Gravi-electromagnetism in five dimensions and moving bodies in Galaxy area

W. B. Belayev*
Center for Relativity and Astrophysics,
185 Box, 194358, Sanct-Petersburg, Russia and
D. Yu. Tsipenyuk†
General Physics Institute of the Russian Academy of Sciences
38 Vavilova str., Moscow, 119991, Russia

February 27, 2008

Abstract

In Klein geometric model of space the mass is manifestation of the quantized charges oscillations in additional compactified dimension. We analyze model in which common in four-dimensional space-time for mass and electric charge of the particle trajectory is disintegrated in five dimensions on movement of the mass along null geodesic line and trajectory of the charge corresponding to the time-like interval in 5D volume. We find relation between five-velocity vector of electric charge and mass. This scheme is regarded to have concern with many worlds theory.

Considered approach is applied to the model of rotating space having four-dimensional spherical symmetry. One proposed appearance additional force in included 4D space-time, which may be explanation of the Pioneer-effect. We analyze also possible part of this force in conservation of the substance in Galaxy area.

Several theories, being studied five-dimensional space-time, are founded on different on physical principles. Generalization of the special theory of relativity for 5D extended space $G(T;\vec{X};S)$ with the metric (+; -, -, -, -) has been proposed and developed in works [1]-[8]. Built model of extended space (ESM) allows integration of the electromagnetic and gravitational interactions.

The peculiarity of ESM is its studying of the particle trajectory in 5D basing on analogy between the light movement in curved space in general relativity and its movement in medium with refraction coefficient being more than unity [2, 3, 6]. In ESM mass of the particle is component of the five-vector energy-impulse-mass in space $G(T;\vec{X};S)$. With changes of coordinate frames in this space the electric, gravity and scalar fields are transformed in each other.

As the 5-th additional coordinate in ESM is used quantity, which already exists in the (1+3)-dimensional Minkowski space $M(T;\vec{X})$, with time coordinate $x^0 = ct$, where c is light velocity, t is time, and space coordinates x^1, x^2, x^3, x^3, namely, interval S:

*e-mail:bwb-rac@ctinet.ru
†e-mail:tsip@kapella.gpi.ru

$$S^2 = (x^0)^2 - (x^1)^2 - (x^2)^2 - (x^3)^2. \quad (1)$$

This quantity is conserved at common Lorentz transformations in the Minkowski space $M(T; \vec{X})$ but varies at turns in the extended space $G(T; \vec{X}; S)$. Thus, Minkowski space $M(T; \vec{X})$ is a cone in extended space $G(T; \vec{X}; S)$.

In 5D gravity theory, begun by Nordström [9] and Kaluza [10], proposed by Klein [11] approach to the particle movement analysis examined, for example, in [12]-[15] requires its trajectory to be null geodesic line in 5D space. One ensures a particle having non-zero rest mass in the 4-D Minkowski space to have it in 5D. The other approach to the kinematics in 5D space is description of the movement of particle, which can be stationary in this space and has non-zero rest mass. At that his trajectory is determined by time-like interval [16]-[20].

In considered model integrated electromagnetism and gravity we will turn to account following from Klein compactification formalism founded on assumption that electric charge and mass of observed in 4D particle have different world lines in 5D space. At that we suppose any particle having a rest mass in 4D to contain combination of electric charges. The mass movement conforms to null interval, i. e.,

$$0 = \tilde{G}_{ij}(x_m) dx^i_m dx^j_m, \quad (2)$$

where x^i_m are mass coordinates and $\tilde{G}_{ij}(x_m)$ is metric tensor of 5D space, which is function of these coordinates. On the contrary, electric charge has trajectory with line element

$$ds^2_e = \tilde{G}_{ij}(x) dx^i dx^j, \quad (3)$$

where x^i are electric charge coordinates.

