On the structure of the force field in electro gravitational vacuum

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Analysis of the field equations for the tensors of the mass and charge components of the general field shows that their source is the charge four-current. In this connection, an assumption is made that it is the charge component of the force field of the electrogravitational vacuum in the form of fluxes of charged particles within the framework of Le Sage's theory of gravitation, which is mainly responsible for both electromagnetic and gravitational interactions, as well as for the action of other fields inside bodies. The parameters of the vacuum's charged particles can be determined quite accurately using the theory of similarity within the theory of infinite nesting of matter, so that the description of the cause of emergence of electromagnetic and gravitational forces is filled with specific content.

Keywords: force field; electromagnetic interaction; gravitational interaction; electrogravitational vacuum.

1. Introduction

The concept of a force vacuum field takes its origin from the appearance of the Fatio-Le Sage's model in the 17th and 18th centuries, in which numerous rapidly moving tiny particles filling the entire space penetrate all bodies and lead to gravitation between bodies [1-4]. The modernized Fatio-Le Sage's model does not only describe the emergence of gravitational forces [5], but also explains the origin of electromagnetic forces [6]. In addition, this model, in combination with the theory of infinite nesting of matter, provides specific parameters of particles, many of which make up the force field of the electrogravitational vacuum. In particular, the energy density and energy flux density, the Lorentz factor, the limiting density of the transferred electric current and the cross-section of interaction between the particles and matter are calculated for the particles like praons. In [7], the Lorentz factor at the center of the proton is determined, and the subsequent use of the similarity theory allows us to

estimate the praon charge, mass and dimensions, and the gravitational constant, Dirac constant and Boltzmann constant acting at the praon level of matter.

As a result of the force vacuum field's action on the matter, such phenomena as electromagnetism and gravitation arise, which are described in modern physics by the field theory. One of the first scientists who pointed out the analogy of the equations of electromagnetic and gravitational fields is Oliver Heaviside [8]. As a result, the gravitational field must have two components, just as the electromagnetic field, which contains the electric and magnetic components [9]. With this in mind, in [10] the theory of acoustic waves is considered, which depend simultaneously on the potentials of both the electromagnetic and gravitational fields and which propagate in solid bodies. The theory of gravitation, constructed similarly to the theory of the electromagnetic field, is presented in [11-13].

In the general theory of relativity, the gravitational field is considered as a tensor metric field and is actually replaced with the spacetime metric, so that the physics of phenomena is "hidden in the shadow" of geometry. In a weak field, the equations of general relativity can be represented as equations of gravitoelectromagnetism, in which the gravitational field is indeed described in terms of two components [14-18].

Contrastingly, in the covariant theory of gravitation, the gravitational field is a physically acting vector field that exists independently of the metric. As a result, the gravitational field is described by its own four-potential and the gravitational field tensor, while the field's stress-energy tensor is derived from the principle of least action in a covariant form [19].

For brevity, we will further consider only four main fields: the gravitational and electromagnetic fields, acceleration field and pressure field. All these fields are vector fields, and, if necessary, other vector fields can be added to them, for example, dissipation field [20], weak and strong interaction fields. All these fields can be combined into one general field [21]. A relativistic uniform system, which has a spherical shape and is in equilibrium under the action of its own gravitation and the other three fields, will be used as a physical model describing the matter.

Our goal will be to analyze the general field theory and then to define the main active component of the force field of the electrogravitational vacuum. This may be important for development of projects for obtaining energy from the vacuum and manufacturing of electrogravitational engines [22-24].

