path x traveled in the matter, on the particle concentration n and on the cross-section σ of gravitons' interaction with the matter particles:

$$dD = -D\sigma n\,dx\,, \qquad\qquad D = D_0 \exp(-\sigma n\,x)\,. \tag{2}$$

The equation (2) is the Beer–Lambert law which relates the attenuation of graviton flux to the properties of the material through which the flux is travelling. If we characterize gravitons as particles with a certain momentum p_g, that move at the speed of light c and have the energy $E_g = p_g c$, then the less gravitons are left after travelling the path x in the matter, the more they transfer their momentum to this matter. Figure 1 shows the section of a uniform massive ball with a radius a, inside which there is a small test body in form of a ball with a radius b.

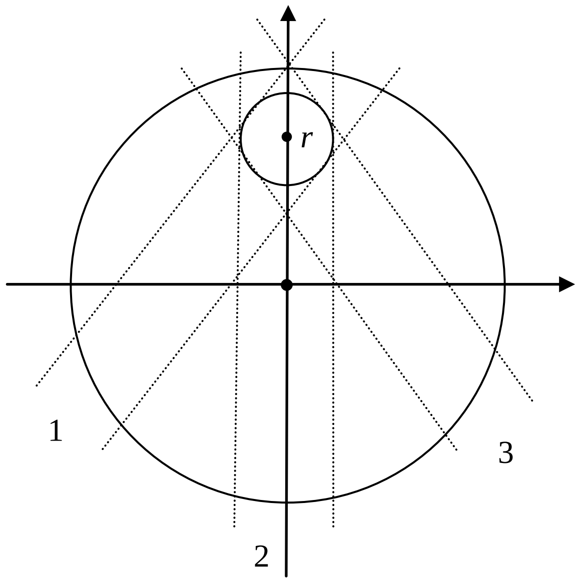

Fig.1. The small ball is at a distance r from the center of the large ball.

The graviton fluxes move along the paths 1, 2, 3, as well as other paths, passing the section of the small ball, which is at a distance r from the center of the large ball. If we replace the small ball with the cube of the same size, then in case of idealized cubic distribution it is enough to consider the vertical fluxes along the path 2. The graviton fluxes passing through the other faces of the small cube will be symmetrical and will not influence the gravitational force. This means that with this approach we will take into account the fluxes along inclined paths 1 and 3 not directly, but indirectly. All these fluxes in case of vector summation will give the force, acting on the small ball and directed to the center of the large ball, and should be added to the force, calculated for path 2.

Let the volume of the small ball be equal to the volume of some cube. Then for the volume of a cube with an edge s and for the mass m of this cube we obtain the relations:

$$s^3 = \frac{4\pi b^3}{3}, \qquad m = n_b M_n s^3, \tag{3}$$

where n_b is the concentration of nucleons in the small ball, M_n is the mass of one nucleon.

The graviton flux falling from above travels the path $a - r - \frac{s}{2}$ in the large ball with the concentration of nucleons n_a in its matter, and reaches the small cube, with which we replaced the small ball. According to (2) at this point the fluence rate decreases to the value:

$$D_1 = D_0 \exp\left[-\sigma n_a \left(a - r - \frac{s}{2}\right)\right].$$

Then the flux passes through the small cube with concentration of nucleons n_b and decreases again:

$$D_2 = D_1 \exp(-\sigma n_b s).$$

The force from this graviton flux is proportional to the square of the face of the small cube and to the number of gravitons, which transferred their momentum per time unit to the cube matter:

$$F_1 = p_g s^2 (D_1 - D_2) = p_g s^2 \left[1 - \exp(-\sigma n_b s)\right] D_0 \exp\left[-\sigma n_a \left(a - r - \frac{s}{2}\right)\right]. \tag{4}$$

On the lower side of the large ball the graviton flux first passes the path $a + r - \frac{s}{2}$ to a small cube and then passes through the cube:

$$D_3 = D_0 \exp\left[-\sigma n_a \left(a + r - \frac{s}{2}\right)\right], \qquad D_4 = D_3 \exp(-\sigma n_b\, s)\,.$$

The force acting on the small cube from this side equals:

$$F_2 = p_g s^2 (D_3 - D_4) = p_g s^2 \left[1 - \exp(-\sigma n_b\, s)\right] D_0 \exp\left[-\sigma n_a \left(a + r - \frac{s}{2}\right)\right]. \qquad (5)$$

The total force is the difference between the forces (4) and (5):

$$F = F_1 - F_2 = p_g s^2 \left[1 - \exp(-\sigma n_b\, s)\right] D_0 \left\{\exp\left[-\sigma n_a \left(a - r - \frac{s}{2}\right)\right] - \exp\left[-\sigma n_a \left(a + r - \frac{s}{2}\right)\right]\right\}. \qquad (6)$$

As a rule, the exponents' values in (6) are small, because σ value is small. In this case, the exponents can be expanded in the small parameter by the rule: $\exp(-\kappa) \approx 1 - \kappa$. With this in mind, we obtain:

$$F = 2 p_g D_0 \sigma^2 s^3 n_b\, n_a r\,.$$

In this expression, we will take into account that the density of the large ball is given by the formula: $\rho = M_n n_a$, and will use (3):

$$F = \frac{2m p_g D_0 \sigma^2 \rho r}{M_n^2}.$$

We arrive at the fact that the force F acts on the small ball in Figure 1, and this force is directed toward the center of the large ball. By definition, the gravitational field strength is the ratio of the force, acting on the test body, to the mass of the test body. Then the vector of the gravitational field strength inside the large ball will be:

$$\mathbf{\Gamma} = \frac{\mathbf{F}}{m} = -\frac{2 p_g D_0 \sigma^2 \rho \mathbf{r}}{M_n^2}. \qquad (7)$$

The minus sign in (7) is associated with the fact that the force is directed opposite to the radius vector $\mathbf{r}$.

In Lorentz-invariant theory of gravitation [8], the vector of the gravitational field strength inside a uniform ball is determined by the formula:

$$\mathbf{\Gamma} = -\frac{4\pi G \rho \mathbf{r}}{3} . \tag{8}$$

From comparison of (7) and (8) we find the expression of the gravitational constant in terms of the parameters of the graviton field in the approximation of cubic distribution of graviton fluxes:

$$G = \frac{3 p_g D_0 \sigma^2}{2\pi M_n^2} . \tag{9}$$

The gravitational constant in (9) depends on the cross-section σ of gravitons' interaction with the nucleons of the matter, on the average momentum of one graviton p_g, on the fluence rate of gravitons D_0 and on the nucleon mass M_n. We can repeat the calculations for the case when instead of nucleons characteristic particles of matter are quarks. Then, in (9) instead of the mass M_n will appear some averaged quark mass, and the cross-section σ changes its value, since the cross-section depends on the kind of interacting particles.

