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ON BOUNDEDNESS OF THE ADMISSIBLE TIME SLOWING DOWN BY THE GRAVITATIONAL FIELD

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Abstract

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It is shown that there exists, in the field theory of gravitation, contrary to the General Theory of Relativity (GTR), a *bound* for admissible time slowing down by the gravitational field which excludes a possibility of *unbounded compression* of matter by the *gravity forces.*

Аннотация

Герштейн С.С., Логунов А.А., Мествиришвили М.А. О границе допустимого замедления времени гравитационным полем: Препринт ИФВЭ 2005–36. – Протвино, 2005. – 4 с., библиогр.: 5.

На примере точного решения уравнений общей теории относительности (ОТО) показано, что в полевой теории гравитации в противоположность ОТО *существует граница* для допустимого замедления времени гравитационным полем, которая исключает возможность *неограниченного сжатия* вещества *силами гравитации.*

In the Relativistic Theory of Gravitation (RTG) gravitational field is considered as a physical field in the spirit of Faraday–Maxwell evolving in the Minkowski space. In such an approach the conserved energy-momentum tensor of matter and gravitational field is a source of the field [1, 2], just as, in electrodynamics, the conserved electric current is a source of electromagnetic field. Such a universal source of gravitational field leads to an "effective Riemannian space" of *simple topology*. Because the gravitational field, as all other physical fields, evolves in the Minkowski space, the fundamental conservation laws of energy-momentum and angular momentum take place in the RTG, contrary to the GTR. This means that special principle of relativity holds rigorously for all physical fields including the gravitational one.

All these properties of the RTG distinguish it in essence from the GTR and lead to a different system of gravitational equations. There are, however, common features, e.g., that the gravitational field is tensorial. In this paper we will show, taking as an example an exact solution to the GTR equations, how physical consequences of the RTG and GTR differ in the strong gravitational field.

In the GTR *the Hilbert–Einstein equations* for the spherically symmetric static problem, defined by the interval

$$ds^2 = c^2 U(W) dt^2 - V(W) dW^2 - W^2 (d\theta^2 + \sin^2\theta \, d\phi^2) \,, \tag{1}$$

and the equation of state for a gas of relativistic particles

$$p(W) = \frac{c^2}{3} \rho(W) \,, \tag{2}$$

have an*exact solution* of the form

$$\rho(W) = \frac{a}{W^2}, \quad a = \frac{3}{7\varkappa}, \quad \varkappa = \frac{8\pi G}{c^2} \,, \tag{3}$$

where G is the gravitational constant.

From the matter equation,

$$\frac{1}{c^2}\frac{dp}{dW} = -\Big(\rho + \frac{p}{c^2}\Big)\frac{1}{2U}\frac{dU}{dW} \,, \tag{4}$$

we find, making use of (2) and (3),

$$\rho U^2 = \alpha \,, \tag{5}$$

here α is an integration constant.

Substituting (3) into (5) we obtain the expression for the metric coefficient U defining the time slowing down

$$U = \sqrt{\frac{\alpha}{a}}\, W\,. \tag{6}$$

It is evident thereof that when W approaches the center the function U decreases, and an unbounded time slowing down occurs up to its stop in the center, where U disappears. This means that there does not exist, in the GTR, a bound for an admissible time slowing down by the gravitational field. In this case the pressure, according to (2) and (3), goes to infinity when approaching the center as

$$\frac{p}{c^2} = \frac{a}{3W^2}\,. \tag{7}$$

Since the pressure p is scalar, this singularity at the center cannot be eliminated by the choice of coordinates. This is also directly seen from the invariant

$$R_{\mu\nu}R^{\mu\nu} = 3\Big(\frac{2}{7}\Big)^2 \frac{1}{W^4}\,,$$

which also goes to infinity, when approaching the center.

Thus, if the matter inside a body obeys to the equation of state (2), then, according to the GTR, the pressure and the density, defined by expressions (3) and (7), become infinite at the center of the body. It means that according to equations of the GTR the forces of gravitational compression are unboundedly strong. All this is a consequence of the *main cause*: the absence in the GTR of a bound for admissible time slowing down by gravitational field. The absence of such a bound essentially contradicts to the very essence of the GTR. For the given problem with density (3) the ball radius R is related to the mass confined inside the ball as follows

$$R = \frac{7}{3}W_g, \quad W_g = \frac{2GM}{c^2} \quad \text{is the Schwarzschild radius.}$$

Nevertheless, though the ball radius exceeds, in this case, the Schwarzschild radius, the pressure and the density in the center of the ball, achieve an infinite value.

