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The force vacuum field as an alternative to the ether and quantum vacuum

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Abstract: - The vacuum field is considered as a force field, which consists of particles moving at speeds of the order of the speed of light, such as neutrinos, photons and charged cosmic rays. This distinguishes it from the classical static ether and some models of the quantum vacuum. In the presented model the occurrence of gravitational and electromagnetic force is substantiated, some vacuum field parameters are predicted, the sources that generate the vacuum field are suggested based on the theory of infinite nesting of matter.

Key-Words: - vacuum field; graviton field; ether; quantum vacuum.

1 Introduction

In regard of the properties of the empty space that contains no observable elementary particles, there are several concepts, describing its properties. Most of these concepts have a long history and an extensive bibliography. Ether theories in various versions were aimed to explain how the light is propagated at great speed over long distances in the absence of visible material environment. In its simplest form the ether presented some all-permeating medium, the moving transverse high-frequency wave oscillations of which were associated with the propagation of light. In this medium the speed of light should depend on the ether density and elasticity with respect to deformation. In the emission model the light is a flux of particles emitted by heated matter, and then the speed of light is the speed of these particles, obtained by them at the time of emission. The emission model easily explained the effects of geometrical optics, but it had difficulties in explaining wave effects, such as interference. The ether as some elastic medium and the ether as the fluxes of luminiferous particles could hardly correlate with each other, as well as with some phenomena such as light refraction. The situation with ether became only worse with appearance of the electromagnetic field theory, since after that the ether should be responsible not only for the transport of light and any electromagnetic waves, but also for the electrostatic and magnetic fields.

Similar problems connected with the ether are posed in the theory of gravitation. The ether model was to explain why the electric force between the charged bodies obeys the Coulomb’s law and the gravitational force between the masses is described by the similar Newton's law. After it turned out that Maxwell equations were invariant with respect to the Lorentz transformations of the special theory of relativity (STR), the interest in the ether theory began to decrease. This was to a large extent due to the fact that it was impossible in one model to correlate all the physical parameters that the ether should have. In STR all the inertial reference frames are considered equal and it seems unclear why the ether in each of these reference frames has the same ability to transfer the light regardless of the velocity of the reference frame. It was therefore assumed that in order to transfer the electromagnetic waves the ether is not needed as a special carrier, it is sufficient that the propagating wave has a displacement current, when the energy of the wave's electric field periodically turns into magnetic energy and vice versa. As for the gravitation theory, the ether seems unnecessary in the general theory of relativity (GTR) as well. In GTR gravitation is reduced to the spacetime curvature, which, being a geometric object, is ascribed a physical attribute that allows it to change the trajectory of physical bodies and our very vision of physical processes.

It is obvious that such an approach poses new questions that have no answers so far: What mechanism underlies the mutual induction of electric and magnetic fields in the electromagnetic wave, which supports the displacement current? How does in GTR a relation appear between the body mass and the degree of spacetime curvature at a distance from the body? Apparently, the described above setting the problem of ether aside is nothing else than an attempt "to sweep the dust under the carpet". Meanwhile, the progress in this area could be important not only from the point of view of the world outlook and the unity of theory, but also from a practical point of view.

The quantum theory, the progress of which as well as of the general theory of relativity took place in the 20th century, instead of the ether uses the notion of physical quantum vacuum. It follows from experiments that the light is propagated in the form of individual quanta, which hardly agrees with the ether as some continuous and elastic medium. Unlike the ether, the quantum vacuum must not only support the propagation of electromagnetic and gravitational waves and quanta, but also the quanta of other fields, which are used, for example, in the theory of strong and weak interactions. As a rule, the lower state of vacuum is characterized by zero quantum numbers, when on the average all the momenta and angular momenta of the vacuum's particles (virtual particle-antiparticle pairs and field quanta) in an arbitrary volume are equal to zero. The electromagnetic vacuum is assumed to be filled with virtual photons and pairs of emerging and annihilating charged particles and antiparticles, which can have sufficiently high energy, but according to the principle of uncertainty must have a short lifetime. Propagation of real quantum is considered as the excited state of this vacuum, while the quantum during motion exchanges energy and momentum with virtual particles. Such a mechanism is to some extent similar to the ether model, in which the role of all-permeating ethereal medium is played by virtual particles. The only difference is that instead of the mechanical model the quantum-mechanical model is now used.