3. The gravitational field strength outside the uniform ball

Figure 1 shows that the formulas (7) and (9) in cubic distribution were obtained without taking into account the action of graviton fluxes moving along the inclined paths of type 1 and 3. The contribution of these fluxes inside the ball is fixed and depends only on the size of the ball. Therefore, if we add the contribution of these fluxes, the meaning of formulas (7) and (9) would not change significantly, except for the appearance of some numerical factors of the order of unity.

The situation changes significantly when the test body in the form of a small ball is outside the large massive ball. In this case, cubic distribution of graviton fluxes in space becomes too rough for describing these fluxes. After all, in reality graviton fluxes are directed not only in six mutually perpendicular directions, but also in any possible directions. So let us move to the spherical distribution, which is more accurate over long distances, for the flux of the following form:

$$B_0 = \frac{dN_0}{dt\,d\alpha\,dA}\,. \tag{10}$$

In contrast to (1), for the fluence rate (10) the graviton detector is some spherical surface, inside of which a number of gravitons dN_0 falls from a solid angle $d\alpha$ per time dt. In this case, the origin of this solid angle is at the center of the said spherical surface and it rests on the surface element area dA, since it is considered that gravitons fall perpendicularly onto the detector's surface. In fact, part of the gravitons will fall on dA at the angles, which differ from the right angle, so that (10) is another approximation to reality.

Further arguments with some variations repeat the conclusions made from [5] and [7]. Figure 2 shows two masses, the interaction of which can be estimated using the fluence rate (10) for spherical distribution.

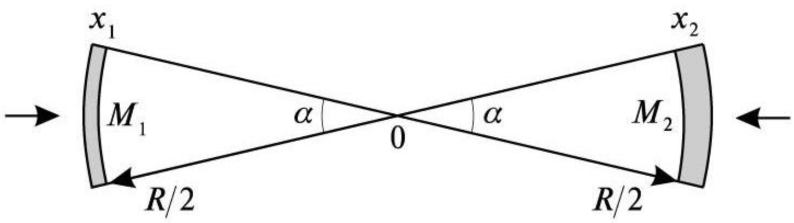

Fig.2. Masses M_1 and M_2 in the form of ball segments with different thickness and matter density, located at the distance R from each other.

Similarly to (2), we can assume that exponential decrease in the number of gravitons occurs in the matter as the graviton fluxes travel along the path x in the matter:

$$B = B_0 \exp(-\sigma n x)\,. \tag{11}$$

For the masses of ball segments which are attracted to each other we can write:

$$M_1 = M_n n_1 x_1 A\,, \qquad M_2 = M_n n_2 x_2 A\,, \qquad A = \alpha \cdot \left(\frac{R}{2}\right)^2 . \tag{12}$$

The detector is located at point 0 in the middle between the two segments. For it, each segment is seen at the same solid angle α at the distance $\frac{R}{2}$, while the transverse areas of the segments are the same and equal A. It means that before we apply further arguments for the two large bodies, we should cut these bodies into segments and then calculate the total gravitational force between all the possible pairs of segments by means of vector summation of particular forces.

Decrease of the graviton flux on the left side after passing the first segment according to (11) depends on the thickness of this segment and on the concentration of nucleons:

$$B_1 = B_0 \exp(-\sigma n_1 x_1).$$

After that the graviton flux passes through the second segment with further decrease of the flux:

$$B_2 = B_1 \exp(-\sigma n_2 x_2).$$

The force acting on the second segment from the left side with regard to (10) will equal:

$$F_1 = p_g \alpha A(B_1 - B_2) = p_g \alpha A[1 - \exp(-\sigma n_2 x_2)] B_0 \exp[-\sigma n_1 x_1].$$

Decrease of the graviton flux, passing through the second segment from the right side, and the force from this side are, respectively:

$$B_3 = B_0 \exp(-\sigma n_2 x_2), \qquad F_2 = p_g \alpha A(B_0 - B_3) = p_g \alpha A[1 - \exp(-\sigma n_2 x_2)] B_0.$$

We find the force of attraction of the second segment to the first one:

$$F = F_2 - F_1 = p_g \alpha A[1 - \exp(-\sigma n_2 x_2)] B_0 [1 - \exp(-\sigma n_1 x_1)]. \tag{13}$$

This force is symmetric with respect to changing the segments' places, so that the first segment is attracted to the second with the same force.

The exponents' values in (13) are small for all space objects, except for the neutron stars where it is not so. Expanding the exponents in the linear approximation by the rule $\exp(-\kappa) \approx 1-\kappa$, taking into account (12), we obtain for the force the following:

$$F = p_g B_0 \alpha A \sigma^2 n_2 x_2 n_1 x_1 = \frac{4 p_g B_0 \sigma^2}{M_n^2} \frac{M_1 M_2}{R^2} .$$

According to the Newton's law, the formula for the magnitude of the gravitational force between two bodies is as follows:

$$F = \frac{G M_1 M_2}{R^2} .$$

Comparing the values of the forces, we arrive at the expression for the gravitational constant in terms of the graviton field parameters in case of idealized spherical distribution of graviton fluxes:

$$G = \frac{4 p_g B_0 \sigma^2}{M_n^2} . \qquad (14)$$

From the expression for the force we determine the gravitational field strength of one mass at the location of the second mass:

$$\mathbf{\Gamma} = \frac{\mathbf{F}}{M_2} = -\frac{G M_1 \mathbf{R}}{R^3} . \qquad (15)$$

4. The graviton field parameters

We will estimate the energy density for cubic distribution of graviton fluxes in space. Suppose there is a cube with an edge s, into which gravitons fly from six sides perpendicularly to the faces of the cube. The speed of gravitons is assumed to be equal to the speed of light, so that in the time $\frac{s}{c}$ the cube will be completely filled. In view of distribution

(1) the number of gravitons in the cube will be: $N_c = \frac{6s^3 D_0}{c}$. If the energy of one graviton is $E_g = p_g c$, then with the help of (9) for the energy density of the graviton field we find:

$$\varepsilon_c = \frac{E_g N_c}{s^3} = 6 p_g D_0 = \frac{4\pi G M_n^2}{\sigma^2}. \qquad (16)$$

Now we will use the spherical distribution (10) to estimate the energy density of the graviton field. An empty sphere with radius R can be filled with gravitons in the time $\frac{2R}{c}$, if the graviton fluxes are directed radially and correspond to the full solid angle 4π. The number of gravitons inside the sphere will equal $N_s = \frac{8\pi A R B_0}{c}$. Multiplying this number by the energy of one graviton and dividing by the sphere's volume we can find the energy density. In view of (14) and the condition $A = 4\pi R^2$, we obtain:

$$\varepsilon_s = \frac{3 E_g N_s}{4\pi R^3} = 24\pi p_g B_0 = \frac{6\pi G M_n^2}{\sigma^2}. \qquad (17)$$

The energy density (17) with spherical distribution is 3/2 times greater than with cubic distribution (16), which emphasizes that our estimates are approximate due to the use of two idealized distributions.