Thus, world line of the particle mass in 5D intersects corresponding world lines of electric charges and, conversely, trajectory of the electric charge is a set of the points appertained to trajectories of corresponding masses. This approach leads us to proposed by Everett [21]-[23] conception of many worlds founded on quantum theory.

Let us touch relation of present scheme to anthropic principle. Our perception of environment arises by means of electro-magnetism and we can not feel gravity direct. This may be considered as account for assumption that to be exact mass, not electric charge moves along null pass in 5D. In this case we can hold that 5D space model with non-zero rest mass of the particle and appropriate time-like interval describes electro-magnetic "trace" of the masses, which appertain consecutively the world line of corresponding electric charges combination. Light velocity in extra dimension in coordinate frame of charge or system of charges being its source is assumed to be null.

Components of mass velocity denoted as $u^i_m = dx^i_m/ds_e$ form a five-vector. With first four components of the five-velocity vector of charge u^i corresponding to interval (3) equalities $u^i_m = u^i$ provide local coincidence of mass and charge coordinates in 4D. Divided Eq. (2) on ds^2_e we obtain

$$0 = \tilde{G}_{ij} u^i u^j + (\tilde{G}_{i4} u^i + \tilde{G}_{4i} u^i) u^j_m + \tilde{G}_{44} (u^4_m)^2, \ i, j \neq 4. \quad (4)$$

At this point the mass velocity along fifth coordinate will be

$$u^4_m = \frac{-(\tilde{G}_{i4} + \tilde{G}_{4i}) u^i + \epsilon \sqrt{(\tilde{G}_{i4} + \tilde{G}_{4i})^2 u^{i2} - 4 \tilde{G}_{44} \tilde{G}_{ij} u^i u^j}}{2 \tilde{G}_{44}}, \ i, j \neq 4, \quad (5)$$

where $\epsilon = \pm 1$. The opposite values of ϵ conform to matter and anti-matter. For extended Minkowski space we have

$$u^4_m = \epsilon\sqrt{1 + u^{42}}. \tag{6}$$

Let us apply considered conception to analysis of metric example of 5D space with such basis vectors that the fifth of them is not orthogonal to others, which are basis of included 4D space. The cosmological model with movement of the matter along fifth coordinate based oneself on metric conforming to this property has been studied in [20]. We analyze space-time, including four-dimensional spherical space, with coordinates $x^i = (ct, a, \theta, \varphi, \chi)$ to be rendered to orthogonal frame by transformation

$$\begin{aligned} \eta_0 &= ct, \\ \eta_1 &= a \cdot \sin\chi \cdot \sin\theta \cdot \cos\varphi, \\ \eta_2 &= a \cdot \sin\chi \cdot \sin\theta \cdot \sin\varphi, \\ \eta_3 &= a \cdot \sin\chi \cdot \cos\theta, \\ \eta_4 &= a \cdot \cos\chi. \end{aligned} \tag{7}$$

This space is assumed to be rotating and the metric is taken in form

$$ds^2 = c^2[1 - a^2B(a)^2]dt^2 - da^2 - a^2[2cB(a)dtd\chi + \sin^2\chi(d\theta^2 + \sin^2\theta d\varphi^2) + d\chi^2], \tag{8}$$

where $B(a)$ is dependent on a coefficient. In accordance with considered approach with $ds > 0$ conforms to the movement of particle's electro-magnetic trace.

In [24] the geodesic line equations was written in form

$$\frac{d}{ds}(\tilde{G}_{ij}u^j) - \frac{1}{2}\frac{\partial\tilde{G}_{mj}}{\partial x_i}u^m u^j = 0. \tag{9}$$