Unfortunately, quantum mechanics has its limitations, associated with the fact that, on the one hand, quantum phenomena are related to the Planck constant, which characterizes the level of elementary particles. On the other hand, the second name of the theory is wave mechanics, which implies that all objects are considered and interact with each other as wave packets, and physical quantities are calculated as the average values with the help of the wave function. In this approach, the picture of processes is blurred, since the mathematical formulas cannot fully convey the physical meaning of phenomena. Loss of clarity is often accompanied by the conclusions that quantum phenomena are not fully cognizable in principle. The Planck constant h, which relates the energy of electromagnetic quanta and the frequency of their oscillations and is a measure of the spin of elementary particles, is often related to other quantities. For example, it is believed that not only for photons but also for gravitons the same ratio of energy and frequency holds [1]. In our opinion, the latter can be erroneous, since gravitons can be particles, produced not by standard elementary particles with their constant h but by much smaller objects, characterized by their own constant h_p. We return to this issue in the next section.

In one of the models of the quantum vacuum [2] instead of gravitons an approach is used, in which the gravitational forces are the result of the vacuum energy gradients in the matter and outside bodies. The vacuum is assumed to be filled with some Bose-Einstein condensate and the space is broken into elementary cells with a volume equal to the cubic Planck length. The energy density of the condensate in the absence of matter is assumed to be equal to the ratio of the Planck energy to the volume of the elementary cell. The more there is mass and its relativistic energy in some isolated volume, the less quantum energy is assumed in this volume, while the total energy in this volume, which also includes electromagnetic energy, remains constant. The resulting vacuum energy gradient near the bodies, according to the model, should generate attraction of these bodies to each other.

By its meaning this model is one of the scalar theories of gravitation, and the gravitational force is similar to the force of the pressure, which is exerted equally in all directions as a scalar field. The shortage of quantum vacuum energy inside and around bodies is equivalent to the appearance of the gravitational scalar potential of the Newtonian theory of gravitation. The known problem of scalar theories of gravitation is the difficulties that arise from their relativistic generalization in the framework of the special theory of relativity to the moving reference frame. Besides, every theory must be tested not only in the framework of the relativity theory, but also must explain, for example, the gravitational redshift and the gravitational time dilation. In the approximation of gravitoelectromagnetism [3] it is known that moving masses generate not only a gravitoelectrical (regular gravitational) field, but also a gravitomagnetic field that has solenoidal nature and influences other moving bodies like a magnetic field in electrodynamics. A similar conclusion is made in the Lorentz-invariant theory of gravitation [4-5]. Such phenomena impose serious limitations on the quantum vacuum scalar field with regard to its interaction with the matter of moving bodies, which is necessary to explain these phenomena. For example, the gravitational field strength, which is proportional to the quantum vacuum energy gradient, should depend as well on the body's velocity, and the changes in the strength should propagate in space at the speed of light.

2 The graviton field

Let us consider instead of the static ether as some luminiferous medium and instead of the vacuum of quantum mechanics another universal object – the graviton field, which must ensure the existence of electromagnetic and gravitational phenomena. The graviton field is the further development of the idea of Fatio-Le Sage's model, according to which gravitation is generated by the action on the bodies of fluxes of some particles that fill the entire space. As gravitons such particles are suggested as neutrinos, photons and high energy charged particles, similar in their properties to cosmic rays. Based on this, in [4], [6] the Newton law of gravitation was derived, and the gravitational constant was defined in terms of graviton field parameters. Also the estimates were obtained for the energy density and the cross-section of interaction of gravitons with the matter, the maximum possible gravitational force and the explanation of the law of inertia was provided.