In (16) and (17) the quantity which is not yet determined is the cross-section of gravitons' interaction with the matter σ. In [9] for the case when gravitons interact with electrons in atoms, there is an estimate of the cross-section $\sigma \approx \ell_p^2$, where ℓ_p is the Planck length. In [10] there is a relation for the cross-section: $\sigma \approx 4\pi^2 \ell_p^2 = 8 \cdot 10^{-69}$ m^2, with the conclusion that the interaction cross-section is only slightly dependent on the type of particles of matter. All these estimates are based on the fact that the energy of gravitons is expressed in terms of the Planck constant and the emission wavelength. But as it will be shown below, from the standpoint of infinite nesting of matter, gravitons appear primarily not at the level of elementary particles and atoms, but at the lower levels of matter. And each level of matter is characterized by its own constant, similar to the Planck constant that differs from it in value. This fact is taken into account in [11], but since the energy of gravitons in the form of photons is related to

Planck units by equating the Planck length to the photons' wavelength, the cross-section of interaction of these photons with nucleons is overrated and equals $\sigma \approx 8 \cdot 10^{-38}$ m^2.

In connection with this, we will take a different approach to determination of cross-section. We can use as a rough estimate of σ the relation $\sigma n x \approx 1$ for the densest objects with high concentration of particles n. According to (2), under this condition, the graviton flux on the way to the center of the star decreases e times or more, where $e = 2.71828...$ is the base of the natural logarithm.

For various stars of equal mass the product of the concentration and the radius of the star varies in inverse proportion to the square of the radius and reaches the maximum with decreasing of the radius. Therefore, neutron stars as the smallest and densest known objects are most suitable for estimation of σ from the condition $\sigma n x \approx 1$. If a star were a uniform ball with the radius of 12 km and the mass of 1.35 solar masses, we would have for it $\sigma < 3.6 \cdot 10^{-49}$ m^2. In [7] we assumed the value of $\sigma = 7 \cdot 10^{-50}$ m^2 for a star with the radius of 15 km, and we found out that the maximum possible rate of energy generation equaled the rest energy of the star, that had been released during the time of gravitons' flight along the star radius. If we apply the same approach for a star with the radius of $R_s = 12$ km, we will obtain:

$$\sigma = \frac{2\pi k G M_n R_s}{c^2} = 5.6 \cdot 10^{-50} \, \mathrm{m}^2, \tag{18}$$

where $k = 0.6$ in case of uniform density.

As a consequence, in [7] we obtained the following value for the limiting force of attraction between two adjacent massive bodies:

$$F_{\max} = \frac{c^4}{16 k^2 G},$$

where the case is implied, when the graviton fluxes are completely absorbed by these bodies.

In [5] we considered the attraction of two neutron stars with minimum distance between them $R = 2R_s$, while the exponents in the expression for the force in (13) could not be expanded with respect to the small parameter and were fully taken into account. This led to the fact that the force of attraction between the stars decreased in comparison with the Newtonian force F_N and was equal to the value of the order of $0.26F_N$.

Another way to estimate the cross-section σ of gravitons' interaction with the matter is the following. If we proceed from the similarity of Maxwell equations for the electromagnetic field and Maxwell-like gravitational equations in the Lorentz-invariant theory of gravitation [8], [12], then there is a correlation between the vacuum permittivity ε_0 and gravitoelectric constant in the form $\varepsilon_g = \frac{1}{4\pi G}$. In addition, the vacuum permeability μ_0 can be related to gravitomagnetic constant in the form $\mu_g = \frac{4\pi G}{c_g^2}$, where c_g is the speed of gravitation propagation. In case of propagation of an electromagnetic wave in the vacuum, the wave impedance is determined by the ratio of the electric field strength amplitude E to the magnetic field strength amplitude H:

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \frac{E}{H} = \frac{\mu_0 E}{B},$$

where B is the wave's magnetic field induction amplitude.

By analogy, we can determine the gravitational wave impedance of the vacuum [13]. On condition that the speed of gravitation propagation c_g is equal to the speed of light we obtain:

$$\rho_{g0} = \sqrt{\frac{\mu_{g0}}{\varepsilon_g}} = \frac{4\pi G}{c} = \frac{\mu_{g0} \Gamma}{\Omega},$$

where $\mu_{g0} = \frac{4\pi G}{c^2}$.

The gravitational wave impedance ρ_{g0} must characterize the propagation of gravitational waves. It is proportional to the ratio of the amplitude of the gravitational field strength Γ to the amplitude of the gravitational torsion field Ω (the latter quantity in the general theory of relativity is called a gravitomagnetic field). We will assume that the gravitational quantum has the same characteristic radius of rotation r as in a circularly polarized photon. For the gravitational Lorentz force we can write the following:

$$F = mV\Omega = \frac{mV^2}{r}, \qquad \Omega = \frac{V}{r},$$

where the mass m moving at the velocity V rotates around the torsion field by a circle with the radius r in the same way as the charge rotates in the magnetic field.

The amplitude of the gravitational field strength Γ can be related to the amplitude of the gravitational potential ψ by a standard relation: $\Gamma = \frac{\psi}{r}$. If we substitute Γ and Ω into the expression for ρ_{g0}, with $V = c$ and with the maximum possible amplitude of the potential $\psi = c^2$, we will obtain $\rho_{g0} = \frac{\mu_{g0}\psi}{V} = \frac{4\pi G}{c}$.

On the other hand, the mass current in case of circumferential rotation is determined by the equation: $I = \frac{dm}{dt} = \frac{mV}{2\pi r} = \frac{m\Omega}{2\pi}$. Expressing Ω from this equation and using the relations $\mathbf{\Gamma} \approx -\nabla\psi$, $\Gamma \approx \frac{\psi}{r}$ and $r \approx \frac{2Gm}{c^2}$, we obtain the following:

$$\rho_{g0} = \frac{\mu_{g0}\Gamma}{\Omega} = \frac{4\pi G}{c^2}\frac{m\psi}{2\pi I r} = \frac{\psi}{I}.$$

Hence it follows that the gravitational wave impedance for a wave can be treated in the same way as the gravitational Ohm's law, when the impedance is directly proportional to the potential difference and inversely proportional to the current. Suppose now that we have some spherical massive object with the mass M and the radius R and the absolute value of the gravitational potential at its surface reaches the limit value, which is equal to the square of the speed of light: $\psi = \frac{GM}{R} \approx c^2$ and $R \approx \frac{GM}{c^2}$. We will estimate the mass current of the graviton field falling on this object with the help of spherical distribution of graviton fluxes (10). To do this, we will multiply (10) by the full solid angle 4π, by the surface area of the sphere $A = 4\pi R^2$ and by the energy of one graviton $E_g = p_g c$, and then divide by the squared speed of light in order to move from the energy flux rate to the mass current. Taking into account (17), we find:

$$I = \frac{4\pi A E_g B_0}{c^2} = \frac{16\pi^2 R^2 p_g B_0}{c} = \frac{4\pi^2 G M_n^2 R^2}{\sigma^2 c}.$$

Our idea is that the gravitational wave impedance is the factor of proportionality between the gravitational potential and the mass current not only in case of the gravitational wave, but also in case of the mass flux I of the graviton field falling on the object with the maximum potential. Hence, taking into account the expression for I, we obtain the following:

$$\rho_{g0} = \frac{4\pi G}{c} = \frac{\psi}{I} = \frac{c^2}{I}, \qquad I = \frac{c^3}{4\pi G} = \frac{4\pi^2 G M_n^2 R^2}{\sigma^2 c}, \qquad \sigma = \frac{4\pi\sqrt{\pi} G M_n R}{c^2}.$$

In the latter expression we make substitution $R \approx \frac{GM}{c^2}$, assuming that the object's mass M is the same as the mass M_s, that we used as the mass of the neutron star model, equal to 1.35 Solar masses. This gives:

$$\sigma = \frac{4\pi\sqrt{\pi} G^2 M_s M_n}{c^4} = 5.54 \cdot 10^{-50} \text{ m}^2,$$

which practically coincides with the estimate in (18). Therefore, we will further use the value of the cross-section σ of gravitons' interaction with the matter from (18).

