The book "The physical theories and infinite nesting of matter" was published by Sergey G. Fedosin in 2009 in Perm, Russia, ISBN 978-5-9901951-1-0. Here is preprint of the book in English, translation in 2012.

§ 7. MODEL OF GRAVITATIONAL INTERACTION IN THE CONCEPT OF GRAVITONS

The law of Newton for the attraction of bodies is derived with the help of the concept of gravitons. The expression for gravitational constant is obtained through the momentum of gravitons and the absorption coefficient. Calculations of the values of the coefficient of absorption and of the energy power of graviton flux in the space were made. It is shown that during the movement with constant speed the law of inertia is acting.

One of the oldest ideas, concerning the nature of gravitation, is the kinetic theory of Fatio-Le Sage [112], in which the mechanical action of particles (gravitons) causes the attraction of bodies to each other. A few years before Le Sage, but apparently later Fatio, Mikhail Lomonosov also interpreted gravitation as attraction of bodies to each other by some corpuscles [145]. Gravitation is not only responsible for the attraction of bodies, but also essentially ensures integrity and stability of bodies themselves. The standard objections against the theory of Fatio-Le Sage are: 1) its inability of precise prediction concerning the possible gravitational shielding, 2) the nature and the properties of graviton flux, 3) explanation of the free movement of bodies by inertia, 4) the possible thermal effect from the gravitons' action, 5) contribution of the gravitational field to the mass of bodies.

We should notice, that in [51] gravitons were accepted as cosmic quanta, the components of photons. The analysis of interaction of these quanta with the substance on the basis of Compton effect allows deducing formulas for the mass of bodies, inertia and gravitational interaction. The model of gravitational interaction suggested below in its own way solves the problems in the concept of gravitons, but as gravitons involves not only the photons, but also neutrinos and relativistic particles, similar to cosmic rays.

The inverse-square law

We will derive the formula of Newton for the force of gravitational attraction of two bodies on the basis of the approach, presented in [7]. Let us designate through A_0 the value, equal to the number of gravitons dN_0, which fly from the outside per time unit dt into the unit solid angle $d\alpha$ and thus have the component of momentum inside this angle:

$$A_0 = \frac{dN_0}{dt\, d\alpha}.$$

According to the definition, A_0 is the graviton flux moving from infinity into a unit solid angle. We will consider that the change in the quantity of gravitons per time unit in the substance layer with the density ρ and the thickness dx is proportional to the number of incoming gravitons:

$$dA = -A\chi\rho y\,dx, \qquad A = A_0 \exp(-\chi\rho y x), \tag{116}$$

where χ – the absorption coefficient,
y – half of the characteristic transverse dimension of the substance layer.

Relation (116) reflects the dependence between the quantity of gravitons falling to the substance layer and outgoing from it from the point of view of the transfer of momentum from the gravitons to the substance. We shall take now two separate bodies at the distance R from each other, and the densities of their substance can be different. Despite of different density we shall consider, that the bodies are identical in the sense that their absorption coefficient χ is the same. In these bodies we should select round surface areas with the radius, equal to y, and we should connect them as it is shown in Figure 8. Then the small solid angle α will meet the condition of the equality of the areas:

$$\alpha \cdot \left(\frac{R}{2}\right)^2 \approx \pi y^2. \tag{117}$$

The solid angle cuts out in the bodies in question the volumes, close to the ball segments, with the masses M_1 and M_2 respectively. The masses of segments M_1 and M_2 depend on the thickness x_1, x_2, and the densities ρ_1, ρ_2, respectively.

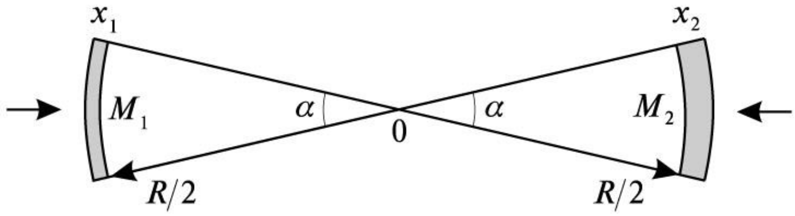

Fig. 8. Masses M_1 and M_2 in the form of ball segments with different thickness and the density of the substances, located at the distance R from each other.

We should show first that in this configuration the attraction of segments under the action of gravitons is due to the Newton's law. We will prove thus that the law of attraction will be valid for the both bodies on the whole. It follows from the arbitrariness of selection of the areas on the surface of these bodies and the possibility of the vector summing up of forces between all the possible pairs of the substance units.

It is evident from Figure 8 that the masses of the segments are equal to:

$$M_1 = \rho_1 x_1 \pi y^2, \qquad M_2 = \rho_2 x_2 \pi y^2, \tag{118}$$

where the masses can be selected infinitely small with the suitable selection of y. Accordingly, infinitely small will be the solid angle α.

The acting force is the momentum, transmitted to the substance by gravitons per time unit:

$$F = p\alpha\,\Delta A, \tag{119}$$

where p – the momentum of one graviton,

ΔA – the change in the graviton flux.

We should examine the propagation of the graviton flux from the left side in Figure 8, first through the mass M_1, then in the space between the masses M_1 and M_2, and finally through the mass M_2.

The force acting on M_1 from the left side, taking into account (119) and (116) is equal to:

$$F_1 = p\alpha\,(A_0 - A_1) = p\alpha\, A_0 \left[1 - \exp(-\chi\rho_1 y x_1)\right] \approx p\alpha\, A_0\, \chi\rho_1 y x_1 \left(1 - \frac{\chi\rho_1 y x_1}{2}\right). \tag{120}$$

In (120) the exponent was expanded to the terms of the second order. In the general case the distance R can be so large that it is necessary to consider weakening of the graviton flux with their propagation in the space from M_1 to M_2. For evaluating this weakening a formula (116) of the following type is used:

$$A_{11} = A_1 \exp\left(-\chi \int \rho(r)\, y(r)\, dr\right), \tag{121}$$

where A_1 – the graviton flux, which passed from the left side through the mass M_1,

A_{11} – the graviton flux, which reached from the left side the mass M_2,

$\rho(r)$ – the substance density between M_1 and M_2.

The force acting on M_2 from the left side similarly to (120) is equal to:

$$F_2' = p\alpha\,(A_{11} - A_2') = p\alpha\, A_{11}\left[1 - \exp(-\chi\rho_2 y x_2)\right] \approx$$
$$\approx p\alpha\, A_{11}\, \chi\rho_2 y x_2 \left(1 - \frac{\chi\rho_2 y x_2}{2}\right).$$

Taking into account the same considerations for obtaining (120), (121) and the quantity $A_1 = A_0 \exp(-\chi\rho_1 y x_1)$, for the force F_2' we find:

$$F_2' = p\alpha\, A_0\, \chi\rho_2 y x_2 \left(1 - \frac{\chi\rho_2 y x_2}{2}\right) \exp\left(-\chi\rho_1 y x_1 - \chi \int \rho(r)\, y(r)\, dr\right). \quad (122)$$

For the graviton flux on the right side similarly to (120) and (122) we have:

$$F_2 \approx p\alpha\, A_0\, \chi\rho_2 y x_2 \left(1 - \frac{\chi\rho_2 y x_2}{2}\right).$$

$$F_1' = p\alpha\, A_0\, \chi\rho_1 y x_1 \left(1 - \frac{\chi\rho_1 y x_1}{2}\right) \exp\left(-\chi\rho_2 y x_2 - \chi \int \rho(r)\, y(r)\, dr\right).$$

The gravitation force, which acts on the mass M_1 from the side of mass M_2, is equal to:

$$F_{01} = F_1 - F_1' = p\alpha\, A_0\, \chi\rho_1 y x_1 \left(1 - \frac{\chi\rho_1 y x_1}{2}\right) \times$$
$$\times \left(\chi\rho_2 y x_2 + \chi \int \rho(r)\, y(r)\, dr\right) \left(1 - \frac{\chi\rho_2 y x_2 + \chi \int \rho(r)\, y(r)\, dr}{2}\right). \quad (123)$$

The force which acts on the element with mass M_2 from the side of mass M_1, is equal to:

$$F_{02} = F_2 - F_2' = p\alpha A_0 \chi \rho_2 y x_2 \left(1 - \frac{\chi \rho_2 y x_2}{2}\right) \times \\ \times \left(\chi \rho_1 y x_1 + \chi \int \rho(r) y(r) dr\right) \left(1 - \frac{\chi \rho_1 y x_1 + \chi \int \rho(r) y(r) dr}{2}\right). \quad (124)$$

Let us remember that in the general case the gravitational masses are subdivided into the passive and the active. By passive mass of the body is understood such mass, which characterizes the body with its acceleration in the specified gravitational field (for example, with the weighing). Accordingly, the active mass of the body is responsible for creation of gravitational field around this body.