The idea of the graviton field obtained its further development in [7]. In these works it is assumed that the average energy of a graviton is given by $E_g = p_g c$, where p_g is the graviton momentum. In case of idealized cubic distribution, the real fluxes of gravitons are divided into six fluxes, falling on the body in the form of a cube from six sides perpendicularly to the faces. Each flux is defined by the fluence rate:

$$D_0 = \frac{dN_0}{dtdA}, \qquad (1)$$

as the number of gravitons dN_0 falling per unit time dt on a unit area dA.

As the flux of gravitons passes through the matter, part of gravitons interact with the matter particles and transfer their momentum to them, and the fluence rate decreases by the Beer–Lambert–Bouguer law:

$$D = D_0 \exp(-\sigma n x), \qquad (2)$$

that is it depends exponentially on the length of the path x traveled in the matter, on the matter concentration n and on the cross-section of interaction of gravitons with the matter σ.

If taking into account (1-2) we consider the balance of forces acting on the mass unit inside a uniform ball, as the total momentum per unit time transferred by gravitons, we can determine the gravitational constant G and the gravitational field strength $\mathbf{\Gamma}$:

$$G = \frac{3p_g D_0 \sigma^2}{2\pi M_n^2}, \qquad \mathbf{\Gamma} = -\frac{4\pi G \rho \mathbf{r}}{3}, \quad (3)$$

where M_n is the mass of one nucleon of matter, $\rho = nM_n$ is the density of the ball, $\mathbf{r}$ is the radius vector from the ball's center to the point, where the mass unit is located.

In [7] the graviton field energy density is specified:

$$\varepsilon_c = 6p_g D_0 = \frac{4\pi G M_n^2}{\sigma^2} = 7.4 \cdot 10^{35} \text{ J/m}^3, \quad (4)$$

while the cross-section value from [6] is used: $\sigma = \frac{2\pi k G M_n R_s}{c^2} = 5.6 \cdot 10^{-50}\ \text{m}^2$, where $k = 0.6$ for the case of uniform density, c is the speed of light, $R_s = 12$ km is the radius of a typical neutron star.

For the case when gravitons are the electromagnetic field quanta we find the temperature of the graviton field:

$$T = \left(\frac{\varepsilon_c}{a_\gamma} \right)^{1/4} = 5.6 \cdot 10^{12}\ \text{K}, \quad (5)$$

where a_γ is the radiation density constant.

The ratios found in [8] allow us to estimate the generalized temperature and pressure at the center of the neutron star and the proton. In particular, the generalized temperatures at the center of the star and the proton are the same and equal:

$$T_{cs} = T_{cp} = \frac{G M_p M_s}{k_B R_s} = 1.8 \cdot 10^{12}\ \text{K}, \quad (6)$$

where M_s is the neutron star mass, which is equal to 1.35 Solar masses, k_B is the Boltzmann constant.

From (5) and (6) it follows that the graviton field cannot heat the center of the star up to its temperature, since part of gravitons passes through the star without transfer of momentum.

The main conclusions obtained in [7] are the following. It is shown that the body mass is defined only by the value of the graviton luminosity, i.e. by the power of energy emission from the body of those gravitons, which interacted with matter and transferred their momentum to it.