From (16) and (18) we obtain an estimate of the energy density of the graviton field:

$$\varepsilon_c = \frac{c^4}{\pi k^2 G R_s^2} = \frac{16 F_{\max}}{\pi R_s^2} = 7.4 \cdot 10^{35} \text{ J/m}^3. \qquad (19)$$

For comparison, the density of the absolute value of the gravitational energy in the volume of the neutron star under consideration is $\frac{3GM_s}{40\pi R_s^4} = 5.6 \cdot 10^{32}$ J/m^3, and the density of the rest energy of the star is $\frac{3M_s c^2}{4\pi R_s^3} = 3.4 \cdot 10^{34}$ J/m^3.

The energy fluence rate as the rate of energy flux of the graviton field in one direction can be found by multiplying the energy of one graviton $E_g = p_g c$ by the fluence rate of gravitons D_0 from cubic distribution (1). In view of (9) and (18-19), we find:

$$P_f = E_g D_0 = \frac{2\pi c G M_n^2}{3\sigma^2} = \frac{c^5}{6\pi k^2 G R_s^2} = \frac{8cF_{\max}}{3\pi R_s^2} = \frac{c\varepsilon_c}{6} = 3.7 \cdot 10^{43} \text{ W/m}^2. \tag{20}$$

The cross-section σ of gravitons' interaction with matter in (18) is so small that it can only be compared with the interaction cross-section of neutrinos with the energy $E_\nu \approx 100$ eV. The peculiarity of neutrinos is that the cross-section of their interaction with matter depends mainly on the energy of neutrinos and the concentration of nucleons, but not on the concentration of electrons.

On the other hand, if gravitons are the electromagnetic field quanta, then we can equate ε_c to the energy density of this field, expressed in terms of the emission density constant a_γ and temperature T. Hence, for the temperature of the graviton field in the form of photons we find:

$$T = \left(\frac{\varepsilon_c}{a_\gamma} \right)^{1/4} = 5.6 \cdot 10^{12} \text{ K}. \tag{21}$$

5. Infinite nesting of matter

Now we will correlate the idea of a graviton field with the theory of infinite nesting of matter [5], [8], [14], according to which in the Universe there are various similar to each other levels of matter, that differ from each other by their location on the scale axis. Two major scale levels of matter, such as the levels of atoms and stars, contain objects with limiting matter density. These include a neutron and a proton, on the one hand, and their stellar analogues – a neutron star and a magnetar, on the other hand. Other analogues are considered to be a muon and a white dwarf, a hydrogen atom and a magnetar with discon, where a discon is a disc near the neutron star, similar to an electron disc in the atom. Galaxies correspond to the smallest dust particles, in the center of which there is solid matter and on the outside there is thick gaseous shell of the different atoms. The latter analogue becomes thicker over time, since the stars in the galaxies evolve and turn into neutron stars and white dwarfs. In this picture magnetars are formed from neutron stars, just as protons are formed from neutrons in beta-decay.

We assume that black holes do not exist, as they are attributed the property of absorbing matter and do not letting anything out. But this contradicts the fact that the graviton field penetrates all bodies, and thereby creates gravitational phenomena. If a black hole would only absorb the energy of graviton fluxes, it would acquire in a short time a huge amount of mass-energy and should grow indefinitely in size, which is not observed.

For objects, held from decay by gravitation, in [15] we found formulas to estimate the temperature and pressure at the center of these objects:

$$T_c = \frac{GM_p M}{k_B R}, \qquad p_c = \frac{9GM^2}{8\pi R^4}, \tag{22}$$

where k_B is the Boltzmann constant, M_p is the proton mass, and the mass M of the object is contained within the sphere with the radius R.

From the relationship between pressure, concentration of particles and temperature in the center in the form of $p_c = n_c k_B T_c$ in (22) it follows that the mass density in the center ρ_c is about 1.5 times greater than the average mass density $\bar{\rho}$ of the object: $\rho_c = M_p n_c = \frac{3}{2}\bar{\rho}$.

For a neutron star with the radius of 12 km and the mass of 1.35 solar masses in (22) we find: the temperature $T_{cs} = 1.8 \cdot 10^{12}$ K; the pressure $p_{cs} = 8.4 \cdot 10^{33}$ Pa; the mass density $\rho_c = 5.7 \cdot 10^{17}$ kg/m^3. We must pay attention that the temperature here is not kinetic, but full generalized temperature. If the kinetic temperature of ideal gas is determined by the kinetic energy of its particles, then for a neutron star the generalized temperature is determined by relation [8]: $T = \frac{L_1}{3k_B}$, where L_1 is the Lagrange function per one particle. This determination of temperature allows us to take into account the potential energy of nucleons' repulsion from each other, which depends in the gravitational model of the strong interaction on the field of strong gravitation and on the kinetic energy of nucleons' rotation [5]. The motion of nucleons in the star is rather rotational than translational, due to the high density of matter, and the resulting mutual repulsion of nucleons opposes the gravitational pressure.

We will now estimate the temperature and pressure in the center of the proton. First we will introduce the coefficients of similarity as the ratio of the corresponding quantities. Dividing the mass of the neutron star by the proton mass, we find the coefficient of similarity in mass: $\Phi = \frac{M_s}{M_p} = 1.62 \cdot 10^{57}$. Similarly, we calculate the coefficient of similarity in size as the ratio of the stellar radius to the proton radius: $P = \frac{R_s}{R_p} = 1.4 \cdot 10^{19}$, here the quantity $R_p = 8.73 \cdot 10^{-16}$ m in the self-consistent model of the proton [16] was used.