Comparison of (123) and (124) shows that the forces F_{01} and F_{02} are not equal to each other because of the presence of additional forces from the sources of mass, which are located between the bodies. Besides, the nonequivalence of the entry of the substance densities ρ_1, ρ_2 in (123) and (124) means that the passive and the active gravitational masses of bodies differ from each other. In this case, the effective active mass exceeds the passive mass due to weakening of the graviton flux in the space between the interacting bodies. It is also possible to say that the presence of the gravitating medium near the body effectively increases its passive mass to the value of the effective active gravitational mass.

The more precise equality of forces between the mass M_1 and M_2 is achieved when the distance between the masses is relatively small, the density $\rho(r)$ of the intermediate substance and the characteristic transverse dimension $y(r)$ are small. Then the change of the graviton flux in the space between the masses can be disregarded.

For evaluating the absorption coefficient χ in the substance we will consider that the term $\chi \int \rho(r) y(r) dr$ in (123) and (124) is insignificant and it is possible to disregard it. After substitution (118), taking into account (117), we obtain for the gravitation force between the substance units M_1 and M_2 the following:

$$F = F_{01} = F_{02} = \\ = \frac{4pA_0 \chi^2 M_1 M_2}{\pi R^2} \left(1 - \frac{\chi \rho_1 y x_1}{2}\right) \left(1 - \frac{\chi \rho_2 y x_2}{2}\right) = \frac{\gamma M_{1G} M_{2G}}{R^2}, \quad (125)$$

here, by M_{1G} and M_{2G} the gravitational masses of the substance units are designated, which are responsible for the force of gravitation. Unlike them the masses M_1 and M_2 are calculated through the measured densities of substance and the volumes of the substance units according to (118). We find from (125):

$$\gamma = \frac{4pA_0\chi^2}{\pi}, \qquad M_{iG} = M_i\left(1 - \frac{\chi\rho_i yx_i}{2}\right), \tag{126}$$

where the index $i = 1, 2$ distinguishes the masses M_1 and M_2. It is evident in (126) that the gravitational constant γ is determined by constants – the mean momentum of a graviton, the graviton flux, which falls per time unit from the unit solid angle, and by the squared coefficient of absorption of gravitons in the substance, consisting of nucleons. It is obvious that in the course of evolution of the Universe and with the displacement of bodies in the space the mean momentum of gravitons and the density of their flux can change, what will influence the effective value of the gravitational constant. Changes in the composition and quality of substances through the absorption factor χ also contributed to the existing gravitational forces.

The absorption coefficient and gravitational shielding

In order to determine the coefficient χ we will use the formula for the gravitational mass in the general relativity theory (for the cold substance without considering the pressure energy):

$$M_G = M\left(1 - \frac{k\gamma M}{R_b c^2}\right), \tag{127}$$

where R_b and M – the radius and the mass of the body,
c – the speed of field propagation,
$k = 0.6$ in the approximation of the uniform substance density.

We should consider preliminarily that the formula (127) is valid for the body in the form of a sphere, and the masses in (126) according to Figure 8 are concentrated approximately in the cylindrical form. If in the sphere we inscribe a cylinder with the height equal to the cylinder's base, then the volume of the sphere will exceed the cylinder's volume $\delta = 4\sqrt{2}/3$ times. The same relation there will be also for the masses. In this case the height of the cylinder will be more than the radius of the sphere, so that $x = 2y = \sqrt{2}\,R_b$. Introducing in (127) the coefficient δ and comparing (126) and (127), we obtain:

$$\frac{\Delta M}{M}=\frac{\chi \rho R_b^2}{2}=\frac{k\gamma M}{\delta R_b c^2}, \qquad \chi=\frac{2k\gamma M}{\delta \rho R_b^3 c^2}=\frac{\sqrt{2}\pi k\gamma}{c^2}. \qquad (128)$$

In (128) the mass of the body M in the form of sphere was expressed through the substance density and the volume. Substituting the constants and the value $k=0.6$, we should estimate the value of the absorption coefficient:

$$\chi = 2\cdot 10^{-27} \text{ m/kg}, \qquad (129)$$

if c is equal to the speed of light.

According to its meaning χ reflects the property of weakening of graviton fluxes during their passing in the substance from the point of view of the transfer of momentum to the substance. The estimation of the length of the free path of gravitons inside the bodies, when they lose their ability to transfer their momentum, can be made on the basis of condition $\chi \rho y x = 1$ for the exponential term in (116). Neutron stars possess the substance density about $3.7\cdot 10^{17}$ kg/m^3. As the value y it is possible to take the diameter of a neutron star. Then in the path of gravitons it is necessary to place not less than 3 neutron stars in order to noticeably decrease the extent of the graviton flux. The penetrating power of gravitons is so large that the gravitons can be compared only to the neutrino with energy of about 100 eV.

We should compare (123), (124) with the expression for the force from [48], which describes the possible effect of the gravitational shielding:

$$F'=\frac{\gamma M_1 M_2}{R^2}\exp\left[-h\int \rho(r)\,dr\right]. \qquad (130)$$

It is assumed in (130) that the presence of the substance between the bodies decreases the force of their attraction by some means.

If we place additional substance near the body with the mass M_1, then according to (124) the force, which acts on the mass M_2 will increase. Increase in the force will occur in the manner simply as if it is the gravitational mass M_1 that increases. In this case the gravitational shielding is not observed, since the general effective force of the influence on the mass M_2 grows by means of composition of forces.

In the opposite situation the additional substance with the density $\rho(r)$ is distributed outside the two bodies from all the sides so that as the result it leads to a change of the product pA_0 for the graviton flux in the unit of solid angle. On bodies will operate, in view of the formula of type (124), the graviton flux:

$$A_0' = A_0 \exp\left(-\chi \int \rho(r)\, y(r)\, dr\right).$$

Replacing in (125) A_0 on A_0', in view of (126) we shall receive:

$$F = \frac{\gamma M_{1G} M_{2G} \exp\left(-\chi \int \rho(r)\, y(r)\, dr\right)}{R^2}. \tag{131}$$

From (131) follows that if shielding occurs because of external substance, then effective force of an attraction between bodies decreases. Unlike the force (130) prospective in [48], effect of gravitational shielding according to (131) depends not only on thickness of a layer of shielding substance, but also from the area of the layer through size $y(r)$.

Strong fields

We should consider relations for gravitational force (120) – (124) with high substance densities, when it is already impossible without error to expand the exponents into series. In particular, for the force F_{01} without gravitating medium between the bodies from (123) we obtain:

$$F_{01} = p\alpha\, A_0 [1 - \exp(-\chi \rho_1 y x_1)]\, [1 - \exp(-\chi \rho_2 y x_2)].$$

We should assume that substance densities are so great that the exponents in this expression can be disregarded. Taking into account (117) for α, (126) for pA_0, (128) for χ, and (131), for maximum force we have:

$$F_{\max} = p\alpha\, A_0 = \frac{c^4 y^2}{2k^2 \gamma R^2} = \frac{\gamma M_{1G} M_{2G}}{R^2}.$$

Designating $M_G = M_{1G} = M_{2G}$, the expression $1 = \frac{2k\gamma M_G}{R_b c^2}$ is obtained with the previously used condition $y = \frac{R_b}{\sqrt{2}}$. Also we have $F_{\max} = \frac{c^4}{16k^2\gamma}$ with condition $R = 2R_b$, for maximum interaction of two massive bodies. We find with the accuracy to the coefficient of about 1 that the gravitational potential on the surface of the massive body cannot exceed c^2.

Another case is obtained for our Metagalaxy with the observed density of its substance in the limits of 10^{-27} – 10^{-26} kg/m^3. If we substitute the dimensions of the Metagalaxy about 10 Gpc for y and x, then the exponents in the forces also become small. It turns out that for the Metagalaxy the gravitational potential cannot exceed c^2 too. In all likelihood, the gravitation, created by the sources inside the Metagalaxy itself, is not able to convert the Metagalaxy into the black hole.