2. Relationships between the four-currents, field tensors and vacuum field components

The equation of the matter's motion in a two-component general field is written in a covariant form as follows [25]:

$$F_{\alpha\beta} j^{\beta} + s_{\alpha\beta} J^{\beta} = -\nabla^{\beta}(W_{\alpha\beta} + T_{\alpha\beta}) = 0.$$ (1)

Here $F_{\alpha\beta}$ is the electromagnetic field tensor, considered as the tensor of the charge component of the general field; $j^{\beta} = \rho_{0q} u^{\beta}$ is the four-vector of charge current; ρ_{0q} is the charge density of a typical particle of the matter in the particle's comoving reference frame; u^{β} is the particle's four-velocity; $s_{\alpha\beta}$ is the tensor of the mass component of the general field; $J^{\beta} = \rho_0 u^{\beta}$ is the four-vector of mass current; ρ_0 is the mass density of a typical particle of the matter in the particle's comoving reference frame; $W_{\alpha\beta}$ is the stress-energy tensor of the electromagnetic field; $T_{\alpha\beta}$ is the stress-energy tensor of the mass component of the general field.

The tensor $s_{\alpha\beta}$ is expressed in terms of the sum of tensors of all vector fields acting in the system, except for the electromagnetic field tensor $F_{\alpha\beta}$. If we denote the gravitational field tensor as $\Phi_{\alpha\beta}$, the acceleration field tensor as $u_{\alpha\beta}$, the pressure field tensor as $f_{\alpha\beta}$, then we can write:

$$s_{\alpha\beta} = \Phi_{\alpha\beta} + u_{\alpha\beta} + f_{\alpha\beta}.$$

In the equation of the matter's motion (1) all the tensors are taken in the volume occupied by the matter.

Outside the matter, the four-currents j^{β} and J^{β} vanish, and as a result the left-hand side of (1) vanishes too. But the electromagnetic and gravitational fields also exist outside the charged matter, and here neither the tensors $F_{\alpha\beta}$ and $W_{\alpha\beta}$, nor the tensor $\Phi_{\alpha\beta}$, nor the stress-energy tensor of the gravitational field $U_{\alpha\beta}$ are equal to zero. In addition, the equalities $s_{\alpha\beta} = \Phi_{\alpha\beta}$, $T_{\alpha\beta} = U_{\alpha\beta}$ become true, and then (1) can be written as follows [26]:

$$-\nabla^{\beta}(W_{\alpha\beta} + U_{\alpha\beta}) = 0.$$ (2)

If we take the index $\alpha = 0$ in (1) and (2), then we will obtain relations describing the generalized Poynting theorem.

Tensor expression (2) represents the relationship between the energy densities, energy flux densities and field tensions at each point in space outside the matter, and it is an equation of motion written for the electromagnetic and gravitational fields without taking into account the matter. Similar equalities involving divergence are known for four-vectors, for example, continuity equations for the four-currents of the form $\nabla^{\beta} j_{\beta} = \nabla_{\beta} j^{\beta} = 0$, $\nabla^{\beta} J_{\beta} = \nabla_{\beta} J^{\beta} = 0$. From the mathematical point of view, equality to zero of the divergence of a four-vector or tensor is an appropriate gauge condition that specifies certain relationships between the components of this four-vector or tensor. Thus, the gauging of the electromagnetic field according to Lorentz implies that the relation $\nabla^{\beta} A_{\beta} = \nabla_{\beta} A^{\beta} = 0$ holds true for the electromagnetic four-potential A_{β}.

The stress-energy tensors $W_{\alpha\beta}$, $T_{\alpha\beta}$ and $U_{\alpha\beta}$ in (1) and (2) are expressed in terms of the field tensors $F_{\alpha\beta}$, $s_{\alpha\beta}$ and $\Phi_{\alpha\beta}$, respectively, and in the notation with contravariant indices have the following form:

$$W^{\alpha\beta} = \varepsilon_0 c^2 \left(-g^{\alpha\nu} F_{\kappa\nu} F^{\kappa\beta} + \frac{1}{4} g^{\alpha\beta} F_{\mu\nu} F^{\mu\nu} \right),$$