The coefficient of similarity in speed equals the ratio of the characteristic speeds of the matter inside the star and the proton, respectively. For the star the characteristic speed C_s is calculated from the energy equality from the standpoint of the general principle of equivalence of mass and energy, generalized with respect to the absolute value of the total energy to any space objects:

$$M_s C_s^2 = \frac{kGM_s^2}{2R_s}, \qquad C_s = \sqrt{\frac{kGM_s}{2R_s}} = 6.8 \cdot 10^7 \text{ m/s.}$$

Similarly, we find for the proton the equality of the characteristic speed of its matter and the speed of light:

$$C_p = \sqrt{\frac{k\Gamma M_p}{2R_p}} = c = 2.99 \cdot 10^8 \text{ m/s}, \qquad (23)$$

while $\Gamma = \frac{e^2}{4\pi\varepsilon_0 M_p M_e} = 1.514 \cdot 10^{29}$ m^3·kg^{-1}·s^{-2} is the strong gravitational constant, calculated from the equation of electric and gravitational forces in the hydrogen atom, and according to [16] $k = 0.62$. Hence, the coefficient of similarity in speed is equal to: $S = \frac{C_s}{C_p} = 0.23$.

The similarity coefficients allow us to use the relations between similar quantities of different objects in accordance with the theory of physical dimensions. For example, the generalized temperature at the center of the proton in view of (22) must equal:

$$T_{cp} = \frac{\Gamma M_{pr} M_p}{k_{pr} R_p}, \qquad (24)$$

where M_{pr} denotes the mass of particle (praon), while the praon is related to the proton, just as the proton is related to the neutron star [17], and k_{pr} is a constant, similar to the Boltzmann constant for the praon level of matter.

From praon definition we see that $M_{pr} = \frac{M_p}{\Phi}$. Besides, according to the theory of dimensions, for the strong gravitational constant we have $\Gamma = \frac{\Phi}{PS^2} G$. The Boltzmann constant has the dimension of J/K, and if the temperature is not subject to similarity transformation, then according to the theory of dimensions we will obtain: $k_{pr} = \frac{k_B}{\Phi S^2}$. Substituting all this in (24), we arrive at the equality of generalized temperatures inside the proton and the neutron star:

$$T_{cp} = \frac{GM_p^2 \Phi}{k_B P R_p} = \frac{GM_p M_s}{k_B R_s} = T_{cs} = 1.8 \cdot 10^{12} \text{ K}. \qquad (25)$$

For the pressure in the center of the proton similarly to (22) we find:

$$p_{cp} = \frac{9 \Gamma M_p^2}{8\pi R_p^4} = 2.6 \cdot 10^{35} \text{ Pa}. \qquad (26)$$

We have found that the pressure in the center of the proton (26) is more than 30 times greater than the pressure in the center of the neutron star. If we take into account that 1 Pa = 1 J/m^3, then the energy density of the pressure field in the center of the proton is about three times less than the energy density of the graviton field (19). The difference of the energy density from the pressure in the center of the neutron star and the energy density of the graviton field (19) is up to 90 times.

In addition, we have the coinciding generalized temperatures in the center of the proton and the neutron star. According to (25) and (21), the generalized temperature in the center of these objects is 3 times less than the temperature of the graviton field, considered as a photon gas. We can explain this by the fact that gravitons are not fully absorbed by the matter of the neutron star or the proton, and therefore they cannot heat this matter to their own temperature.

From the point of view of the theory of similarity of matter levels, we should expect that at every level of matter the ratio between the energy density of the graviton field and the energy density of the pressure field in the center of the densest object is the same. Since the characteristic speed of matter and the pressure in the center of the proton are higher than the analogous quantities in the neutron star, then the energy density of the graviton field of strong gravitation at the atomic level accordingly must be greater. This implies the dependence of the effective energy density of the graviton field on the level of matter.

In our opinion, the main sources of the graviton field at a certain level of matter are the emissions from the densest objects at the lower levels of matter. For example, the core of a neutron star is constantly heated under the action of incident fluxes of gravitons. The degree of heating can be estimated by the formula (22), which gives the generalized temperature. The kinetic temperature at the surface of neutron stars is determined from observations and has the typical value of about 10^6 K, and the thermal luminosity rarely exceeds 10^{26} J/s [18].

Although the kinetic temperature is less than the generalized temperature, the stellar core is heated enough to constantly emit neutrino fluxes, escaping from the star and flowing into the surrounding graviton field. At the time of formation of a neutron star or during its transformation into a magnetar with reconfiguration of the magnetic moment, intense neutrino fluxes directed by the magnetic field (due to the connection between the total magnetic field and the magnetic moments of nucleons) arise, which will act effectively at a higher level of matter than the stellar level.

Neutron stars generate not only neutrino fluxes, but also give rise to cosmic rays, as it follows from the study of supernova remnants. In [5] and [8] the assumption is made that magnetars can have a positive electric charge of up to $Q_s = eS\sqrt{\Phi P} = 5.5 \cdot 10^{18}$ Cl, where e is the elementary electric charge and the similarity coefficients are used. The proton energy on the surface of the charged magnetar will reach $E_{pe} = \frac{eQ_s}{4\pi \varepsilon_0 R_s} = 6.6 \cdot 10^5$ J or $4 \cdot 10^{24}$ eV. For comparison, the highest recorded values of cosmic ray energies per 1 nucleon according to estimations are of the order of $6 \cdot 10^{19}$ eV, and so is the maximum recorded energy of photons and neutrinos [19-20]. If we assume that the cosmic rays are accelerated from the surface of the discon surrounding the magnetar, then for the energy of emitted particle with one elementary charge we can write: $E_d = \frac{eQ_s}{4\pi \varepsilon_0 R_d} = 11\,\text{J}$ or $6.7 \cdot 10^{19}$ eV, where $R_d = 7.4 \cdot 10^8$ m denotes the stellar Bohr radius, while $R_d = P r_B$, where r_B is the Bohr radius in the hydrogen atom, P is the coefficient of similarity in size. The coincidence of the energy E_d with the energy of the recorded particles suggests that the possible source of cosmic rays can actually be magnetars with discons.

In this picture the energy of the gravitational field is transformed by neutron stars with the help of different mechanisms into the energy of particles (neutrinos, protons, photons), the high energy of which causes the high penetrating ability of these particles. Applying this to other levels of matter, we find the source of the graviton field – it is the emissions from the densest objects, such as nucleons and neutron stars, including the emission of such objects as atoms. The presence of constant electric charge in the magnetar allows it to generate cosmic rays and various particles for a long time – similarly to a proton, which is practically eternal. Thus, if each level of matter would have a long lifetime, it will be enough to transform the energy of the graviton field at the lower levels of matter into the energy of gravitons, which will act at the higher levels of matter.

The presence in graviton fluxes of charged particles helps to explain the mechanism of attraction and repulsion between the charges of different and opposite signs [5], which acts similarly to the Fatio-Le Sage's mechanism for the force of gravitational attraction of masses. This implies the same form of laws in the Coulomb force for the charges and in the Newton force for the masses, as well as the similarity of Maxwell equations and the equations of the gravitational field in the Lorentz-invariant theory of gravitation [8].