The motion of energy

Under the action of graviton fluxes penetrating all bodies the gravitational force appears. It is obvious that many other values in stationary bodies which seem constant to us – the gravitational acceleration, the energy of the field, the rest energy of particles, etc. – they can be the consequence of dynamic processes.

We should find, with the help of (126) for pA_0 and (128) for χ, the expression for the maximum energy force of the graviton flux (radiant intensity), or of energy power per unit of solid angle in the given direction:

$$W = pcA_0 = \frac{c^5}{8\pi k^2 \gamma} = 4 \cdot 10^{51} \text{ W/st}, \tag{132}$$

if c is equal to the speed of light.

We can approximately calculate the effective energy density of gravitons in space for the case, if this energy is channeled from the entire space in only one point. From the full solid angle $\alpha = 4\pi$ steradian per second inside a sphere can pass the energy with the value $4\pi W$. During this time, energy can leave the sphere, if the radius of the sphere will be equal to the value of light speed. The volume of such sphere is equal to $\frac{4\pi c^3}{3}$. By dividing the amount of energy $4\pi W$ on volume of the sphere, we find the effective energy density of gravitons:

$$\varepsilon_e = \frac{3c^2}{8\pi k^2 \gamma} = 1.5 \cdot 10^{26} \text{ J/m}^3.$$

The value ε_e is very high, it is many times greater than the achievable in the present time energy density in short pulses of high power lasers (about $3 \cdot 10^{13}$ J/m^3). The energy density ε_e sets not the entire spatial energy density of graviton flux, but only the part that can get to a given point from all directions per unit time for the hypothetical case of a unidirectional motion of energy.

We shall estimate now the maximum power of the energy generation in material bodies. From (132) and (116) for the situation in Figure 8 we have:

$$\frac{dE_G}{dt} = \alpha \Delta W = \alpha pc \Delta A = \alpha pc A_0 \chi \rho y x = \alpha W \chi \rho y x .$$

Using (118) in the form of $\rho_i y x_i = \frac{M_i}{\pi y}$, expressing the mass of the cylinder M_i through the mass of sphere M, reduced in $\delta = 4\sqrt{2}/3$ times, using the condition $2y = \sqrt{2}\, R_b$ (R_b – the radius of the sphere) and the condition $\alpha = 4\pi$ for the complete solid angle, taking into account (128) and (132) we will obtain:

$$\frac{dE_G}{dt} = \frac{4\sqrt{2}\, W \chi M}{\delta R_b} = \frac{3\sqrt{2}\, M c^3}{8 k R_b} . \qquad (133)$$

According to (133) with an accuracy to the coefficient of about 1, the maximum power of the energy generation is equal to the rest energy of the body, radiated during the time when the gravitons pass the radius of the body: $t = R_b / c$. Hence it follows that the rest energy of bodies is created and is supported exactly by gravitation.

Actually, the graviton flux with the specific energy and the temperature passes through each body. In the stationary case the energy of incident and outgoing fluxes are equal, but the temperature of the graviton flux outgoing from the body must be less because of the previous interaction with the particles of the body. As the result the bodies obtain the negentropy from the outside, which is compensated by the production of the corresponding entropy. The energy, connected with the entropy of the body, is realized in the form of stresses inside the body which appear under the action of gravitational forces.

The formula for the entropy of the body at a constant amount of matter according to the definition of entropy in [7] has the form:

$$S = -\int_V \frac{\boldsymbol{r} \cdot \mathrm{grad}(u + L - P_0)}{T} \, dV , \qquad (134)$$

where $\boldsymbol{r}$ – radius vector of the volume dV ,

u – density of electromagnetic and gravitational energy,

$L = \int \frac{P_0}{\rho_0} d\rho_0$ – function of pressure P_0 and density ρ_0 of matter at rest (the compression function),

T – temperature as a function of location of the volume unit.

According to (134), for the gravitationally-bound bodies the basic contribution to the entropy is made by the potential energy of gravitational field and pressure of the substance. These energies are connected with the body and can partially pass into kinetic energy only in the case of the imbalance between the force of gravitation and the internal pressure. In the hypothetical case of complete isolation of the body from the external gravitation, the body will be converted to the state of equilibrium with an increase in the volume up to the dispersion of substance. The entropy in this case will increase, and the gravitational energy will pass into the kinetic energy of substance and emission.

The energy, connected with the entropy according to (134), is close enough to the energy of gravitational field (summed with the pressure energy). As a matter of fact, this energy is responsible for the decrease of the mass according to (127). The energy of the graviton flux determines the rest energy of the bodies and their observed mass, similarly the gravitational energy contributes to a change in the mass of the body from M to M_G in (127). The denser the body with the constant mass becomes, the stronger the interaction of gravitons with the substance is. This leads to the increase of the module of gravitational energy of the body, and to the increase of the module of entropy and stresses in the body. The existence of potential gravitational energy and stresses in the bodies itself is the consequence of the transfer of the energy-momentum of gravitons to the substance and the conversion of the entropy of gravitons. In § 21 we give a formula for the entropy which refines (134). This will be possible due to the fact that the entropy can be obtained in the form of a tensor. We mention here that in the tensor components of the entropy are the rest energy of substance, energies of substance in gravitational and electric fields and the energy of the pressure of the substance.

From the qualitative standpoint (133) can be understood from the following discourses. It is known, that in supernovae a large amount of energy is radiated in the form of neutrinos, photons and fast particles. At the initial stage of collapse of supernova substance and photodisintegration of iron nuclei and seizure of electrons by protons and nuclei, in the impulse with duration about 10 ms electron neutrinos ν_e are radiated. The share of this impulse in the general balance of neutrino radiation of the supernova equals approximately 5 %. After the collapse of the substance, a neutron star which has been formed is getting cool. At the same time the reactions with electrons and positrons are taking place and neutrinos and antineutrinos are generated, for example in reaction: $e^- + e^+ = \nu_i + \widetilde{\nu}_i$, where the index $i = e, \mu, \tau$ differentiates electronic, muonic and $\tau-$leptonic neutrinos (antineutrinos). Typical energies of the neutrinos which are formed $10-15$ MeV, their main flux is radiated during the first 4 sec. Based on the results of the measurements of number of neutrino events fixed, different evaluations of energy of supernova SN 1987A give for the radiation of the antineutrino $\widetilde{\nu}_e$ the value $(1-8)\cdot 10^{45}$ J. This energy should be increased, taking into account the radiation of other types of neutrinos and antineutrinos. The evaluation of gravitational energy of neutron star equals: $\left|E_g\right| = \frac{k\gamma M_s^2}{R_s} = 2.4 \cdot 10^{46}$ J (with the mass of a typical star $M_s = 1.35 M_c$, where M_c – the mass of the Sun, and the radius of the star $R_s = 12$ km). In [121] it is possible to find an estimation of mass of the substance turning in neutrinos and in gravitational waves – approximately $0.2 M_c$. It turns out, that in formation of a neutron star the energy of the neutrinos being radiated can be compared to the full gravitational energy of the star.

Before the substance is included in the neutron star composition, it should come through different stages of transformation. First the low density hydrogen cloud gets condensed under the influence of gravitational forces, and a star is formed in which thermonuclear reaction take place. After long stay in the main sequence and burning-out of the thermonuclear fuel, an iron nucleus is formed in the star. This nucleus collapses in a neutron star after the increase of the mass limit, admissible for such nucleus. We should move from stars to elementary particles. In [7] it was shown, how we can introduce a concept of strong gravitation which binds the substance of the elementary particles based on the analogy of nucleons and neutron stars (more on this in § 10). If nucleons are formed based on the similar scheme as the neutron stars, then in forming of each nucleon a large amount of particles of small size is also radiated. We can assume that at least some of these particles serve as the gravitons. These particles should be similar by their qualities to neutrinos and antineutrinos radiated while neutron stars are formed. The total energy of all gravitons, which appear when one nucleon is formed from smallest rarified substance, must be close to the gravitational binding energy of the substance of this nucleon and to the rest energy of the nucleon. Thus, if the average concentration of the substance in our Metagalaxy equals 1 nucleon/m^3, then the corresponding energy of the substance in 1 m^3 at rest will equal approximately $E_p = M_p c^2 = 1.5 \cdot 10^{-10}$ J, where M_p – is the mass of a proton. The density of the energy of gravitons from nucleons prospective by us is of the same level as the density of the energy of substance at rest, that means $\varepsilon < 1.5 \cdot 10^{-10}$ J/m^3.