$$T^{\alpha\beta} = \frac{c^2}{4\pi\varpi} \left(-g^{\alpha\nu} s_{\kappa\nu} s^{\kappa\beta} + \frac{1}{4} g^{\alpha\beta} s_{\mu\nu} s^{\mu\nu} \right),$$

$$U^{\alpha\beta} = -\frac{c^2}{4\pi G} \left(-g^{\alpha\nu} \Phi_{\kappa\nu} \Phi^{\kappa\beta} + \frac{1}{4} g^{\alpha\beta} \Phi_{\mu\nu} \Phi^{\mu\nu} \right),$$

where ε_0 is the electric constant, c is the speed of light, $g^{\alpha\beta}$ is the metric tensor, ϖ is the coefficient of the mass component of the general field, G is the gravitational constant.

In turn, the field tensors $F_{\alpha\beta}$, $s_{\alpha\beta}$ and $\Phi_{\alpha\beta}$ are determined from the corresponding field equations derived from the principle of least action:

$$\nabla_{\beta}F^{\alpha\beta} = -\frac{1}{c^2\varepsilon_0}j^{\alpha}, \qquad\qquad \varepsilon^{\alpha\beta\gamma\delta}\nabla_{\gamma}F_{\alpha\beta} = 0. \qquad (3)$$

$$\nabla_{\beta}s^{\alpha\beta} = -\frac{4\pi\varpi}{c^2}J^{\alpha}, \qquad\qquad \varepsilon^{\alpha\beta\gamma\delta}\nabla_{\gamma}s_{\alpha\beta} = 0. \qquad (4)$$

$$\nabla_{\beta}\Phi^{\alpha\beta} = \frac{4\pi G}{c^2}J^{\alpha}, \qquad\qquad \varepsilon^{\alpha\beta\gamma\delta}\nabla_{\gamma}\Phi_{\alpha\beta} = 0. \qquad (5)$$

Here $\varepsilon^{\alpha\beta\gamma\delta}$ is the Levi-Civita symbol. It was found in [26] that

$$\varpi = -\frac{\rho_{0q}^2}{4\pi\varepsilon_0\rho_0^2}. \qquad (6)$$

When deriving (6), we used the condition

$$\eta + \sigma = G - \frac{\rho_{0q}^2}{4\pi\varepsilon_0\rho_0^2}, \qquad (7)$$

where η is the acceleration field coefficient, σ is the pressure field coefficient.

Condition (7) implies that a relativistic uniform system is considered, in which the acceleration field and the pressure field are also taken into account in addition to the gravitational and electromagnetic fields. The relation between the field coefficients in (7) is a consequence of the balance of forces in the equation of motion [27] and the balance of energies in the generalized Poynting theorem [26], and it was used in [28] in formulation of the virial theorem.

Equations (3) and (5) were solved in [29-30] for a uniform relativistic system. In this case, similarity of expressions for the field tensors was found:

$$\frac{\Phi_{\alpha\beta}}{G} = -\frac{4\pi\varepsilon_0\rho_0 F_{\alpha\beta}}{\rho_{0q}} = -\frac{u_{\alpha\beta}}{\eta} = -\frac{f_{\alpha\beta}}{\sigma}. \qquad (8)$$

Relation (8) was used to derive (6) along with (7).

The components of the tensor $\Phi_{\alpha\beta}$ are the gravitational field strength $\mathbf{\Gamma}$ divided by the speed of light and the torsion field $\mathbf{\Omega}$. Similarly, the components of the tensor $F_{\alpha\beta}$ are the electric field strength $\mathbf{E}$ divided by the speed of light and the magnetic field $\mathbf{B}$. In a generally motionless uniform relativistic system, the vectors $\mathbf{\Omega}$ and $\mathbf{B}$ become equal to zero, and then we can assume that $\dfrac{F_{\alpha\beta}}{\Phi_{\alpha\beta}} = \dfrac{E}{\Gamma}$. Let us suppose now that we are modeling a proton using the relativistic uniform system. Then the density of the electric force acting in the proton matter will equal $f_e = E\rho_{0q}$, and the density of the gravitational force will be $f_g = \Gamma\rho_0$. In view of (8), for the relation of the magnitudes of the force densities we can write the following:

