JINR D2-95-223

Fermilab Library
0 1190 0049523 9

СООБЩЕНИЯ
ОБЪЕДИНЕННОГО
ИНСТИТУТА
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

JINR D2-95-223

V.N.Strel'tsov

ON THE RELATIVISTIC NEWTON THEORY OF GRAVITY

T

FERMILAB
NOV 20 1995
LIBRARY

Jun

1995

This and the previous author's works [1, 2] are in essence the development of the known Poincare [3] and Minkowski [4] approach to the relativization of the Newton theory of gravity*. Research in this direction becomes especially urgent after realization that the low (principle) of mass and energy equivalence (considered as one of the main results of the special theory of relativity (STR)) contradicts the Lorentz covariance, i.e., the very essence of this theory.

The kinetic potential. According to the Newtonian (non-relativistic) definition, the momentum of a material body (particle) is equal to the product of its mass and velocity

$$\mathbf{p} = m\mathbf{v} \,. \tag{1}$$

As one says, the mass plays the role of body inertia measure here. The equation

$$p^i = mu^i \tag{2}$$

is the relativistic generalization of expression (1). Here the 4-vector of energy-momentum $p^i = (E/c, \mathbf{p})$ figures on the left, and on the right — the covariant 4-velocity $u^i = dx^i/d\tau$, where τ is the proper time, $i = 0, 1, 2, 3$. Eq. (2) reminds the known expression for the energy and momentum of charge in the electromagnetic field, described by the 4-potential A^i

$$G^i = eA^i. \tag{3}$$

Therefore one can say that the 4-velocity plays the role of the relativistic kinetic potential.

At the same time from an evident covariant form of eq. (2) it follows that the mass is the Lorentzean scalar (invariant), i.e., it does not charge when transitting from one inertial reference system to another one**. However, the opinion still exists, particularly in popular accounts of relativity theory, that the body mass

*In this connection see, e.g., also [5, 6], where one can find references to the works of similar subjects.
**A detailed consideration of this problem can be found in the article by L.Okun [7].

© Объединенный институт ядерных исследований, Дубна, 1995

increases with velocity: $m_v = m\gamma$, where γ is the Lorentz-factor ($\gamma \equiv u^0$). In the language of 4-dimensional representation this means that we deal here with a 4-vector component. For this its other components must depend on the velocity direction. As a result, negative values of mass become possible. But the previous formula has served as the basis of the law of mass and energy equivalence.

The relativistic theory of gravity. Remind that relativistic generalization of the Poisson equation takes the form

$$\Box\ g^i = 4\pi G J^i. \tag{4}$$

Here the 4-current mass density figures on the right; whence it follows that the relativistic potential of gravity should be also described by a 4-vector. The expression for g^i can be obtained by means of the Lorentz transformation of the Newton potential [1] and is of the form

$$g^i = -\frac{MU^i}{U^i R_i}. \tag{5}$$

Here M is the mass of a moving particle; U^i, its 4-velocity; and R^i, the retarded distance.

The energy and momentum of a particle of mass m in the gravitational field by analogy with (3) are described by the equetion

$$P^i = mg^i. \tag{6}$$

For the relativistic Newton force of gravity we have

$$F^i = -mG^{ik}u_k, \tag{7}$$

where G^{ik} is the gravitational field tensor; u^i, the 4-velocity of a trial particle of mass m. In so doing, we incline nevertheless to the opinin that G^{ik} is rather an antisymmetrical tensor as in the case of electromagnetic field. Though special research is certainly required here.

In accordance with our supposition for the gravitational field in the absence of acceleration, we obtain

$$G^{ik} = -G\frac{Mc^2}{(U^i R_i)^3}(U^i R^k - U^k R^i). \tag{8}$$

As a result, basing on (7) for the relativistic Newton force we have

$$\mathbf{F} = -G\frac{mM\Gamma^{-2}\gamma}{R^2(1-\mathbf{Bn})^3}[\mathbf{n}(1+\boldsymbol{\beta}\mathbf{B}) - \mathbf{B}(1+\boldsymbol{\beta}\mathbf{n})] , \tag{9}$$

where $\mathbf{n} = \mathbf{R}/R$, $\boldsymbol{\beta}\boldsymbol{\beta} = u^\alpha/u^0$, $\gamma = (1-\beta^2)^{-1/2}$, $\mathbf{B} = U^\alpha/U^0$, $\Gamma = (1-B^2)^{-1/2}$.

However, according to the representations generally accepted at the present time, the gravity field is described by the general theory of relativity (GTR). In the basis of GTR lays the so-called equivalence law (principle) of mass and energy — «the proportionality of energy and inertial mass that is the consequence of the usual theory of relativity...» [8]. Just in accordance with this «law», the mass density of a 4-vector component on the right of the non-relativistic Poisson equation is replaced by the energy density given by a component of the symmetrical tensor of rank 2 [9].

Incompatibility of «the equivalence law of mass and energy» with the Lorentz covariance [10, 2]. «One of the main results of relativity theory is the statement that any energy E has inertia (E/c^2) proportional to it» [11]. Although this statement is considered as a consequence of the relativity theory, it contradicts its very essence. As we have already noted, the statement of mass and energy proportionality is just only for a resting system, when a material body after energy loss (say, in the form of radiation) remains at rest. In all other reference systems such proportionality does not take place because of mass invariance. What is more, if energy answers any mass, then mass answers not any energy. Thus, the famous Einsteinean formula

$$E = mc^2 \tag{10}$$

is valid only in the resting system. In general, in accordance with (2), we have

$$p^i = (E/c, \mathbf{p}) = mu^i$$

whence it follows that

$$E = mu^0c . \tag{11}$$

For the corresponding densities in the rest system

$$\varepsilon^* = \rho^* c^2 \quad \text{or} \quad \rho^* = \varepsilon^*/c^2 \tag{10'}$$

but in a moving system

$$\rho \neq \varepsilon/c^2 \quad (J^0 \neq T^{00}/c^2).$$

Thus, the very basis of GTR and other gravity theories with the tensor potential is falling down.