The mechanism is presented, by which the magnetars as charged and strongly magnetized neutron stars emit high-energy cosmic rays and neutrinos and photons associated with them. According to the theory of infinite nesting of matter, the analogues of magnetars at the level of elementary particles are protons, which also emit similarly to neutron stars. At the lower level of matter there are praons, that are related to protons just like the latter are related to neutron stars. Praons, protons and magnetars are the densest objects at the corresponding levels of matter, and these objects are the main sources of gravitons, consisting of particles such as neutrinos, photons and cosmic rays. The main contribution into the graviton field, that cause gravitation at the level of stars, is made by the gravitons, produced at the lowest levels of matter. It is assumed that at the level of elementary particles strong gravitation is acting, which is considered as the basis of strong interaction [4]. The value of the strong gravitational constant is many orders of magnitude greater than the ordinary gravitational constant: $\Gamma = \frac{e^2}{4\pi \varepsilon_0 M_p M_e} = 1.514 \cdot 10^{29}\ \text{m}^3 \cdot \text{kg}^{-}$

$^{1}\cdot s^{-2}$, where e is the elementary charge, ε_0 is the vacuum permittivity, M_p and M_e are the masses of the proton and electron, respectively. With the help of the strong gravitational constant we can precisely calculate the radius of the proton and its magnetic moment [9].

Thus it is shown that the graviton field can be the source of gravitation, leading to strengths, scalar and vector field potentials, which are used in the Lorentz-invariant theory of gravitation [4] and in the covariant theory of gravitation [10-11].

3 Electromagnetic force

Let us now proceed from gravitation to electromagnetic phenomena. We consider the vacuum field as a multicomponent field, containing neutral neutrinos and photons, as well as energetic charged particles. The field of gravitons is a part of the vacuum field. In order to understand the electric interaction of bodies at a distance from each other, let us consider in Figure 1 the motion of charged small particles in the vicinity of two bodies, one of which is neutral and the second is positively charged.

As can be seen, both positive and negative particles act symmetrically on the positively charged body, which does not result in emerging of any additional force in comparison with the force of gravitation. The same applies to the second neutral body.

Figure 2 a) shows that the positive particles push the negatively charged body to the left, and Figure 2 b) shows that the negative particles push the positively charged body to the right (when the smallest particles pass through the body similarly to gravitons, they transfer their momentum to them). Consequently, both bodies will be attracted to each other.

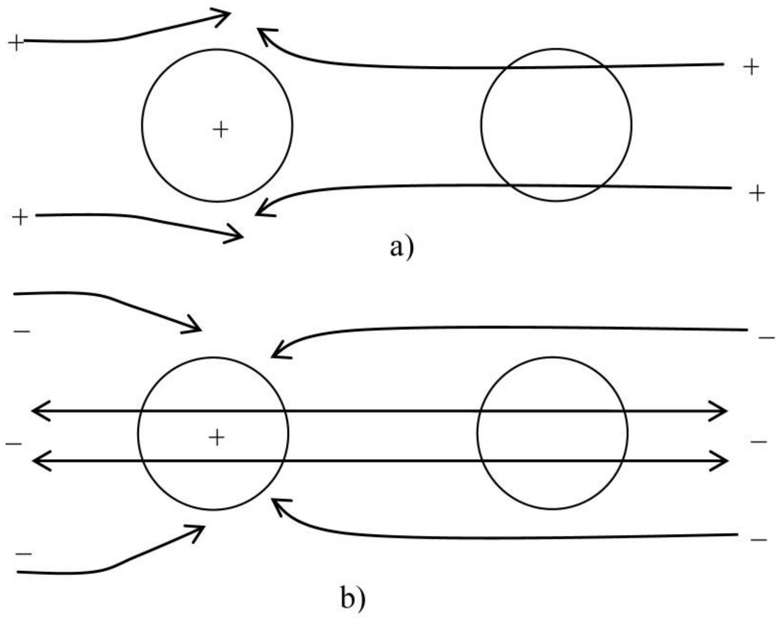

Fig. 1. The lines of motion of the small particles of the vacuum field, which are a) positively charged, b) negatively charged, near two bodies one of which is neutral and the other is positively charged.