The similarity coefficients allow us to calculate many quantities, characterizing different levels of matter. For example, in addition to the Planck constant h, we will introduce into consideration two other similar constants. One of them, the stellar Planck constant, is calculated using the similarity coefficients: $h_s = h \Phi P S = 3.5 \cdot 10^{42}$ J·s. This quantity characterizes the rotation of stars. If we assume that the quantity $\frac{h_s}{4\pi} = \frac{\hbar_s}{2}$ is equal to the angular momentum of the neutron star $L = 0.4 M_s R_s^2 \omega_s$, where $\omega_s = \frac{2\pi}{T_s}$, then we can find the rotation period of this star: $T_s = \frac{(4\pi)^2 M_s R_s^2}{5h_s} = 3.5 \cdot 10^{-3}$ s. For comparison, the rotation period of one of the fastest pulsars PSR J1748-2446ad is 2.5 times shorter and equals $1.396 \cdot 10^{-3}$ s. Similarly, in quantum mechanics for a proton the quantity $\frac{h}{4\pi} = \frac{\hbar}{2}$ is assumed as the value of the particle's spin. In [16], the proton radius is equal to $R_p = 8.73 \cdot 10^{-16}$ m, the angular velocity of rotation is $\omega = 1.03 \cdot 10^{23}$ rad/s with the proton spin $\frac{\hbar}{2}$, and the maximum angular velocity reaches $6.17 \cdot 10^{23}$ rad/s.

In the sequence "neutron star – proton" the object of the underlying level of matter is the praon, for which the characteristic Planck constant is $h_p = \frac{h}{\Phi PS} = 1.3 \cdot 10^{-109}$ J·s. Due to the fact that different levels of matter have different corresponding Planck constants and different energies of emission of corresponding quanta, at each level of matter the ratio for the energy of electromagnetic quantum $E = h\nu$ must contain its own Planck constant. Thus, at the level of praons the quantum energy is $E_p = h_p \nu_p$, where ν_p is the quantum frequency.

Let us turn our attention to on the length of free path of gravitons. In cosmic space, according to the findings of Lambda-Cold Dark Model ($\Lambda - CDM$), the critical mass density reaches the value $\rho_{cr} = \frac{3H_0^2}{8\pi G} = 9.2 \cdot 10^{-27}$ kg/m^3, if we assume that the Hubble constant H_0 is 70 km/(s·Mpc) [21]. The physical density of the visible baryon matter is $0.0227\rho_{cr} = 2.1 \cdot 10^{-28}$ kg/m^3, which gives the concentration of $n = 0.13$ nucleons per cubic meter. From the ratio $\sigma n x \approx 1$ at a given concentration of nucleons and the value σ according to (18) we find the length of free path of gravitons: $x = 1.4 \cdot 10^{50}$ m. This value is 23 orders of magnitude greater than the apparent size of the Universe, which is estimated as 14 billion parsecs or $4 \cdot 10^{27}$ m. Consequently, gravitons can get into our visible Universe from outside.

From the standpoint of similarity of matter levels, the set of all stars in the visible Universe corresponds to extremely rarefied atomic gas. At first glance, this rarefied gas of stars, even in view of the lower levels of matter, cannot create this energy density of the graviton field $\varepsilon_c = 7.4 \cdot 10^{35}$ J/m^3, which we have found in (19). But in remote areas of cosmic space the density of matter can be much greater and reach such values, that it can generate the necessary energy density of the graviton field, reaching our Universe.

In [17] we explained the effects of red shift of the galaxy spectra and the attenuation of emission from distant supernovae by the fact that the light is scattered on new particles. These particles are neutral particles of muon type, which emerged naturally in the same way as white dwarfs emerge in the course of stellar evolution. The sizes of new particles and their concentration in space, according to the theory of infinite nesting of matter, are so just such that can explain the scattering of light. New particles also explain the appearance of background emission and the effects attributed to dark matter. If we admit the existence of new particles, then the most important arguments in favor of the Big Bang model become useless. We are not limited by time period of 13.8 billion years as the age of the Universe. If the Universe has existed longer than this time, then gravitons could have got into our Universe from outside and carried out their action here.

6. The origin of the mass

Let us consider the energy density of the graviton field inside the body and near it. Suppose there is a body in the form of a cube with an edge s. The number of gravitons D per unit time through a unit area during gravitons' motion in the matter decreases according to formula (2). During time $\frac{s}{c}$ six fluxes of gravitons from each side will pass inside the cube through the faces with the area s^2 and will change up to the value:

$$D_1 = D_0 \exp(-\sigma n s), \qquad N = \frac{6s^3 D_0}{c} \exp(-\sigma n s),$$

where N is the number of gravitons that passed through the cube.

If gravitons flew through the same empty volume, the number of gravitons coming out would be $N_0 = \frac{6s^3 D_0}{c}$. Consequently, the number of gravitons, which interacted with the matter, equals:

$$\Delta N = N_0 - N = \frac{6s^3 D_0}{c}\left[1 - \exp(-\sigma n s)\right] \approx \frac{6\sigma n s^4 D_0}{c}.$$

Let us assume that all these gravitons did not just transfer their momentum to the matter and created the force of gravitation, but also transferred all their energy to the matter. Then for the energy density in view of (16) we obtain:

$$\varepsilon_m = \frac{\Delta N E_g}{s^3} \approx \varepsilon_c \sigma n s \,. \tag{27}$$

If the neutron star has the radius 12 km and the mass 1.35 Solar masses, then the average concentration of nucleons will be $\bar{n} = \frac{3M_s}{4\pi M_n R_s^3} = 2.2 \cdot 10^{44}$ m^{-3}. Using (18-19) and assuming $s \approx R_s$, we find $\sigma \bar{n}\, s \approx 0.15$ and $\varepsilon_m \approx 1 \cdot 10^{35}$ J/m^3. Thus, if the gravitons interacting with the matter would transfer not only the momentum but also their energy to it, the density of this energy would reach the enormous value ε_m in a short time $\frac{s}{c} \approx 10^{-4}$ s. Since we cannot imagine that the neutron star could accumulate such amounts of energy, then we should assume that although the gravitons transfer their momentum to the stellar matter, but almost all their energy must be re-emitted back. If we multiply ε_m in (27) by the star's volume and divide by the time $\frac{R_s}{c}$, we will obtain the estimate of the graviton luminosity of the star as the rate of the energy flux of the gravitons, interacting with the stellar matter: $2 \cdot 10^{52}$ W.

In nature there are many processes, in which the energy falling on bodies is almost completely reflected or scattered without heating up the bodies. One of the examples is the mirror, which receives the momentum of photons and reflects it back with the same energy. Another example is the heating of planets by the Sun – no matter how much the Sun is emitting, all the light energy falling on the planets' surface is eventually emitted back into the space. But the closer a planet is to the Sun, the greater energy flux falls on it and the higher is the temperature of the planet's surface and of its atmosphere. Since the graviton field is the same everywhere, so wherever the body is located, the temperature inside the body, which arises as a consequence of transformation of the energy of graviton fluxes, will be unchanged, if the body's parameters do not change. Apparently, the temperature of graviton fluxes does not exceed the maximum temperature, which corresponds to the virial theorem that connects the internal (thermal) energy of the massive body and its gravitational energy.