$$\left| \frac{f_e}{f_g} \right| = \frac{\rho_{0q}}{\rho_0} \left| \frac{E}{\Gamma} \right| = \frac{\rho_{0q}}{\rho_0} \left| \frac{F_{\alpha\beta}}{\Phi_{\alpha\beta}} \right| = \frac{\rho_{0q}^2}{4\pi\varepsilon_0 G\rho_0^2} \approx \frac{e^2}{4\pi\varepsilon_0 Gm_p^2} \approx 1.2 \cdot 10^{36}. \qquad (9)$$

Here e is the elementary charge, m_p is the proton mass. According to (9), the electric interaction in the proton exceeds the gravitational interaction by about a factor of 10^{36}. The same will happen if we divide the constant of electromagnetic interaction (fine structure constant) $\alpha = \dfrac{e^2}{4\pi\varepsilon_0 \hbar c}$ by the constant of gravitational interaction $\alpha_g = \dfrac{Gm_p^2}{\hbar c}$. The ratio $\dfrac{\alpha}{\alpha_g}$ defines the ratio of the energy of the electrical interaction of two protons to the absolute value of the energy of their gravitational interaction, without taking into account the energies associated with the torsion fields and magnetic fields. The provided example shows that (8) is valid even when applied to the proton.

If we substitute (6) into (4), and take into account that $J^\alpha = \rho_0 u^\alpha$, $j^\alpha = \rho_{0q} u^\alpha$, we will obtain the following:

$$\nabla_\beta s^{\alpha\beta} = \frac{\rho_{0q}}{\varepsilon_0 \rho_0 c^2} j^\alpha, \qquad\qquad \varepsilon^{\alpha\beta\gamma\delta} \nabla_\gamma s_{\alpha\beta} = 0. \qquad (10)$$

From the equations for $s^{\alpha\beta}$ in (10) and for $F^{\alpha\beta}$ in (3) it follows that the main source for the tensors of the mass and charge components of the general field is the charge four-current j^α. In [25], the mass and charge components of the general field were related to the corresponding components of the force vacuum field in such a way that the vacuum field generates the general field at the macroscopic level by acting on the corresponding four-currents of the matter. We can also take into account the results obtained in [5-6] regarding the vacuum field components. Hence we arrive at the following hypothesis:

In the framework of the modernized Fatio-Le Sage's model, the force vacuum field has two components – the field of gravitons and the field of charged particles. Among these charged particles we can distinguish praons, which are identified as the main objects of the underlying level of matter that make up all elementary particles. Similarly, stars, planets and ordinary matter at the stellar level of matter are made up of nucleons, which are the main objects of the nucleon level of matter. The fluxes of charged praons can be similar in their properties to high-energy cosmic rays, these fluxes emerge near nucleons and, when interacting with the charged four-current j^α of the matter, lead to electromagnetic interaction. Photons, neutrinos and praons are assumed as particles of the graviton field, which generates ordinary gravitation. Since in (10) we related the tensor of the mass component of the general field $s^{\alpha\beta}$ to the charge four-current j^α, it is logical to assume that the fluxes of charged praons are the main component of the vacuum field. These fluxes in the neutral matter create gravitational forces, as well as interactions of all those fields (acceleration field, pressure field, dissipation field, etc.), in the equations of which the source is the mass four-current J^μ. If there are uncompensated charges in the matter, then the fluxes of charged praons also generate electromagnetic interaction of these charges with each other.