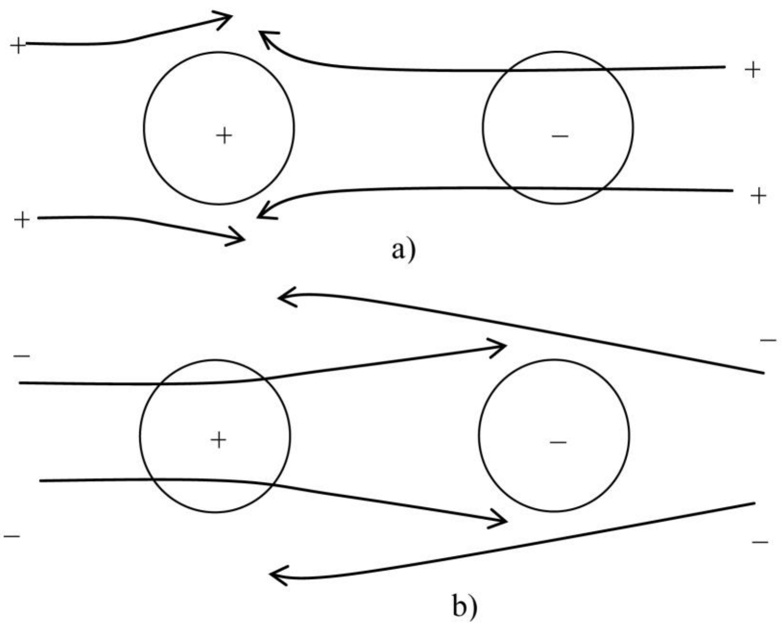

Fig. 2. The lines of motion of the small particles of the vacuum field which are a) positively charged, b) negatively charged, near two bodies, one of which is negatively charged and the other is positively charged.

Figure 3 shows the lines of motion of the negative particles of the vacuum field near two positively charged bodies. Both bodies attract the negative particles and obtain an additional momentum from them, which leads to repulsion of bodies. The motion of the positive particles of the vacuum field in Figure 3 is not shown. It is assumed that they are repelled from the bodies and therefore their interaction with them is weak.

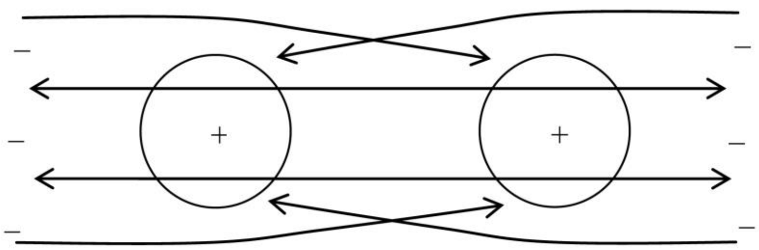

Fig. 3. The lines of motion of the small particles of the vacuum field, which are negatively charged, near two positively charged bodies.

For two negatively charged bodies the interaction is similar to the one shown in Figure 3, only it is necessary to replace the signs of all charges. This results in the repulsion of similarly charged bodies. The picture described above can be found in [10]. The common in all the Figures is the fact that depending on the sign of the charge of two bodies the number of charged particles falling on the bodies changes so that after calculating the momentum transferred by these particles the electric force in necessary direction arises.

Thus, we reduce the interaction between the charges at a distance to the interaction by means of the charged particles of the vacuum field.

Let us compare the Coulomb's law and the Newton's law:

$$F_C = \frac{q_1 q_2}{4\pi\varepsilon_0 R^2}, \qquad F_N = \frac{G m_1 m_2}{R^2}.$$

For the charged particles the relation must hold for the fluence attenuation of charged particles in the matter similarly to (2), with substitution of the concentration of nucleons n with the concentration of the electric charge η inside the body. Instead of the body mass $m = nM_n$ the absolute value of body charge should be used $|q| = \eta e$, where e is the elementary charge. As a result, instead of (3-4) we arrive at the approximate expression for the vacuum permittivity:

$$\varepsilon_0 = \frac{e^2}{6 p_q D_{0q} \vartheta^2} = \frac{e^2}{\varepsilon_q \vartheta^2}, \qquad (7)$$

where p_q is the average momentum of a charged particle, D_{0q} is the fluence rate of the charged particles of the vacuum field, ϑ is the cross-section of interaction of the charged particles with the matter of charged bodies, ε_q is the energy density of the charged particles in space.