We should find now the relation between the density of the gravitons energy ε and the value W from (132). We will assume that there is a sphere of a radius R. The time of gravitons motion from the centre of the sphere outside does not exceed $t = \frac{R}{c}$. The value W can be obtained by means of multiplication of the density of energy ε to the sphere's volume, and the following division to the value of the full solid angle and the time $t = \frac{R}{c}$: $W = \frac{\varepsilon}{4\pi t} \cdot \frac{4\pi R^3}{3} = \frac{\varepsilon c R^2}{3}$. If we will insert W from (132) and $\varepsilon < 1.5 \cdot 10^{-10}$ J/m^3, it will be possible to evaluate the radius of the sphere: $R \approx 5 \cdot 10^{26}$ m or about 17 Gpc. This value exceeds the distance to the most remote galaxies and is close to the size of Metagalaxy. Thus the graviton fluxes which are born by the nucleon substance of the Metagalaxy and are penetrating it can be the reason of generating gravitation of macroscopic bodies.

In spite of the relatively small value of the energy density of gravitons ε originating from nucleons, the value of the graviton's energy power per unit of solid angle in the given direction W according to (132), and the effective energy density of gravitons ε_e are sufficiently large. Distinction between ε and ε_e can be presented as follows. If we take some point Q, then the contributions to the graviton flux, which come to this point from a single solid angle, create different spheres of space, which are located at different distances from Q within the given solid angle. The farther from Q the sphere of space radiating gravitons is located, the earlier the radiation should be produced so that it could be summed up in the point Q with the graviton fluxes from other spheres. Thus, the effect of accumulation of the power of gravitation flux can arise due to large size of the Metagalaxy. It is assumed that Metagalaxy is not in a stationary state, and the quantity of nucleon matter increases with time due to the formation of new nucleons from the smallest particles of substance.

In addition to the neutrino, electromagnetic radiation and cosmic rays of the lowest scale levels of matter can do the contribution to gravitation. Indeed, usual and neutron stars constantly radiate photons and fast particles, and the same thing suppose to be at the level of nucleons. Now we can specify the meaning of the relation (133) in the following way: Strong gravitation produces substance in the form of nucleons and creates the graviton fluxes, electromagnetic quanta and fast particles; the full energy of nucleons is connected with strong gravitation, and the full energy of neutron stars – with common gravitation; gravitons can not press the substance denser to the condition when the gravitational binding energy of the substance would exceed the rest energy of the substance.

The thermal heating in the massive bodies is usually connected with the release of energy in the processes of gravitational differentiation of substance, with the presence of the decomposed radioactive elements, with the nuclear reactions of synthesis. In cosmic bodies there are no other important internal sources of heat. Consequently, the action of gravitons in the stationary bodies does not lead to the essential additional thermal electromagnetic radiation from the bodies or the thermal motion of substance. We should assume that the energy of graviton fluxes inside the bodies in general are converted so that it pass again in the energy of graviton fluxes. Then the action of gravitons is reduced not to the constant increase in internal energy of the body or to its heating, but rather to the transfer of momentum as to the source of pressure and gravitational stresses in the body. To illustrate this, we give an example of an elastic repulsion of small particles from a large body. The interaction of the particle almost does not change its energy, but will give the body a large double momentum. If many such particles will interact with the body in an isotropic manner, the body will be fixed, but will be under constant pressure from the flux of incident particles.

Since interaction of gravitons with matter is not completely elastic, then in certain reactions, such as in reactions of weak interactions, some fraction of the energy released. It means, that the gravitationally-connected bodies can have a stable source of heating of their substance. It is possible to assume, that allocated thermal energy for one nucleon does not exceed potential energy of gravitational binding calculated for one nucleon (it is clear from the virial theorem and work of gravitation for matter compression and reduction of its volume).

In accordance with (133) and (133'), the rate of generation of gravitational energy in the bodies depends on the properties and speed of gravitons. Gravitational energy is a quantity which characterizes the dynamic process of interaction of gravitons with the matter. Hence, the internal thermal energy of cosmic objects is a function of the graviton flux, with the difference that the substance in the stationary objects while subjected to the gravitational pressure, but has nearly constant volume. Note that calculated on the basis of the virial average internal temperature of celestial bodies (the Sun and the Earth), according to [7] are really close to their present average temperatures.

The law of inertia

Let us try to find the explanation to that fact that during the motion with the constant speed the bodies are not decelerated by gravitons, but continue inertial motion. We shall consider for example the formula for gravitational force (120). It contains the term $pA_0\chi = \frac{\sqrt{2}\,c^2}{8k}$, which is obtained in this form according to (132) and (128). This term includes the speed c, which we assume to be constant in the inertial reference frames. In (120) there are other products of values of the type ρyx. During the motion of body with the constant speed its transverse dimension is not changed, and the apparent longitudinal size according to the theory of relativity is experiencing the Lorentz contraction. At the same time the apparent density of substance increases due to the Lorentz contraction of the body volume. If we assume that y and x are transverse and longitudinal sizes of the body, then during the motion of the body with the constant speed along x the value ρyx remains the same.

The dependence of the coefficient χ on the speed, which is located in the expression $\left(1-\frac{\chi\rho_1 yx_1}{2})\right)$, can be the possible source of deviation from the law of inertia. Thus, in (120) almost all the terms remain constant and the gravitational forces do not depend on the speed of motion with the accuracy at least to the second order by the mass, when it is necessary to consider the contribution of field's energy to the gravitational mass. In the same approximation it is possible to consider the special relativity theory also precise, since it includes the law of relativity of motion. The difference between mass-energy of moving and stationary gravitational field is described in § 8.

We can apply this result to the motion of the planets around the Sun. Suppose that a planet moves relative to the reference system in which graviton fluxes are isotropic. If the velocity of the planet is changing slowly, the difference in the pressure force of gravitons from the front and rear with respect to the direction of the velocity is small. As the estimates in [7] was made the calculation of braking force and the corresponding dipole emission of gravitational waves of Jupiter, arise due to the centripetal acceleration toward the Sun. For the lifetime of Jupiter in a circular orbit, there is value of $3 \cdot 10^{16}$ year. This means that the braking force for the planet is small and has little effect on their movement.

Alternative derivation of Newton's formula

As can be seen from the above calculations in (116) and in subsequent relationships there are values y and ρ. It turns out that it is possible to obtain Newton's formula for bodies' gravitation with the help of other physical variables. Let's designate by B_0 the graviton flux which cross per time unit the unit area dS perpendicular to the flux from a unit solid angle $d\alpha$:

$$B_0 = \frac{dN_0}{dt\, d\alpha\, dS}.$$

We should designate the next formulae by numbers with a stroke, if they are similar by meaning with the formulae, which were mentioned earlier. The value dS on the Figure 8 corresponds to the area of spherical segments, and the angle α we will understand as a unit angle $d\alpha$ .Then instead of (117) we will have:

$$d\alpha \cdot \left(\frac{R}{2} \right)^2 = dS. \qquad (117')$$

We can assume that changing of the graviton flux because of attenuation in the substance layer with width dx is proportional to concentration n of dispersing particles (which can be nucleons or atoms) and to the primary gravitons flux:

$$dB = -B\sigma n\, dx, \qquad B = B_0 \exp(-\sigma n x), \qquad (116')$$

where σ – a certain coefficient, which has the meaning of effective cross-section of the dispersion of gravitons in substance.

For the segments' mass on the Figure 8 we have instead of (118):

$$M_1 = M_n n_1 x_1 dS, \qquad M_2 = M_n n_2 x_2 dS, \qquad (118')$$

where M_n – the mass of a nucleon,

n_1 and n_2 – concentrations of nucleons in masses M_1 and M_2.

The effective force as the momentum per time unit from the flux of absorbed gravitons will equal:

$$F = p\,d\alpha\,dS\,\Delta B\,, \tag{119'}$$

where p – the momentum of one graviton.