For metric (8) zeroth, first and fourth components of these equations with comoving coordinates of convenional type ($u^1 = u^2 = u^3 = 0$) yield

$$\frac{d}{ds}[(1 - a^2B^2)u^0 - a^2Bu^4] = 0, \tag{10}$$

$$aB\left(B + a\frac{\partial B}{\partial a}\right)u^{02} + a\left(2B + a\frac{\partial B}{\partial a}\right)u^0u^4 + au^{42} = 0, \tag{11}$$

$$\frac{d}{ds}[a^2Bu^0 + a^2u^4] = 0. \tag{12}$$

Solution of this system must be compatible with set by metric (8) condition

$$u^{02} - a^2(u^4 + Bu^0)^2 = 1. \tag{13}$$

Such solution will be

$$u^0 = \xi,\ u^4 = -\xi B(a), \tag{14}$$

where ξ takes values 1 and -1. Corresponding fifth component of mass five-velocity (5) is following:

$$u^4_m = \xi \left[\frac{\epsilon}{a} + B(a) \right]. \tag{15}$$

We notice that this equation with other four components of u^i_m does not put null geodesics of particle mass but it is only velocity of mass in every point of charge geodesics.

Considered coordinate frame is transformed to coordinates $x^i = (ct, r, \theta, \varphi, y)$ having only 3D symmetry by expressions

$$\begin{aligned} r &= a \cdot \cos\chi, \\ y &= a \cdot \sin\chi. \end{aligned} \tag{16}$$

We find acceleration d^2r/ds^2 with condition of particle geodesic movement set by Eqs. (14) when the fifth coordinate is $\chi = 0$. In this case we obtain $y = 0$ and $dr/ds = 0$. The fifth component of the five-velocity is written as

$$u^4 = \frac{1}{r^2 + y^2} \left(r\frac{dy}{ds} - y\frac{dr}{ds} \right). \tag{17}$$

This equation yields

$$\frac{dy}{ds} = -\xi \cdot rB(r). \tag{18}$$

Equation of the system (9) with $i = 1$ is rewritten as

$$\frac{d^2a}{ds^2} = 0. \tag{19}$$

After some transformations we obtain

$$\frac{d^2r}{ds^2} = -rB(r)^2. \tag{20}$$

Thus, rotation in 5D gives additional force in included 4D space. This force is invariable with

$$B(a) = Ka^{-1/2}, \tag{21}$$

where K is constant. One may be considered as explanation of additional acceleration of the Pioneer 10 $a_p = 8.5 \cdot 10^{-8}\mathrm{cm/s^2}$ towards to the receiving antenna on the Earth [25]-[27]. Assumed interval to be $ds = cdt$ we obtain value of the constant which is $K = 0.97 \cdot 10^{-13}\mathrm{cm}^{-1/2}$.

This additional acceleration satisfies to the constraint $a_pR \gtrsim v^2_{sw}$, where R is Galaxy radius and v_{sw} is velocity of the solar wind [28]. It follows from this that if Pioneer-effect spreads on whole Galaxy area, it is conducive to conservation of the matter within the bounds of Galaxy belt.

References

[1] D.Yu. Tsipenyuk, V.A. Andreev, *Krattkie Soobstcheniya po Fizike* (Bulletin of Lebedev Physics Institute (Russian Academy of Sciences)) **6**, 23–34, (2000); arXiv: gr-qc/0106093.

[2] D.Yu. Tsipenyuk, V.A. Andreev, *Issledovano v Rossii*, **60**, (1999) (in Russian); http://zhurnal.ape.relarn.ru/articles/1999/060.pdf .

[3] D.Yu. Tsipenyuk, *Gravitation and Cosmology*, Vol. **7**, No.**4**(28), 336–338, (2001); arXiv: physics/0203017.

[4] D.Yu. Tsipenyuk, *Krattkie Soobstcheniya po Fizike* (Bulletin of Lebedev Physics Institute (Russian Academy of Sciences)) **7**, 39–49, (2001); arXiv: physics/0107007.

[5] D.Yu. Tsipenyuk, V.A. Andreev, *Krattkie Soobstcheniya po Fizike*(Bulletin of Lebedev Physics Institute (Russian Academy of Sciences)) **6**, 3–15, (2002); arXiv: physics/0302006.