From (27) we will calculate the graviton luminosity of a body in the form of a cube, multiplying ε_m by the volume s^3 and dividing by the time $\frac{s}{c}$. Expressing the concentration of nucleons in terms of the mass, in view of (16) we have:

$$n = \frac{M}{M_n s^3}, \qquad P_g = \varepsilon_m s^2 c = \varepsilon_c \sigma n s^3 c = \varepsilon_c \sigma c \frac{M}{M_n} = \frac{4\pi c G M_n M}{\sigma}. \tag{28}$$

From (28) it follows that the graviton luminosity of the body P_g, understood as the luminosity of those graviton fluxes that interacted with the matter and gave their momentum to it, is proportional to body mass M. This means that the mass, as a measure of body's inertia, can be expressed in terms of the parameters of the graviton fluxes interacting with the body. The more gravitons transfer their momentum to the body per unit time, the greater is the mass and inertia of the body and the greater force is required to accelerate the body.

In (28) there is a product $n s^3$ equal to the number of nucleons in the body under consideration. Then the graviton luminosity per one nucleon, in view of (16), will equal:

$$P_1 = \frac{P_g}{n s^3} = \varepsilon_c \sigma c = 6 p_g D_0 \sigma c = 6 E_g D_0 \sigma = 1.2 \cdot 10^{-5} \text{ W}. \tag{29}$$

The ratio of the luminosity P_1 to the average energy of a graviton $E_g = p_g c$ gives the number of gravitons that interact with one nucleon of matter per unit time and gave their momentum to it. According to (29), this number of gravitons is equal to the product $6 D_0 \sigma$, while the cross-section σ characterizes the effective area of nucleon's interaction with gravitons, and the coefficient 6 is associated with the six sides of cubic distribution of graviton fluxes D_0 in (2).

We can also substitute the quantity σ from (18) into (28):

$$P_g = \frac{2 M c^3}{k R_s}.$$

This relation shows that the graviton luminosity is proportional and almost equal to the rest energy of the body, released from the body per time $\frac{R_s}{c}$ as the time of gravitons' passing the radius of the body. On the one hand, it is the consequence of determining the cross-section σ of gravitons' interaction with the matter in (18). On the other hand, the influence of strong gravitation at the level of atoms leads to the fact that the characteristic speed of the nucleons' matter is equal to the speed of light. Besides, according to (23) the total energy of a nucleon, which is approximately estimated as half of its energy in the field of strong gravitation, is equal by its absolute value to the rest energy as the product of mass and the squared speed of light. In nuclear reactions with nucleons part of the rest energy is released, and based on the above-mentioned we have every reason to believe that this energy results from the energy of the graviton field acting at the atomic level of matter.

7. Conclusion

The expressions for the gravitational field strengths inside the ball (8) and outside (15), obtained in the model of gravitons, are in good agreement with the values of the field strengths in the Lorentz-invariant theory of gravitation. From the field strengths we can easily proceed to the scalar potentials of the gravitational field, since the strength is up to a sign determined as the potential gradient. The field's scalar potential is found up to an integration constant by the contour integral of the field strength, taken along some path. In this case, the potential specifies the energy of unit mass in the gravitational field, which can be seen from the fact that the strength in the contour integral is the gravitational force calculated per unit mass.

As long as the matter density is less than the matter density of neutron stars, the superposition principle will hold for the formulas of the field strengths and potentials, according to which the strength or the potential of the system of particles is equal to the sum of the corresponding values of individual particles. As it was shown in [22], applying the superposition principle and the method of retarded potentials to the system of point particles inside the sphere leads to the formulas, according to which the gravitational potential of the system looks as if it emerges from a single particle with the mass, equal to the total mass of particles in this system, which is located in the center of the system. The formulas obtained further are transformed using Lorentz transformations in accordance with the Lorentz-invariant theory of gravitation.

Once we find the gravitational scalar potential, then with the help of a special procedure [23] in the framework of the Covariant Theory of Gravitation we can find the 4-potential, the stress-energy tensor of the gravitational field, the gravitational field equations, the gravitational force, as well as the contribution of the gravitational field into the equation for the metric. This means that the gravitational field theory both in the flat Minkowski space and in the curved spacetime is fully proved at the substantial level through the graviton field. And the dependence of metric on the gravitational field potential allows us to take into account the influence of the inhomogeneous graviton field on the results of space-time experiments, based as a rule on the use of electromagnetic waves and devices.

We can use also axiomatic approach to General Relativity which is described in [24], for derivation of the geodesic equation and other equations. The Newtonian theory of gravitation is a base for the General Relativity since we can calibrate the metric derived from Einstein equations choosing the low field limit and approximation of the classical law of universal gravitation.

The Covariant Theory of Gravitation and General Relativity are both the metric theories. The main difference between them is that in the Covariant Theory of Gravitation the gravitation is a real fundamental force and in General Relativity the gravitation is replaced by action of metric field. In both theories the metric should describe some phenomena such as gravitational dilation, gravitational redshift and so on, which are seen as corrections to results of the Newtonian theory of gravitation.

In (19) we made an estimate of the energy density of the graviton field, in (18) we presented the cross-section of gravitons' interaction with the matter, in (20) we estimated the rate of the energy flux of the graviton field in one direction, in (21) we obtained the temperature $T = 5.6 \cdot 10^{12}$ K of the graviton field in the form of photons. The generalized temperature at the center of a typical neutron star and a proton is apparently less than the temperature of the graviton field, as a consequence of the fact that these objects do not completely absorb the graviton fluxes. Based on the principles of the theory of infinite nesting of matter, the densest objects at each level of matter are assumed as the sources of the graviton field – neutron stars and magnetars, nucleons and atoms, praons as the components that make up nucleons, etc. These objects emit neutrinos, photons and high-energy cosmic rays that can make contribution to the graviton field at all levels of matter.

Recent experiments at relativistic ion collider in Brookhaven have shown [25] that nucleon matter can be heated in collisions up to $4 \cdot 10^{12}$ K. In this case, the nucleon matter behaves similarly to a liquid with very low viscosity, and its temperature is less than the temperature of the graviton field.

In formula (28) we expressed the body mass in terms of the luminosity of those graviton fluxes that interacted with the body matter and transferred their momentum to it. The body mass at a constant volume is proportional to the concentration of nucleons, and similarly the number of interactions of gravitons with nucleons increases with increasing of concentration of nucleons. Thus, the body's inertia as the resistance to the applied force and gravitational mass of the body are caused by the action of the graviton field on the given body. As it follows from the principle of relativity, at a constant velocity the action of graviton fluxes from different sides is balanced, but it is not so in case of the body's acceleration. When the body is accelerated, a force must be applied and work must be carried out to bring the body from the state with one velocity into the state with a different velocity. This work is done against the action of gravitons fluxes and leads to the concept of mass as a measure of the body's inertia proportional to the applied force and inversely proportional to the emerging acceleration. In this case the main contribution to the bodies' inertia is made by the graviton field at the atomic level, where there is strong gravitation.