3. Additional notes

Analysis of the dependence of the electromagnetic and gravitational interactions on the fluxes of charged particles of the vacuum field shows that this dependence is not linear. This can be seen from the fact that during transition between the matter levels the electric constant ε_0 does not change, while during transition from the macroscopic level of stars to the level of nucleons the gravitational constant G must be replaced with the strong gravitational constant G_a, as indicated in [30-32]. At the same time, according to [6], the cross-section of interaction of gravitons with the matter, leading to strong gravitation, coincides with the

cross-section of interaction of praons with the matter, leading to electromagnetic interaction, and is approximately equal to the proton cross-section. The equality of the interaction cross-sections substantiates the fact that charged particles, which can differ from each other and have different origins, are responsible both for strong gravitation and for electromagnetic phenomena at the level of nucleons.

In particular, the level of graons is the matter level that lies below the level of the praons, and by induction it is assumed that praons consist of graons, and the fluxes of charged graons act similarly to the fluxes of charged praons and are a separate component of the vacuum field that generates strong gravitation.

From the foregoing it follows that the electromagnetic field is primary relative to the gravitational field in the sense that the fluxes of charged particles at different levels of matter form a multicomponent vacuum field and are the source of electromagnetic and gravitational interactions. In turn, primacy of the gravitational field relative to the electromagnetic field is seen in the fact that it is gravitation that forms the main objects at the matter levels, such as neutron stars, nucleons, praons, graons, etc. Each main object has strong electric, magnetic and gravitational fields, is made up of the main objects of the underlying levels of matter, and when interacting with them it generates fluxes of charged particles. These fluxes of particles from numerous main objects are added together and generate a force vacuum field that fills the entire space and imparts inertia and mass to bodies [5].

Electromagnetic waves are usually considered as fluxes of photons, which is best of all proved by the phenomenon of photoeffect. The substantial photon model assumes that a photon is produced by an excited atom due to the action of fields of the nucleus and electrons on the charged particles of the vacuum field (praons) crossing the atomic volume [33]. In this case, strong gravitation is responsible for the integrity of the emerging photon, which holds praons together, similarly to the action of strong gravitation on the nucleons in atomic nuclei. As a result, both photons and atomic nuclei turn out to be very stable objects.

The physical mechanism of action of the fluxes of tiny charged particles of vacuum in the matter is described in [6]. Charged particles have both charge and mass, and therefore they interact with electric and magnetic fields, as well as with strong gravitational fields and torsion fields (gravitomagnetic fields) of the atomic nuclei and electrons of the matter. Such interaction is described by the Lorentz force, which does not significantly change the amplitude of the particles' velocity, but changes the direction of motion of these particles. As a result, the particles change the direction of their momenta, which leads to the emergence of

electromagnetic and gravitational forces in the matter. Since the particles almost do not lose their energy when moving in the matter, no noticeable heating of the bodies is observed.

An increase in thermal energy in the matter is accompanied by an increase in the Lorentz factors of motion of atoms, nucleons and electrons, while all the fields in the matter are proportional to these Lorentz factors. This leads to an increase in the interaction of the vacuum's charged particles with the matter, to an increase in the energy and inertial mass of the system. Based on the presented mechanism, the Le Sage's model explains contribution of any kind of energy to gravitational and electromagnetic phenomena.

On the other hand, in the equilibrium relativistic uniform system the temperature at the center always exceeds the temperature of the matter at other points of the system. In equilibrium, at specified sizes of the system, taking into account the thermal energy emission into the outer space, certain temperature distribution is preserved inside the system. Since the motion of the system's matter and the forces acting in this matter are a consequence of action of the fluxes of vacuum's charged particles, it can be assumed that the kinetic energy and some heating of the matter occur due to the loss of energy by the fluxes of charged particles in the matter.

The denser is the matter, the more it heats up. Thus, an estimate of the temperature at the center of a neutron star found using the field theory with the help of the Lorentz factor γ_c gives the value $T_c = 2.8 \times 10^{11}$ K [7].