The force from the left side to mass M_1 on Figure 8 taking into account (119') and (116') equals:

$$\begin{aligned} F_1 &= p\,d\alpha\,dS\,(B_0 - B_1) = p\,d\alpha\,dS\,B_0[1-\exp(-\sigma n_1 x_1)] \approx \\ &\approx p\,d\alpha\,dS\,B_0\,\sigma n_1 x_1\left(1-\frac{\sigma n_1 x_1}{2}\right). \end{aligned} \tag{120'}$$

Changing of graviton flux during its propagation in space between masses M_1 and M_2 we can obtain with the formula:

$$B_{11} = B_1 \exp\left(-\sigma \int n(r)\,dr\right), \tag{121'}$$

where $B_1 = B_0 \exp(-\sigma n_1 x_1)$ – graviton flux, which have come from the left side through the mass M_1,

B_{11} – graviton flux, which reached from the left side the mass M_2,

$n(r)$ – substance's concentration between M_1 and M_2 as a function of the coordinate r.

The force from the left side at M_2 similarly to (5') equals:

$$\begin{aligned} F_2' &= p\,d\alpha\,dS\,(B_{11} - B_2') = p\,d\alpha\,dS\,B_{11}[1-\exp(-\sigma n_2 x_2)] \approx \\ &\approx p\,d\alpha\,dS\,B_{11}\,\sigma n_2 x_2\left(1-\frac{\sigma n_2 x_2}{2}\right). \end{aligned}$$

If we substitute here with (121') and then use $B_1 = B_0 \exp(-\sigma n_1 x_1)$, for the force F_2' we obtain:

$$F_2' = p\, d\alpha\, dS\, B_0\, \sigma n_2 x_2 \left(1 - \frac{\sigma n_2 x_2}{2}\right) \exp\left(-\sigma n_1 x_1 - \sigma \int n(r)\, dr\right). \qquad (122')$$

For the graviton flux from the left side similarly to (120') and (122') we find:

$$F_2 \approx p\, d\alpha\, dS\, B_0\, \sigma n_2 x_2 \left(1 - \frac{\sigma n_2 x_2}{2}\right).$$

$$F_1' = p\, d\alpha\, dS\, B_0\, \sigma n_1 x_1 \left(1 - \frac{\sigma n_1 x_1}{2}\right) \exp\left(-\sigma n_2 x_2 - \sigma \int n(r)\, dr\right).$$

The gravitation force which influences the mass M_1 from the side of M_2, equals:

$$\begin{aligned} F_{01} = F_1 - F_1' = p\, d\alpha\, dS\, B_0\, \sigma n_1 x_1 \left(1 - \frac{\sigma n_1 x_1}{2}\right) \times \\ \times \left(\sigma n_2 x_2 + \sigma \int n(r)\, dr\right) \left(1 - \frac{\sigma n_2 x_2 + \sigma \int n(r)\, dr}{2}\right). \end{aligned} \qquad (123')$$

The mass M_2 from the side of mass M_1 is influenced by the force, which is equal to:

$$\begin{aligned} F_{02} = F_2 - F_2' = p\, d\alpha\, dS\, B_0\, \sigma n_2 x_2 \left(1 - \frac{\sigma n_2 x_2}{2}\right) \times \\ \times \left(\sigma n_1 x_1 + \sigma \int n(r)\, dr\right) \left(1 - \frac{\sigma n_1 x_1 + \sigma \int n(r)\, dr}{2}\right). \end{aligned} \qquad (124')$$

To make it simpler we can assume, that section σ of the interaction of gravitons with nucleon form of substance is equal for masses M_1 and M_2. From (123') and (124') we see, that forces F_{01} and F_{02} are not equal because of additional forces from the sources of mass which are between the bodies.

We can assume, that interacting masses M_1 and M_2 are situated in vacuum and concentration of substance $n(r)$ between them equals to zero. Then for the gravitation force between the masses M_1 and M_2 taking into account (118') and (117'), we obtain:

$$F = F_{01} = F_{02} = \frac{4pB_0\,\sigma^2 M_1 M_2}{M_n^2 R^2}\left(1-\frac{\sigma n_1 x_1}{2}\right)\left(1-\frac{\sigma n_2 x_2}{2}\right) = \frac{\gamma M_{1g} M_{2g}}{R^2}, \tag{125'}$$

here through M_{1g} and M_{2g} effective masses of the substance are designated, which are involved in gravitation. From (125') we find:

$$\gamma = \frac{4pB_0\,\sigma^2}{M_n^2}, \qquad M_{ig} = M_i\left(1-\frac{\sigma n_i x_i}{2}\right), \tag{126'}$$

where index $i = 1, 2$ differentiates masses M_1 and M_2.

According to (126'), gravitational constant γ is determined by constant values – the momentum p of one graviton; graviton flux B_0, which falls in time unit from unit solid angle to unit area; square effective cross-section σ of graviton absorption in nucleon substance; mass M_n of one nucleon.

The maximum value σ can be estimated from the condition $\sigma n x \approx 1$ for the exponents of (116'). As a result of the high substance density of neutron stars the concentration n of nucleons in them reaches 10^{44} m^{-3}. If we take a triple diameter of the stars as the length of the gravitons' path x, that means a value about 90 km, we will obtain interaction section of gravitons in substance: $\sigma < 10^{-49}$ m^2. This section is very small and can be compared to section for neutrino with energy about 100 eV. On the other hand, if the laws for change of graviton flux (116) and (116') are similar, then the corresponding terms inside the exponents can be equated to one another: $\chi \rho y x = \sigma n x$. For a neutron star $\frac{\rho}{n} = M_n$, and when $y = \sqrt{2} R_s$ (where R_s – the radius of the neutron star) for section in view of (129) is found: $\sigma = \sqrt{2} R_s \chi M_n = 5.7 \cdot 10^{-50}$ m^2.

The main conclusions about the effect of gravitational shielding, which were obtained above remain valid. If we add for example substance near mass M_1, then the force which influences mass M_2, will increase in the same way as mass M_1 increases. If substance's mass increases beyond the limits M_1 and M_2, then instead of (131) we will have:

$$F = \frac{\gamma M_{1g} M_{2g} \exp\left(-\sigma \int n(r)\, dr\right)}{R^2}. \qquad (131')$$

Equation (131') is close by its meaning to (130). It means that if in the absence of external substance masses M_1 and M_2 will move towards each other under influence of gravitational attraction, then with enough quantity of external substance it can decelerate the motion of M_1 and M_2 towards each other because of decrease of the effective force between M_1 and M_2.

In strong gravitational field if we would not expand the exponents into series in (120') – (124'), the expressions for the forces will be different. For example for the force F_{01} from (123') we obtain:

$$F_{01} = p\, d\alpha\, dS\, B_0 \left[1 - \exp(-\sigma n_1 x_1)\right]\left[1 - \exp(-\sigma n_2 x_2)\right].$$

With high concentrations of substance n_1 and n_2 for two interacting masses, for example for two identical close neutron stars contribution from exponents becomes rather small and it can be not taken into account as first approximation. In this case, taking into account (117') and (126') for the maximum force we have:

$$F_m = p\, d\alpha\, dS\, B_0 \approx \frac{\gamma M_n^2 \Delta S^2}{\sigma^2 R^2}, \qquad \text{and by Newton's law:} \qquad F_m = \frac{\gamma M_s^2}{R^2},$$

where M_s – the mass of neutron star,

R – the distance between star's centers.

It follows that $\frac{M_s}{M_n} \approx \frac{\Delta S}{\sigma}$. But ratio of the neutron star mass to the nucleon mass is the similarity coefficient $\Phi = 1.614 \cdot 10^{57}$ by mass between star and nucleon levels of matter according to Table 8 in § 6. If we take as ΔS the section of a neutron star and divide it by the value of the section of gravitons' interaction with substance $\sigma < 10^{-49}$ m^2, then we will obtain the value close to Φ.

On the other hand as force F_m we can understand the force of maximum gravitational interaction of two nucleons. In this case $R \approx 2R_n$, where R_n – nucleon's radius, $\Delta S \approx \pi R_n^2$. For the force we obtain:

$$F_m \approx \frac{\gamma M_n^2 \pi^2 R_n^4}{4\sigma^2 R_n^2} = \frac{\Gamma M_n^2}{4R_n^2},$$

where Γ – the constant of strong gravitation. According to [7], the constant Γ can be obtained from the condition of equality of gravitational and electrical forces between a proton and a electron at the Bohr radius in hydrogen atom (this conclusion is confirmed by the results of § 14). It is determined by the expression $\Gamma = \frac{e^2}{4\pi\varepsilon_0 M_p M_e} = 1.514 \cdot 10^{29}$ m^3·kg^{-1}·s^{-2}, where e and M_e – electron's charge and mass, M_p – proton's mass, ε_0 – electrical constant. At the same time, as it is shown in § 10, with the help of the constant Γ the full energy of nucleon can be calculated, which is equal to its rest energy.