[6] D.Yu. Tsipenyuk, *Issledovano v Rossii* **81**, 907–916, (2001)(in Russian); http://zhurnal.ape.relarn.ru/articles/2001/081.pdf .

[7] D.Yu. Tsipenyuk, V.A. Andreev, "Electrodynamics in Extended Space", *preprint IOFAN* **9**, Moscow, (1999)(in Russian).

[8] D.Yu. Tsipenyuk, V.A. Andreev, "Gravitational effects in Extended Space", *preprint IOFAN* **4**, Moscow,(2001)(in Russian).

[9] G. Nordstrom, *Phyz. Zeitschr.***1**, 504 (1914) (in German).

[10] T. Kaluza, *Sitz. Preuss. Akad. Wiss.* Phys. Math. K**1**, 966 (1921) (in German).

[11] O. Klein *Z. Phys.* **37**, 895 (1926).

[12] J. Van Dongen, arXiv: gr-qc/0009087.

[13] P.S. Wesson, S.S. Seahra, *Gen. Rel. Grav.*, **33**, 1731 (2001); arXiv: gr-qc/0105041.

[14] W.B. Belayev, "Extra force in Kaluza-Klein gravity theory", Invited talk at "Gravitation, Cosmology and Relativistic Astrophysics" (Kharkiv, Ukraine, June 23-27, 2003); arXiv: gr-qc/0308076.

[15] P.S. Wesson, *Gen. Rel. Grav.* **35**, 307 (2001); arXiv: gr-qc/0302092.

[16] J.M. Overduin, P.S. Wesson, *Phus. Rept.*, **283**, 303 (1997); arXiv: gr-qc/9805018.

[17] J. Ponce de Leon, *Phys. Lett. B* **523**, 311 (2001); arXiv: gr-qc/0110063.

[18] R. Maartens, "Geometry and dynamics of the brane-world", invited talk at EREs2000, Spanish Relativity Meeting; arXiv: gr-qc/0101059.

[19] F. Dahia, E.M. Monte, C. Romero, *Mod. Phys. Lett. A* **25**, 1173, (2003); arXiv: gr-qc/0303044.

[20] W.B. Belayev, *Spactime and Substance* **7**, 63 (2001); arXiv: gr-qc/0110099.

[21] B.S. DeWitt, R. N. Graham, "The many-worlds Interpretation of Quantum Mechanics", eds. R. N. Graham, Princeton Series in Physics, Princeton University Press (1973).

[22] F.J. Tipler, in "Quantum Concepts of Space and Time", eds R. Penrose and C. Isham, Oxford University Press (1986).

[23] D. Bohm, B.J. Hiley, "The Undivided Universe", Routledge Press, London, 1993.

[24] G.C. McVittie, "General Relativity and Cosmology" Chapman and Half Ltd., London, 1956. (Russian translation: G.C. Mac-Vitti, "General Relativity and Cosmology", IIL, Moskow, 1961.)

[25] J.D. Anderson, P.A. Laing, E.L. Lau, A.S. Liu, M.M. Nieto, S.G. Turushev, *Phys. Rev. Lett.* **81**, 2858 (1998); arXiv: gr-qc/9808081.

[26] S.G. Turushev, J.D. Anderson, P.A. Laing, E.L. Lau, A.S. Liu, M.M. Nieto, "The apparent anomalous, weak, long-range acceleration of Pioneer 10 and 11", XXXIV-th Rencontres de Morion Meeting on Gravitational Waves and Experimental Gravity 1999, Les Arcs, Savoi, France; arXiv: gr-qc/9903024.

[27] J.D. Anderson, P.A. Laing, E.L. Lau, A.S. Liu, M.M. Nieto, S.G. Turushev, *Phys. Rev. D* **65**, 082004 (2002); arXiv: gr-qc/0104064.

[28] K. Trenčevski, unpublished data, 2004.