Another way to estimate the average temperature $\bar{T}$ of the stellar matter is to use the virial theorem [28]. For more convenience, in [34] the kinetic energy E_k of motion of the system's typical particles was associated not only with the total potential energy of the system, as in the ordinary virial theorem, but also with the energy of the gravitational and electromagnetic fields outside the system, which can be easily calculated:

$$-\frac{Gm_b^2}{2a} + \frac{q_b^2}{8\pi\varepsilon_0 a} \approx -\frac{50\sqrt{14}\,\gamma_c}{81} E_k \, .$$

Here m_b and q_b denote the total invariant mass and the total charge of all the system's typical particles, respectively; a is the radius of the system. We can assume that

$$E_k = \frac{3}{2} N k \bar{T} \, , \qquad\qquad m_b = N m_p \, ,$$

where k is the Boltzmann constant, N is the number of typical particles, m_p is the mass of a typical particle.

Hence, for the case $q_b = 0$ we have:

$$\bar{T} \approx \frac{27 G m_b m_p}{50 \sqrt{14}\, \gamma_c k a}.$$

In an uncharged neutron star $q_b = 0$; m_b is practically equal to the mass of a typical star $M_s = 1.35 M_c$, where M_c is the mass of the Sun; m_p can be assumed equal to the proton mass; a is equal to the radius of the star 12 km; $\gamma_c = 1.04$. As a result we obtain the volume-averaged temperature $\bar{T} = 2.5 \cdot 10^{11}$ K. Thus, if the star's radius does not change, the virial theorem guarantees a certain constant temperature $\bar{T}$ of the star's matter. In our opinion, this is possible when a cooling star, after its formation, loses by radiation part of its initial energy, obtained at the moment of a supernova explosion. At some point, the loss of energy due to radiation will become equal to the inflow of energy from the fluxes of vacuum's charged particles falling on the star, and an equilibrium state will be reached.

4. Conclusion

From the equations of vector fields acting in the considered physical system, we conclude that the charge four-current j^α is the source of not only the electromagnetic field tensor $F_{\alpha\beta}$, but also of the tensor $s_{\alpha\beta}$. Also it should be noted that the main contribution to $s_{\alpha\beta}$ is made by the gravitational field tensor $\Phi_{\alpha\beta}$. The tensors $F_{\alpha\beta}$ and $s_{\alpha\beta}$ represent the tensor of the general field's charge component and the tensor of the general field's mass component, respectively. In [25], it was assumed that the general field's charge component manifests itself in connection with the vacuum field's charge component, and the general field's mass component is associated with the vacuum field's mass component. But the dependence of $F_{\alpha\beta}$ and $s_{\alpha\beta}$ on j^α indicates that the vacuum field's charge component in the form of fluxes of charged particles like praons can play a central role in the emergence of electromagnetic

and gravitational effects, in the action of acceleration fields and pressure fields in the matter, as well as in the manifestation of action of other vector fields.

By definition in [20] the dissipation field is considered as a vector field and it describes the additional forces that appear in the matter in the process of friction. These forces also convert the energy from the kinetic form into the potential form and vice versa. The weak and strong interaction fields can also be considered as vector fields, so that they can be assigned their own tensors and stress-energy tensors [21]. These fields are most important for calculations in stellar interiors, where active reactions involving weak and strong interactions take place. Since we reduce any motion in the matter to the action of the fluxes of charged particles of multicomponent electrogravitational vacuum, it is logical to assume that the dissipation field and the macroscopic fields of weak and strong interaction also emerge due to the charge component of the force vacuum field.

References

1. Duillier N. Fatio de (1690), "Lettre N° 2570", in Société Hollandaise des Sciences (ed.), Oeuvres complètes de Christiaan Huygens, 9, The Hague (published 1888–1950), pp. 381-389.