From the expression for the force F_m it follows that there should be $\Gamma \approx \frac{\gamma \pi^2 R_n^4}{\sigma^2}$. Substituting here gravitational constant γ, nucleon's radius about $R_n = 8.7 \cdot 10^{-16}$ m, section $\sigma < 10^{-49}$ m^2, we obtain the value close to Γ. We should notice that the force $F_m = \frac{\Gamma M_n^2}{4R_n^2}$ between two nucleons is rather big. In § 10 it is shown, that the force in atomic nuclei can be balanced by electromagnetic forces and by the force from strong gravitational torsion field.

With the help of (126') we can evaluate the radiance of the graviton flux as power of energy per unit area from unit solid angle:

$$U = pcB_0 = \frac{\gamma c M_n^2}{4\sigma^2} > 10^{42} \text{ W/(st·m}^2\text{)}, \qquad (132')$$

if c is taken equal to light speed.

Dividing (132 ') on the speed c and multiplying it by the full solid angle 4π, we find the maximum possible momentum per unit time delivered gravitons per unit area.

This value equals the maximum gravitational pressure from gravitons: $P_G = 4\pi p B_0 > 4 \cdot 10^{34}$ Pa. Besides, $P_G = \varepsilon_G$, where ε_G is the energy density of graviton flux, averaged in space and in all directions. Accordingly, ε_G many times greater than the effective energy density $\varepsilon_e = 1.5 \cdot 10^{26}$ J/m^3 delivered by graviton flux at a given point per unit time for the model case of unidirectional movement of energy.

In common models of neutron stars the pressure in substance does not exceed P_G, as a substantial part of gravitons passes through matter without interaction with transmitting force impulse. But in nucleons the density of substance and its pressure exceed the corresponding values in neutron stars. Then pressure P_G from gravitons could be almost enough for maintaining the integrity of nucleons. On the other hand, if gravitons like neutrino, photons and relativistic particles are generated by nucleons, their energy would not be enough for gravitational binding of the nucleon's substance. Hence the conclusion about necessity of existence gravitons of deeper levels of matter, with even greater density of energy from here follows.

Based on the section of graviton's interaction with the substance we can assume that gravitons are for example neutrino with energy $E_\nu = pc = 100$ eV $= 1.6 \cdot 10^{-17}$ J. Then we can obtain the momentum p, and with its help the graviton flux $B_0 = \frac{U}{E_\nu} \approx 10^{59}$ s^{-1}st^{-1}m^{-2} is determined from (132').

We can find now the power of energy generation in gravitationally bound bodies. With the help of (116') from (132') we have:

$$\frac{dE_G}{dt} = \Delta\alpha\, \Delta S\, \Delta U = \Delta\alpha\, \Delta S\, pc\, \Delta B = \Delta\alpha\, \Delta S\, pc B_0\, \sigma n x = \Delta\alpha\, \Delta S\, U \sigma n x .$$

We use (118') in the form $nx\Delta S = \frac{M}{M_n}$, with condition $\Delta\alpha = 4\pi$ for the full solid angle, and also disclose U with the help (132'). Finally, for the stars with $M = M_s$ we use the condition obtained above $\frac{M_s}{M_n} \approx \frac{\Delta S}{\sigma}$, substituting $\Delta S = \pi R^2$, where R – the star's radius. The result is the following:

$$\frac{dE_G}{dt} = \frac{4\pi U\, \sigma M}{M_n} = \frac{\pi \gamma M M_n c}{\sigma} = \frac{\pi \gamma M^2 c}{\Delta S} = \frac{\gamma M^2 c}{R^2} \approx \frac{E_G}{R/c} . \qquad (133')$$

From (133′) it follows that the power of generation of gravitational energy in bodies is approximately equal to gravitational energy of the body, which is radiated during the time of gravitons' passing the radius of the body: $t = R/c$. Gravitational energy of the nucleons' binding is almost equal to its rest energy, that is why (133′) applied to nucleons (substituting γ by Γ) coincides with (133) for maximum gravitation energy.

We can estimate the radius of action of gravitation in the substance with low density. The condition for a substantial weakening of gravitation during the passage of gravitons in the medium range x with the concentration n of nucleons has the form: $\sigma n x \approx 1$. Assuming that there is a substance with nucleon density equal to water density $\rho_E \approx 10^3$ kg/m^3 and the concentration of nucleons $n_E \approx \frac{\rho_E}{M_p}$, we find the distance: $x_E = \frac{M_p}{\sigma \rho_E} > 1.7 \cdot 10^{19}$ m if $\sigma < 10^{-49}$ m^2. To go to the appropriate distance for strong gravitation, x_E must be divided by a factor of similarity in size $P = 1.379 \cdot 10^{19}$ from Table 8 in § 6: $X_E = \frac{x_E}{P} > 1$ m. The resulting length determines the distance in substance with some density ρ, at which the effect of strong gravitation disappears. Estimate of the quantity ρ can be made on the basis of similarity theory and the dimension of physical units included in the density. This gives the following: $\rho = \frac{\rho_E P^3}{\Phi} = 1700$ kg/m^3, here Φ is the similarity ratio by mass from Table 8 in § 6. For comparison, the average density of Earth is 5518 kg/m^3.

The inertial force

As it is known, during acceleration all bodies have resistance, which is called the inertial force. Let the body of the constant mass be accelerated rectilinearly by a certain force $\boldsymbol{F}$. If at the given moment the velocity of the body is $\mathbf{v}(t)$, then for changing of the energy of the body it is possible to write down:

$$\frac{dE}{dt} = \boldsymbol{F} \cdot \mathbf{v}(t), \qquad \text{where} \quad E = \frac{M c^2}{\sqrt{1 - \mathbf{v}(t)^2 / c^2}}.$$

Differentiating energy by the time, we can express the force through the acceleration:

$$\boldsymbol{F} = \frac{M}{\left(1 - \mathbf{v}(t)^2 / c^2\right)^{1,5}} \frac{d\mathbf{v}(t)}{dt}.$$

Before the acceleration $\frac{d\mathbf{v}(t)}{dt}$ there is the so-called longitudinal mass. For an arbitrary motion the force according to (580) is:

$$\boldsymbol{F} = \frac{M}{\left(1-\mathbf{v}(t)^2/c^2\right)^{1,5}}\left[\frac{d\mathbf{v}(t)}{dt} + \frac{\mathbf{v}(t)\times\left[\mathbf{v}(t)\times\frac{d\mathbf{v}(t)}{dt}\right]}{c^2}\right].$$

The obtained force must be equal to the inertial force according to the third Newton's law about the equality of the action and reaction forces. However, what is the reason of the inertial force, why do bodies resist a change in their velocity? Based on what was stated earlier, the action of the graviton flux must be the reason of the inertial forces. Firstly, the gravitons are responsible for the gravitational energy and the rest energy of the bodies at the nucleon level, and consequently the change in energy as the result of the change in bodies' motion must be connected with gravitons. Secondly, with the constant velocity of motion the inertial force is not observed, but it appears with the acceleration of bodies. Consequently, with the acceleration the work towards the body is done, simultaneously the body does work against the graviton flux. It is possible to consider that regardless of the form of the work done to the body, this work is done to the graviton flux, passing through the body.

The relativity of motion

We should consider the situation, when two bodies with mass M_1 and M_2 are located on a straight line along the vertical axis OY, and are moving with the constant speed in horizontal direction along the axis OX of the reference system *K*. We will assume that in the reference system K', where the both bodies are at rest, the axes OX', OY', OZ' are parallel to the axes OX, OY, OZ of the reference system *K*. In K' there is attraction between the bodies due to the mutual shielding of graviton fluxes. But how will gravitational interaction proceed during the simultaneous motion of these bodies from the point of view of a motionless observer in K?

Firstly, for calculation of the forces the concept of the delay of gravitational effect due to the limited speed of gravitation propagation should be used. In the case, the condition of equality of the time must be met: as the mass M_1 passes the way Δx with the speed v, the graviton flux from the mass M_2 is moving towards the mass M_1 with the speed c. This can be expressed in the following way: $t = \frac{\Delta x}{\mathrm{v}} = \frac{\sqrt{(\Delta x)^2 + y^2}}{c}$, where y – the distance between the masses. Secondly, for an observer in K it seems that since the gravitons from the mass M_2 are moving, as if overtaking the mass M_1, their momentum is not directed strictly along the axis OY. Then a force should appear, which would decelerate the motion of M_1 along the axis OX. The same can be said about deceleration of the mass M_2. However, the direction of force between M_1 and M_2 must not change in the reference system K', since the masses are moving with the constant speed at the constant distance from each other.