As it was shown in [4], the ratio of the energy density of strong gravitation to the electromagnetic energy density of the proton is equal to the ratio of the proton mass to the electron mass $\frac{M_p}{M_e}$. Indeed, for the field energies and their relations with regard to definition of strong gravitational constant $\Gamma = \frac{e^2}{4\pi\varepsilon_0 M_p M_e}$, we have: $E_g = \frac{k\Gamma M_p^2}{R}$, $E_e = \frac{ke^2}{4\pi\varepsilon_0 R}$, $\frac{E_g}{E_e} = \frac{4\pi\varepsilon_0 \Gamma M_p^2}{e^2} = \frac{M_p}{M_e}$. We believe that the same relationship holds for the energy density of neutral and charged particles in the vacuum field that allows us to estimate the energy density of charged particles and their cross-section of interaction:

$$\varepsilon_q = \varepsilon_c \frac{M_e}{M_p} = 4 \cdot 10^{32} \text{ J/m}^3,$$

$$\vartheta = \frac{e}{\sqrt{\varepsilon_0 \varepsilon_q}} = 2.67 \cdot 10^{-30} \text{ m}^2.$$

This cross-section has the value, which is comparable with the cross-section of nucleon and exceeds the cross-section of gravitons $\sigma = 5.6 \cdot 10^{-50}$ m^2.

If the described picture is true, then from the Coulomb force we can easily move to the field strength of the electric field around a point charge and then to the scalar field potential. After that, dividing the scalar potential by the square of the speed of light and multiplying by the 4-velocity we obtain the 4-potential of the particle. Then use of the procedure in [11] allows us to find all of the electromagnetic field properties and to derive all the field equations, including the Maxwell equations.

4 Conclusion

After a brief analysis of the models of ether and quantum vacuum and after enumerating the problems existing in these models, we presented the force vacuum field as some alternative. If we assume that the vacuum field consists of such particles as neutrinos, photons and charged high-energy particles, generated at the lowest levels of matter, it helps to explain the high penetrating ability of the particles. The fluxes of gravitons and charged particles of the vacuum field due to the small cross-section of interaction with the matter penetrate all the objects and transfer their momentum to them. Only such dense objects as neutron stars have the ability to appreciably absorb and dissipate the fluxes of gravitons.

According to the estimates in [6], it is necessary to put into a line three neutron stars for significant absorption of the fluxes of gravitons passing through them. Taking into account the fact that the analogues of neutron stars at the atomic level are nucleons and the assumption that the strong gravitation is acting between the nucleons instead of the ordinary gravitation, in [10] and [12] we can explain the effect of saturation of the nuclear forces binding the atomic nuclei. The essence of the explanation lies in the fact that as the number of nucleons increases, the specific energy of strong gravitation per nucleon, which is proportional to the specific nuclear binding energy, stops increasing linearly, as the gravitational field potential usually increases with increasing of the mass. Saturation becomes noticeable in the nuclei, containing about 20 nucleons or more. In these nuclei, due to almost complete absorption of gravitons by nucleons, addition of a new nucleon brings into the system almost the same binding energy, and therefore the dependence of the specific nuclei binding on the atomic number has the saturation effect.

In the presented model the vacuum field is responsible for both gravitational and electromagnetic forces. In contrast to the models of ether and quantum vacuum, in which there is some static substance with certain properties, the vacuum field is a multi-component and dynamic field, consisting of particles moving at about the speed of light. Electromagnetic and gravitational waves in this case must be the waves transferred by the particles of the vacuum field. In particular, in [13] we have presented the model of a photon, which consists of charged particles.

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