2. Le Sage G.L. Letter à une académicien de Dijon.., Mercure de France, pp. 153-171 (1756).

3. Le Sage G.L. Essai de Chymie Mécanique. pp.121 (1761).

4. Le Sage G.L. Physique Mécanique. In: Prévost, P. Deux traités de physique mécanique, publiés par Pierre Prévost, comme simple éditeur du premier et comme auteur du second. J.J. Paschoud, Genève, Switzerland (1818).

5. Fedosin S.G. The graviton field as the source of mass and gravitational force in the modernized Le Sage's model. Physical Science International Journal, Vol. 8, Issue 4, pp. 1-18 (2015). doi: 10.9734/PSIJ/2015/22197.

6. Fedosin S.G. The charged component of the vacuum field as the source of electric force in the modernized Le Sage's model. Journal of Fundamental and Applied Sciences, Vol. 8, No. 3, pp. 971-1020 (2016). doi: 10.4314/jfas.v8i3.18.

7. Fedosin S.G. The Gravitational Field in the Relativistic Uniform Model within the Framework of the Covariant Theory of Gravitation. International Letters of Chemistry, Physics and Astronomy, Vol. 78, pp. 39-50 (2018). doi: 10.18052/www.scipress.com/ILCPA.78.39.

8.   Heaviside O. A gravitational and electromagnetic analogy. The Electrician, Vol. 31 (Part I), pp. 281-282 and 359 (1893).

9.   Jefimenko O.D. 2006. Gravitation and cogravitation. Developing Newton's theory of gravitation to its physical and mathematical conclusion. Electret Scientific Publishing, Star City, USA. pp. 367.

10. Zakharenko A.A. On piezogravitocogravitoelectromagnetic shear-horizontal acoustic waves. Canadian Journal of Pure and Applied Sciences, Vol. 10 (3), pp. 4011-4028 (2016). doi: 10.5281/zenodo.1301184.

11. Borodikhin V.N. Vector theory of gravity. Gravit. Cosmol. Vol. 17, pp. 161-165 (2011). doi: 10.1134/S0202289311020071.

12. Flanders W.D., Japaridze G.S. Photon deflection and precession of the periastron in terms of spatial gravitational fields. Class. Quant. Gravit. Vol. 21, pp. 1825-1831 (2004). doi: 10.1088/0264-9381/21/7/007.

13. Nyambuya G.G. Fundamental Physical Basis for Maxwell-Heaviside Gravitomagnetism. Journal of Modern Physics, Vol. 6, pp. 1207-1219 (2015). doi: 10.4236/jmp.2015.69125.

14. Behera H. Comments on gravitoelectromagnetism of Ummarino and Gallerati in "Superconductor in a weak static gravitational field" vs other versions. Eur. Phys. J. C. Vol. **77**, Article number 822 (2017). doi: 10.1140/epjc/s10052-017-5386-4.

15. Ummarino G.A., Gallerati A. Superconductor in a weak static gravitational field. Eur. Phys. J. C. Vol. 77, Article number 549 (2017). doi: 10.1140/epjc/s10052-017-5116-y.

16. Ruggiero M.L., Tartaglia A. Gravitomagnetic effects. II Nuovo Cimento B, Vol. 117, Issue 07, pp. 743-768 (2002).

17. Mashhoon B. On the gravitational analogue of Larmor's theorem. Phys. Lett. A, Vol. 173, pp. 347-354 (1993).

18. Clark S.J., Tucker R.W. Gauge symmetry and gravito-electromagnetism. Classical and Quantum Gravity. Vol. 17 (19), pp. 4125-4157 (2000). doi: 10.1088/0264-9381/17/19/311.

19. Fedosin S.G. The Principle of Least Action in Covariant Theory of Gravitation. Hadronic Journal, Vol. 35, No. 1, pp. 35-70 (2012). doi: 10.5281/zenodo.889804.

20. Fedosin S.G. Four-Dimensional Equation of Motion for Viscous Compressible and Charged Fluid with Regard to the Acceleration Field, Pressure Field and Dissipation Field. International Journal of Thermodynamics. Vol. 18 (No. 1), pp. 13-24 (2015). doi: 10.5541/ijot.5000034003.