ADDITION
(On relativistic rotation [12])

Let us consider two reference systems S^* and S. S^* is an inertial system and S a non-inertial system that rotates with constant angular velocity ω around the z-axis, which coincides with the z^*-axis of the S^*-system. Let us present for clearness the S-system as a disk in the (x, y) plane.

Let us present further that U^* and D^* similar rigid rods are laid along the circle and the diameter of the disk. Then we should have

$$\frac{U^*}{D^*} = \pi ,$$

when rotation is absent. But if S rotates, we obtain another result. All rods situated along the circle are contracted relative to S^*, but the rods on the diameter are not contracted. Consequently,

$$\frac{U}{D} > \pi .$$

«Thus one can conclude that the laws of rigid rod configurations in S do not agree with these laws of rigid rod configurations that correspond to the Euclidean geometry» [13]. This result is interpreted as a «crash of the Euclidean geometry» [14] and serves as an argument for the introduction of the more general Rimanean geometry.

But it should be stressed here that, generally speaking, we also have no Euclidean geometry in STR as space part of the interval is not an invariant value in the frames of this theory. Therefore in the discussed case the talk can be only about the justice of pseudo-Euclidean geometry in all the 4-space.

On the other hand, it turns out that the interval form-invariance*

$$ds^2 = c^2 dt_*^2 - r_*^2 d\varphi_*^2 - dr_*^2 \qquad (A.1)$$

is accomplished if we take the following precise tangential transformation [15, 12]

$$t^* = [t - (\beta^2/\omega)\varphi]\gamma_\omega, \quad \varphi^* = (\varphi - \omega t)\gamma_\omega, \quad r^* = r = \text{const.} \qquad (A.2)$$

instead of the usually used approximate formulae, where $\gamma_\omega = (1 - \beta^2)^{-1/2}$, $\beta = \omega r/c$, the z-coordinate is omitted. In its very sense this transformation should

*Or, one can say, the Lorentz covariance.

describe the relativistic rotation, i.e., it includes the cases when the product ωr is near to the light velocity c.

But if it is true, then the obtained result means that in the rotating system a light signal along any circle (with the center $r = 0$) propagates (as in the inertial system) with velocity $c_t = c$.

Thus, as we see, neither the previous argument nor especially the result: «the principle of mass and energy equivalence», ascribing to STR, cannot serve as the basis for describing the gravitational field by a metrical tensor.

REFERENCES

1. Strel'tsov V.N. — JINR D2-94-326, Dubna, 1994.
2. Idem — JINR P2-95-216, Dubna, 1995.
3. Poincare H. — Rend. Circ. Mat. Palermo, 1906, 21, p.129. RCMMA
4. Minkowski G. — Phys. Z., 1909, 10, p.104. PHZTA
5. Afanasiev G.N., Asanov R.A. — Ann. Phys. Leipz., 1981, 38, p.169.
6. Vizgin V.P. — The Relativistic Theory of Gravity. M.: Nauka, 1981, p.268.
7. Okun L.B. — Sov. Phys. Usp., 1989, 32, p.629. SOPUA
8. Einstein A — Naturforsch. Gesellschaft, Zurich, Vierteljahrschr., 1913, 58, p.284.
9. Idem — Ann. Phys., 1916, 49, p.769.
10. Strel'tsov V.N. — JINR D2-94-481, Dubna, 1994.
11. Einstein A. — Ann. Phys., 1912, 38, p.1059. APNYA
12. Strel'tsov V.N. — JINR P2-11385, Dubna, 1978.
13. Einstein A. — The Meaning of Relativity. Princeton Univ. Press. Princeton, NY, 1921.
14. Born M — Einstein's Theory of Relativity. Dover, NY, 1962, p.317.
15. Strauss M. — Intern. J. Theor. Phys., 1974, 11, p.107. IJTPB

Received by Publishing Department
on June 2, 1995.

Стрельцов В.Н. Д2-95-223

О релятивистской теории тяготения Ньютона

В соответствии с подходом Пуанкаре–Минковского рассматривается релятивистское обобщение теории тяготения Ньютона. Как следствие лоренц-ковариантности уравнения Пуассона потенциал гравитационного поля является 4-вектором. Предполагается, что напряженности поля тяготения описываются антисимметричным тензором 2-го ранга.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна, 1995

Strel'tsov V.N. D2-95-223

On the Relativistic Newton Theory of Gravity

The relativistic generalization of the Newton theory of gravity is considered in accordance with the Poincare–Minkowski approach. As a consequence of the Lorentz covariance of the Poisson equation, the potential of gravitational field is a 4-vector. It is supposed that the gravity field is described by an antisymmetric tensor of rank 2.

The investigation has been performed at the Laboratory of High Energies, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna, 1995

NAME	I D No.	M.S.

RETURN TO FERMILAB LIBRARY

Редактор Э.В.Ивашкевич. Макет Т.Е.Попеко

Подписано в печать 4.07.95
Формат 60×90/16. Офсетная печать. Уч.-изд.листов 0,56
Тираж 240. Заказ 48365. Цена 336 р.

Издательский отдел Объединенного института ядерных исследований
Дубна Московской области