In order to avoid the contradiction, we should consider that if the masses M_2 and M_1 move with the speed v, the graviton flux interacting with the masses has the component of speed, also equal to v and directed along the axis OX. The combined speed of gravitons in the reference system K must equal c, therefore the speed of gravitons along the axis OY must be less than c and must equal c_y. Consequently, $c_x = \mathrm{v} = \sqrt{c^2 - c_y^2}$. For transformation of gravitons' speed in different reference systems we should use vector formula of speed summation from relativity theory (51):

$$\boldsymbol{V}' = \frac{d\mathbf{r}'}{dt'} = \frac{\boldsymbol{V} + \left(\frac{(\beta - 1)\,(\mathbf{V_0} \cdot \boldsymbol{V})}{V_0^2} - \beta \right) \cdot \mathbf{V_0}}{\beta \left(1 - \frac{\mathbf{V_0} \cdot \boldsymbol{V}}{c^2} \right)},$$

here $\boldsymbol{V}'$ – the speed of any object in the reference system K',
$\boldsymbol{V}$ – the speed of the given object in the reference system K,
$\mathbf{V_0}$ – the speed of motion of reference system K' along K,
$\beta = \frac{1}{\sqrt{1 - V_0^2/c^2}}$.

We obtain $V_x = c_x = \mathrm{v}$, $V_y = c_y$, $V_{0x} = \mathrm{v}$, $V_{0y} = 0$. From the speed summation formula we obtain: $V'_x = 0$, $V'_y = \frac{c_y}{\sqrt{1 - \mathrm{v}^2/c^2}} = c$. From the point of view of the second observer, who is located at the moving mass M_1, the graviton flux which falls on it from the mass M_2 is directed along the axis OY' only. Therefore, there will be no deceleration of masses along the axes OX and OX'. In case of parallel motion of two masses M_2 and M_1 along the axis OX it follows from the calculation [7] for the gravitation force's module in reference systems K' and K: $F' = \frac{\gamma M_1 M_2}{y^2}$,

$F = \frac{\gamma M_1 M_2 \sqrt{1 - \mathrm{v}^2/c^2}}{y^2}$, where y – the distance between the masses along the axis OY. At the same time for an observer in the reference system K the force F between the masses is reducing as the speed v of masses' motion is increasing. It conforms to the fact that the effective speed of gravitons along the axis OY for the moving masses is also reducing: $c_y = \sqrt{c^2 - \mathrm{v}^2} = c\sqrt{1 - \mathrm{v}^2/c^2}$.

Gravitons and the relativity theory

Above the relativity of motion was shown, where speed is transformed according to the formula of speed summation in the relativity theory. In the special relativity theory we should consider the retardation of gravitational influence not simply from a moving mass point, but from the body which is limited by its size. This makes such a correction into the potential of gravitational field, which in the result leads to the Lorentz transformation of coordinates. In this case the gravitational force between two moving bodies, calculated through the potential gradient, has deficiency in force. If analogous deficiency in electric force is compensated by the magnetic force, as it occurs in electromagnetism, then in gravitation an additional force from the torsion field should be introduced.

In the Lorentz-invariant Theory of Gravitation (LITG) the equations for the field strengths have the form (60):

$$\nabla \cdot \boldsymbol{G} = -4\pi\gamma\rho, \qquad \nabla \cdot \boldsymbol{\Omega} = 0,$$
$$\nabla \times \boldsymbol{G} = -\frac{\partial \boldsymbol{\Omega}}{\partial t}, \qquad c_g^2 \nabla \times \boldsymbol{\Omega} = -4\pi\gamma \boldsymbol{J} + \frac{\partial \boldsymbol{G}}{\partial t}, \tag{135}$$

where the vectors $\boldsymbol{G}$ and $\boldsymbol{\Omega}$ – the strength of the gravitational field (gravitational acceleration) and the torsion respectively,

$\boldsymbol{J}$ – the vector of the density of the mass current,

c_g – the speed of gravitation propagation.

The gravitational force, which acts on the mass m, is determined by the expression: $\boldsymbol{F} = m\boldsymbol{G} + m\boldsymbol{V} \times \boldsymbol{\Omega}$, where $\boldsymbol{V}$ – the speed of the motion of mass.

The vectors $\boldsymbol{G}$ and $\boldsymbol{\Omega}$ can be expressed with the help of the scalar ψ and the vector $\boldsymbol{D}$ potentials of gravitational field according to (61), (62):

$$\boldsymbol{G} = -\nabla\psi - \frac{\partial \boldsymbol{D}}{\partial t}, \qquad \boldsymbol{\Omega} = \nabla \times \boldsymbol{D} \tag{136}$$

With the potentials of the field it is possible to compose the 4-vector of potential D_i:

$$D_i = \left(\frac{\psi}{c_g} \ , -\boldsymbol{D} \right).$$

We should also use 4-vector of the momentum density:

$$J_i = \rho_0 \, u_i = \left(\frac{\rho_0 \, c_g}{\sqrt{1 - V^2 / c_g^2}} \, , -\frac{\rho_0 \, V}{\sqrt{1 - V^2 / c_g^2}} \right) = \left(\rho \, c_g \ , -\boldsymbol{J} \right).$$

It follows from (135) and (136) that the action of four-dimensional d'Alembertian on the 4-vector of potential gives the vector, proportional to the 4-vector J_i:

$$\Box^2 D_i = \frac{1}{c_g^2} \frac{\partial^2 D_i}{\partial t^2} - \nabla^2 D_i = -\frac{4\pi\gamma}{c_g^2} J_i . \tag{137}$$

Equation (137) is a wave equation for the potentials, similar to (64). We should say that if we move from the General Theory of Relativity (GTR) to weak gravitational fields by expanding the equations for the metric to the first order, then exactly the equations of LITG (135) are obtained. This is shown, for example, in [49] and [50], when the shielding effect of the gravitational field was searched for. Thus, the concept of gravitons will be conforming to LITG, and gravitational forces do not require their substantiation through GTR. In this case, what role does GTR play in respect of the gravitation from the point of view of LITG?

The special relativity theory revealed the dependence of phenomena and the results of time-spatial measurements on the speed of the motion of reference systems, taken with respect to the speed of light. GTR makes the following step – it takes into account the fact that the mass-energy of substance and the fields existing in the space influences the course of time and the measured lengths. Such influence is accompanied by a change in the speed of the electromagnetic waves (of the light), used as well in the measuring instruments.

In LITG gravitational field is an independent physical field. Therefore for the correct use of GTR (or the corresponding metric theory) it is necessary preliminarily to take the stress-energy tensor of gravitational field, determined in LITG by covariant means. After this, knowing all the components of the stress-energy tensors of substance, electromagnetic and gravitational fields, it is possible to substitute them in the equations for the metric.

The obtained solution in the form of components for the metric tensor, cross-linked on the boundaries between the substance and the empty space, where only the field is present, determines the degree of difference in the metric of the noninertial system in question from the inertial reference system. The metric field, which consists of the components of metric tensor and which depends on the time and the coordinates of the point, where it is determined, will be derived as summary effect from the existing density of substance, pressure in it, the state of the motion of this substance (speed, acceleration), and also from the existing gravitational and electromagnetic fields and other possible values of energy-momentum (more on this is in § 19).

The calculations, made in the book [7] with respect to the contribution of energy of gravitational field to the metric, showed that the additive has a second-order value and contains terms with the fourth power of the speed of field propagation. The covariant theory of gravitation (CTG), developed by us in §§ 17–20, leads to similar amendments. The growing accuracy of gravitational experiments will probably make it possible in the near future to verify the presence of the corrections indicated. In the described approach the metric field can no longer be considered the field of gravitation. At the same time the known problem with covariance of the stress-energy tensor of gravitational field in GTR is solved, as this tensor is present in the covariant form in LITG and in CTG for the case of Riemannian space.