We should also note the difference in how we understand the concept of the graviton field. In our approach, the graviton field is the source of gravitational force, it exists as a necessary addition to the matter in the form of elementary particles and bodies composed of them, it creates these bodies in the processes of gravitational clustering of scattered matter, and is generated due to the emission from the densest objects, such as nucleons and neutron stars.

In contrast, in the quantum theory of gravitation the concept of a graviton field is maximally reduced to such a graviton field, to which any gravitational wave corresponds. Such gravitons are attributed, by analogy with the electromagnetic wave and photons, the dependence of the graviton energy on the Planck constant h and on the frequency of the gravitational wave ν. In our opinion, this approach could be erroneous, especially if we take into account that most part of gravitons can be generated not at the level of atoms, but at a lower level of matter, where the Planck constant should be replaced with some other similar constant. On the other hand, considering the elementary process of emission in the hydrogen atom shows [5], that together with the electromagnetic quantum, during transition of an electron from a certain energy level to a lower level, the atom produces quadrupole emission of the gravitational quantum with the energy $E_g = \frac{M_e V^2}{M_p c^2} h\nu$, which depends not only on the Planck constant, but also on the electron's velocity V and on the ratio of the electron mass to the proton mass $\frac{M_e}{M_p}$. It implies the difference of processes of emission of electromagnetic and gravitational quanta at the atomic level, as well as the difference of processes of absorbing these quanta.

In the General Relativity, two bodies rotating near each other, emit a quadrupole gravitational wave. From the standpoint of the Covariant Theory of Gravitation [5], each body produces mainly dipole emission, but in the total emission of the system the dipole components are canceled and only the quadrupole component is left. The gravitational wave carries the energy and angular momentum away from the system. This happens because during rotation the bodies have a time-varying centripetal acceleration and the bodies carry out work against the graviton fluxes, when their angular momentum is reduced. As a rule, the energy of the gravitational wave is equal to the change in the total energy of the system in the form of two bodies. Obviously, such a gravitational wave is just a ripple on the graviton field, which is involved in producing the gravitational force between the bodies of the system. Accordingly, the gravitons of this wave, if we artificially separate them with the help of the Planck constant as portions of the gravitational energy, can have nothing in common with real gravitons, which produce the graviton field in our model.

8. References

1. Fatio de Duillier, N. (1701), *Die wiederaufgefundene Abhandlung von Fatio de Duillier: De la cause de la Pesanteur*, in Bopp, Karl, "Drei Untersuchungen zur Geschichte der Mathematik", *Schriften der Straßburger Wissenschaftlichen Gesellschaft in Heidelberg* (Berlin & Leipzig, published 1929) **10**: 19–66.
2. Georges-Louis Le Sage (1756), "Letter à une académicien de Dijon..", *ercure de France*: 153–171.
3. Ritz W. Recherches critiques sur l'Électrodynamique générale. Ann. de chim. et phys., 13, 1908.
4. C. W. Misner, K. S. Thorne, and J. A. Wheeler, *Gravitation* (W. H. Freeman, San Francisco, CA, 1973).
5. Sergey Fedosin, *The physical theories and infinite hierarchical nesting of matter*, Volume 1, LAP LAMBERT Academic Publishing, pages: 580, ISBN-13: 978-3-659-57301-9.
6. Fedosin S.G. *Sovremennye problemy fiziki: v poiskakh novykh printsipov*. Moskva: Editorial URSS, 2002, 192 pages. ISBN 5-8360-0435-8.

7. Fedosin S.G. Model of Gravitational Interaction in the Concept of Gravitons. Journal of Vectorial Relativity, 2009, Vol. 4, No. 1, P. 1 – 24.
8. Fedosin S. G. *Fizika i filosofiia podobiia ot preonov do metagalaktik*. (Perm, 1999). ISBN 5-8131-0012-1.
9. Rothman, T.; Boughn, S. (2006). Can Gravitons be Detected? Foundations of Physics, **36** (12): 1801–1825. doi:10.1007%2Fs10701-006-9081-9 .
10. Freeman Dyson. Is a Graviton Detectable? Poincare Prize Lecture, International Congress of Mathematical Physics, Aalborg, Denmark, August 6, 2012.
11. Maurizio Michelini. A Flux of Micro Quanta Explains Relativistic Mechanics and the Gravitational Interaction. Apeiron. 2007, Vol. 14, No 2, P. 65-94.
12. Fedosin S.G. Electromagnetic and Gravitational Pictures of the World. Apeiron, 2007, Vol. 14, No. 4, P. 385 – 413.
13. Kiefer, C.; Weber, C. On the interaction of mesoscopic quantum systems with gravity. Annalen der Physik, 2005, Vol. 14, Issue 4, Pages 253 – 278.
14. Fedosin S.G. Scale Dimension as the Fifth Dimension of Spacetime. Turkish Journal of Physics, 2012, Vol. 36, No 3, P. 461 – 464.
15. Fedosin S.G. The Integral Energy-Momentum 4-Vector and Analysis of 4/3 Problem Based on the Pressure Field and Acceleration Field. American Journal of Modern Physics. Vol. 3, No. 4, 2014, pp. 152-167. doi: 10.11648/j.ajmp.20140304.12.
16. Fedosin S.G. The radius of the proton in the self-consistent model. Hadronic Journal, 2012, Vol. 35, No. 4, P. 349 – 363.
17. Fedosin S.G. Cosmic Red Shift, Microwave Background, and New Particles. Galilean Electrodynamics, 2012, Vol. 23, Special Issues No. 1, P. 3 – 13.
18. Alexander Y. Potekhin, Andrea De Luca and Jose A. Pons. Neutron Stars – Thermal Emitters. arXiv:1409.7666. Accepted by Space Science Reviews.
19. Piotr Homola. Ultra-high energy photon studies with the Pierre Auger Observatory. Proceedings of the 31st International Cosmic Ray Conference, Lod´z, Poland, 2009.
20. Javier Tiffenberg. Limits on the diffuse flux of ultra high energy neutrinos set using the Pierre Auger Observatory. Proceedings of the 31st International Cosmic Ray Conference, Lod´z, Poland, 2009.
21. Hinshaw, G.F., et.al. Nine-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Parameter Results. ApJS., 2013, Vol. 208, 19H.
22. Fedosin S.G. 4/3 Problem for the Gravitational Field. Advances in Physics Theories and Applications, 2013, Vol. 23, P. 19 – 25.

23. Fedosin S.G. The Procedure of Finding the Stress-Energy Tensor and Equations of Vector Field of Any Form. Advanced Studies in Theoretical Physics, Vol. 8, 2014, no. 18, 771 – 779. http://dx.doi.org/10.12988/astp.2014.47101.
24. Fedosin S.G. The General Theory of Relativity, Metric Theory of Relativity and Covariant Theory of Gravitation: Axiomatization and Critical Analysis. International Journal of Theoretical and Applied Physics (IJTAP), 2014, Vol. 4, No. 1, P. 9 – 26.
25. 'Perfect' Liquid Hot Enough to be Quark Soup. Brookhaven National Laboratory News, 2010.