In the Relativistic Theory of Gravitation the equations of the gravitational field for the interval (1) have the form

$$\acute{Z} - \frac{2Z}{U}\acute{U} - 2\frac{Z}{W} - \frac{m^2W^3}{2}\Big(1 - \frac{U}{V}\acute{r}^2\Big) = -\varkappa W^3\Big(\rho + \frac{p}{c^2}\Big)U\,, \tag{8}$$

$$1 - \frac{1}{2}\frac{1}{UW}\acute{Z} + \frac{m^2}{2}(W^2 - r^2) = \frac{1}{2}\varkappa W^2\Big(\rho - \frac{p}{c^2}\Big)\,, \tag{9}$$

$$\text{where } Z = \frac{UW^2}{V}\,. \tag{10}$$

Equations (8) and (9) under assumption that

$$m^2(W^2 - r^2) \ll 1, \quad \frac{U}{V} \ll 1 \tag{11}$$

can be somewhat simplified and, for the equation of state (2), take the form

$$-U\acute{Z} + 2U^2W = \frac{2}{3}\varkappa\alpha W^3\,, \tag{12}$$

$$UZ' - 2ZU' - \frac{2ZU}{W} - \frac{m^2}{2} UW^3 = -\frac{4}{3} \varkappa \alpha W^3 \,. \tag{13}$$

These equations do not change under the multiplicative transformations

$$U \to tU, \quad Z \to tZ, \quad m^2 \to tm^2, \quad \alpha \to t^2 \alpha \,. \tag{14}$$

With terms of the order of βW^2 neglected equations (12) and (13) have the solution

$$U = \beta + \sqrt{\frac{\alpha}{a}}\, W \,, \tag{15}$$

$$Z = W^2 \Big(\beta + \frac{4}{7} \sqrt{\frac{\alpha}{a}}\, W \Big) \,. \tag{16}$$

The constant β is non-zero and, due to multiplicative transformations (14), *is proportional to the gravitation rest mass squared*.

That is the quantity β that defines the bound for the admissible slowing down of time by a gravitational field. In the GTR this quantity is equal to zero, and this fact leads to an unbounded slowing down of time up to its stop, as well as to the infinite values of density and pressure, and even to such non-physical objects as “black holes”. According to the RTG such mystic objects are absent from Nature.

Comparing (10) and (16) we find for the second metric coefficient V the expression

$$V = \frac{\beta + \sqrt{\frac{\alpha}{a}}\, W}{\beta + \frac{4}{7} \sqrt{\frac{\alpha}{a}}\, W} \,. \tag{17}$$

Taking into accounts (15) and (17) we find

$$\frac{U}{V} = \beta + \frac{4}{7} \sqrt{\frac{\alpha}{a}}\, W \,.$$

Due to smallness of the gravity β, which is proportional to m^2, this expression for small values of W is small enough in compare with unity and this justifies approximation (11).

Making use of (15) in (5) we find for the density of matter, ρ, the expression

$$\rho = \frac{\alpha}{\Big(\beta + \sqrt{\frac{\alpha}{a}}\, W \Big)^2} \,. \tag{18}$$

It is evident thereof that the density of matter, ρ, defined by expression (18), and the pressure of matter, according to formula (2) are bounded due to the bound of the admissible slowing down of time, β. So, in contrast with the GTR, the forces of gravitational compression are always finite in the RTG. It means that the gravitational field, slowing down the run of time, cannot stop it, what is quite natural from physical standpoint. It follows from the above analysis, as well as from the analysis of the exact internal Schwarzschild solution made in [8], that physical gravitational field in the RGT has a property to stop the process of gravitational compression due to the bound of the admissible time slowing down by gravitational field. We call such a phenomena that follows from a physical property of gravitational field to *restrict itself* as *“gravitational selfstop”*. So, an *unbounded* gravitational compression of matter takes place in the GTR; gravitational compression of matter in the RTG *always bounded* and the *gravitational selfstop* takes place.

This makes the difference between the physical consequences of the GTR and the RTG. Such a difference leads to essential changes both in the Universe evolution [4] and in the process of collapse [5].

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