Conclusions

Taking into account what was stated above the following picture appears: the graviton fluxes from all sides penetrate the bodies almost without the loss of their total momentum. As the result of the effect of mutual shielding and interaction of gravitons with the substance all bodies have attraction to each other. Interaction of gravitons with the substance occurs in the way that the bodies are constantly obtaining and returning the energy, equal to their binding gravitational energy. In the static case, the situation reminds the phenomenon of almost perfect mirror reflection of light when the mirror is under pressure from the radiation, but the energy is transferred to the mirror only in a small degree. Similarly, all bodies have a gravitational pressure, but gravitation does not lead to significant heating of these bodies.

In our opinion, gravitons are numerous particles of a very small size, which move with the speed close to the speed of light and which are similar to low energy neutrinos. Then the integrity of all material objects is the consequence of the balance of forces of gravitation and internal forces from the pressure (motion) of the particles, which compose these objects. From the proportionality of gravitation forces to the mass of bodies it follows that the gravitational mass reflects the ability of the body to obtain impulse of force from the gravitons. According to General Theory of Relativity, the mass is determined not only by the quantity of particles in the body, but also by the nature of their interaction or by full (summary) energy. If the gravitons are more or less evenly distributed in the space and are the characteristic property of matter, then this makes it possible to connect the global and the local, inert and gravitational masses in the somewhat altered Mach principle: “The accelerations of bodies during interactions are determined not only by the bodies themselves (their masses), but also by the properties of their environment".

In assumption that gravitons are the smallest relativistic particles, we can make conclusions with the help of the theory of Infinite hierarchical nesting of matter [113]. At every level of matter either nucleon or star levels the most dense and gravitationally bound objects generate in different processes their own graviton fluxes. Then there is a whole range of gravitons of different energy and density levels which contribute to gravitation. As it has been shown above, all volume of the Metagalaxy participates in creation of the graviton fluxes.

We can assume that common gravitation in some extent is generated by relativistic particles from nucleon form of substance. Reasoning by induction we should assume that the nucleons appear under influence of relativistic particles of deeper level of matter (in the process of compression of substance under the influence of strong gravitation). Besides we see that fluxes of neutrino or gravitons of higher levels of matter consist of fluxes of neutrino and gravitons of lower levels of matter. Actually, neutrino impulse of a neutron star in any of transformations of its substance is combined fluxes of neutrino and antineutrino from star's nucleons. As during the motion downward by scale levels of matter the density of energy of the corresponding objects increases, then similarly the density of gravitons' energy and the force of gravitation must also increase.

We can estimate density of energy of graviton flux for the metagalactic level of matter which as exceeds the star level of matter as the star level exceeds the nuclear level. According to the theory of similarity, the ratio of energy density is connected with factors of similarity: $\frac{\varepsilon_m}{\varepsilon} = \frac{\Phi S^2}{P^3}$, where $S = 0.23$ is the factor of similarity in the speeds (see Table 8 in § 6). Substituting here $\varepsilon < 1.5 \cdot 10^{-10}$ J/m^3, $P = \frac{R_s}{R_n} = 1.4 \cdot 10^{19}$, $\Phi = 1.62 \cdot 10^{57}$, we find $\varepsilon_m < 5 \cdot 10^{-12}$ J/m^3. As gravitation at some level of matter is caused by graviton flux of lowest level of matter it is necessary to compare ε_m to density of energy of possible sources of gravitons, existing at the star level matter.

Well-known sources are the microwave background radiation with the energy density of order $4.18 \cdot 10^{-14}$ J/m^3, light radiation of stars with the energy density of about $8 \cdot 10^{-13}$ J/m^3, and cosmic rays, providing approximately $1.3 \cdot 10^{-13}$ J/m^3. Thus, the gravitons for metagalactic level of matter may be fluxes of photons, neutrinos and relativistic particles, mostly protons of high energy. From here follows, that usual gravitation at the level of planets and stars has sources of gravitons, belonging lower level, than nucleon-atomic level of matter.

It would be natural to call isotropic such reference system where all graviton fluxes are distributed isotropically in space evenly in all directions. In such reference system with condition of infinite smallness of the system's mass, the graviton fluxes become homogeneous, equal in all points of the reference system. Then the gravitational acceleration in the system tends to zero, and the isotropic reference system becomes inertial. Due to the inertia law such systems which move with the constant speed in relation to the isotropic reference system will be inertial too. But the isotropic reference system does not preset the absolute space according to Newton, as in space the graviton fluxes can not be homogeneous and in every point there is its own isotropic reference system. In § 8 we show the probable difference between isotropic and any other inertial frame of reference – at rest relative to an isotropic reference system the body has a certain energy of the gravitational field and no field momentum and at rest with respect to some inertial reference systems and motion relative to an isotropic reference system in the body there is an additional mass-energy of the gravitational field and the momentum of the field.

The existence of the isotropic reference system is one of the axioms in the extended special relativity theory (ESRT), presented in [4]. As it appears, the formulas of the special relativity theory can be derived from two main postulates – the relativity principle and the existence of isotropic reference system. One of the results of ESRT was derivation of the principle of light speed constancy in inertial reference systems. This principle could not be proven earlier and was considered to be an axiom of the relativity theory.

From the point of view of the concept of gravitons it is possible to determine the difference between the passive and the active gravitational masses, which differ also from the mass, determined from the measurements through the density and the volume. The analysis of the predicted effect of gravitational shielding proves to be true for the case, when the substance screens the bodies from the outside.

A special case is a rotating charged substance that appears to effectively dissipate the graviton fluxes. So, in § 14 it is assumed that the electron cloud rotating around the atomic nuclei in the molecule significantly reduces the gravitational force between the nuclei. Rotation of nucleons in the nuclei means rotation of the charged and magnetically ordered substance of the nucleons. This can be the reason that when nucleons connect in the nucleus the effective gravitational force acting between them decreases (more on this in § 10).

Due to the fact that the gravitational field equations (135) – (137) are very similar to Maxwell's equations for electromagnetic field, in [7] both fields were combined into a single electrogravitic field. Consequently, the carriers of both fields, the photon and the graviton, can be integrated into a single whole. In particular, the photon can be represented as an orderly motion of gravitons that transfers electromagnetic energy. This energy can be dissipated during the motion of the photon in substance, and the ordering of gravitons can disappear. The photon energy in this case will transfer to substance, while the gravitons will continue to participate only in the gravitational interaction (for more on this and the inertia see also § 19).

It should be noted that according to [7] in many cases is found out that the ratio of gravitational energy to electromagnetic energy is equal to the ratio of the nucleon mass to the mass of the electron. This can be seen for the ratio of the gravitational energy of strong gravitation to the electromagnetic energy of the nucleon; for the ratio of gravitational energy density of strong gravitation for nucleons to the energy density of zero-point fluctuations of electromagnetic radiation in a black-body cavity with envelope made of nucleons; for essentially the same ratio for the energy density of nucleons in the universe, and the electromagnetic radiation (taking into account the fact that the rest energy of nucleon is up to a factor of order of unity equal to the energy of strong gravitation, fastening the substance of the nucleon).

In § 14, describing the properties of electron, we find that the Thomson cross-section of the electron exceeds the cross-section of the nucleon. This means that if we compress the electron to the size of the nucleon, then due to the increased charge density the substance of the electron will completely re-emit all the energy of the electromagnetic wave falling on it. We shall now assume that the nucleon like the proton carries a charge equal by the absolute value to the electron charge, and some part of the graviton flux falling on the nucleon are electromagnetic quanta. Then we should expect full re-emission of energy of such electromagnetic gravitons by the substance of the nucleon and a certain balance between the forces of gravitation and internal pressure forces in the substance. This indicates that the detected size of nucleons and neutron stars as their analogues can be determined by the combination of parameters, which includes the maximum electric charge of these objects. For example, in § 13 in relations (316) and (319) the radius of proton is expressed through the strong gravitational constant $\mathit{\Gamma}$. But the constant $\mathit{\Gamma}$ is in its turn is determined by the mass of proton and electron, as well as through the elementary electric charge. Substituting into (316) the ratio $\mathit{\Gamma} = \frac{e^2}{4\pi\varepsilon_0 M_p M_e}$, for the radius of proton we find:

$$R_p = \frac{e^2}{14\pi\varepsilon_0 c^2 M_e} = 8 \cdot 10^{-16} \text{ m.}$$

We have repeatedly, and from various positions addressed the question of neutron stars as the densest stellar mass objects and of the impossibility of black holes. The situation in which the gravitons are largely re-radiated back by the substance of neutron stars can be an additional argument in the dispute between supporters and opponents of black holes.