21. Fedosin S.G. The Concept of the General Force Vector Field. OALib Journal, Vol. 3, pp. 1-15 (2016), e2459. doi: 10.4236/oalib.1102459.

22. Shawyer R. Second generation EmDrive propulsion applied to SSTO launcher and interstellar probe. Acta Astronautica, Vol. 116, pp. 166-174 (2015). doi: 10.1016/j.actaastro.2015.07.002.

23. White H., March O., Lawrence J., Vera J., Sylvester A. Measurement of Impulsive Thrust from a Closed Radio-Frequency Cavity in Vacuum. Journal of Propulsion and Power, Vol. 33, no. 4, pp. 830-841 (2017). doi: 10.2514/1.B36120.

24. Леонов В.С., Бакланов О.Д., Саутин М.В., Костин Г.В., Кубасов А.А., Алтунин С.Е., Кулаковский О.М. Неракетный нереактивный квантовый двигатель: идея, технология, результаты, перспективы. Воздушно-космическая сфера, No 1 (98). C. 68-75 (2019). doi: 10.30981/2587-7992-2019-98-1-68-75; Leonov V.S., Baklanov O.D., Sautin M.V., Kostin G.V., Kubasov A.A., Altunin S.Y., Kulakovsky O.M. Non-rocket non-reactive quantum engine: idea, technology, results, prospects. Aerospace Sphere Journal, No 1 (98). pp. 68-75 (2019).

25. Fedosin S.G. Two components of the macroscopic general field. Reports in Advances of Physical Sciences, Vol. 1, No. 2, 1750002, 9 pages (2017). doi: 10.1142/S2424942417500025.

26. Fedosin S.G. The generalized Poynting theorem for the general field and solution of the 4/3 problem. International Frontier Science Letters, Vol. 14, pp. 19-40 (2019). doi: 10.18052/www.scipress.com/IFSL.14.19.

27. Fedosin S.G. Estimation of the physical parameters of planets and stars in the gravitational equilibrium model. Canadian Journal of Physics, Vol. 94, No. 4, pp. 370-379 (2016). doi: 10.1139/cjp-2015-0593.

28. Fedosin S.G. The virial theorem and the kinetic energy of particles of a macroscopic system in the general field concept. Continuum Mechanics and Thermodynamics, Vol. 29, Issue 2, pp. 361-371 (2016). doi: 10.1007/s00161-016-0536-8.

29. Fedosin S.G. Relativistic Energy and Mass in the Weak Field Limit. Jordan Journal of Physics, Vol. 8, No. 1, pp. 1-16 (2015. doi: 10.5281/zenodo.889210.

30. Fedosin S.G. The Integral Energy-Momentum 4-Vector and Analysis of 4/3 Problem Based on the Pressure Field and Acceleration Field. American Journal of Modern Physics, Vol. 3, No. 4, pp. 152-167 (2014). doi: 10.11648/j.ajmp.20140304.12.

31. Fedosin S.G. (1999), written at Perm, pages 544, Fizika i filosofiia podobiia ot preonov do metagalaktik, ISBN 5-8131-0012-1.

32. Fedosin S.G. The radius of the proton in the self-consistent model. Hadronic Journal, Vol. 35, No. 4, pp. 349-363 (2012). doi: 10.5281/zenodo.889451.

33. Fedosin S.G. The substantial model of the photon. Journal of Fundamental and Applied Sciences, Vol. 9, No. 1, pp. 411-467 (2017). doi: 10.4314/jfas.v9i1.25.

34. Fedosin S.G. The binding energy and the total energy of a macroscopic body in the relativistic uniform model. Middle East Journal of Science, Vol. 5, Issue 1, pp. 46-62 (2019). doi: 10.23884/mejs.2019.5.1.06.