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YEREVAN PHYSICS INSTITUTE

H.L.BAYATIAN

IS THE METRIC IN GRT CORRECT?
A NEW METRIC WITHOUT RIEMANNIAN GEOMETRY

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Г.Л.БАЯТЯН

ПРАВИЛЬНА ЛИ МЕТРИКА В ОТО?
НОВАЯ МЕТРИКА БЕЗ РИМАНОВОЙ ГЕОМЕТРИИ

Найдено новое явление зависимости массы от гравитационного потенциала. Оно приводит к значению новой пространственно-временной метрики, в два раза отличающейся от ОТО. Несмотря на такое различие, новая метрика позволяет для трех "знаменитых" эффектов ОТО вычислить значения, хорошо совпадающие с экпериментальными данными, а также дать принципиально новое определение потенциальной энергии.

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To the liberation struggle of
Armenians of Karabagh is devoted

Experiment will never say "yes" to theory but will at best say "maybe", and mostly it simply says "no". When experiment fits theory, it means for the latter "maybe", and when it does not - the sentence is: "no".

Albert Einstein

Introduction

The general relativity theory (GRT) is based on distinguishing between the notions of "gravitational field" and "matter". The unnaturalness of such a separation issues from the relativistic mass gain (matter) due to the energy of gravitational acceleration. This unnaturalness could not remain unnoticed by Einstein. "It is therefore possible", he wrote, "that this theory is invalid for very high densities of matter" [1] . Experimental verification of Dicke's idea [2] that the energy of gravitational field of the Earth is part of its both inertial and gravitational masses [3] , which was realized using the Nordtvedt effect [4] by means of Lunar laser ranging, makes the expedience of such a separation doubtful. Thus, in the GRT the gravitational field energy is separated from the rest masses of interacting bodies and the latters do not change in the course of gravitational interactions, and the energy balance occurs owing to the gravitational field energy. Without arguing the question why in the energy balance the preference should be given to the field energy as against the rest masses of interacting particles (and how one can separate the rest mass of the particle from the energy of the field created by it), we note that such an approach, together with the mentioned in [5] denial of the GRT from the representation about the gravitational field as a physical field of Faraday-Maxwellian type, puts the gravitational interaction in an exceptional position compared to other types of matter interaction (nuclear, Coulomb and weak), where because of large energy release (the mass defect) the change in the rest masses of interacting particles is beyond doubt. Quite another thing is that lack of knowledge of potentials in the case of nuclear and weak interactions does not allow one to calculate the values of the mass defects without experimental data. In the case of gravitational interactions the potential is well known, which makes such a calculation feasible.

Another important property of the gravitational forces is their proportionality to masses, which advantageously distinguishes the gravitational interaction and, as will be shown below, together with the representation that the rest mass of the bo y includes the energy of gravitational [2] and other fields created by it enables one to calculate the relative

share of the mass defect for each of the bodies participating in gravitational interaction. The emerged gravitational mass defect calculated on the basis of the energy-mass conservation law in the framework of representations on the gravitational field as on a physical field of Faraday-Maxwellian type determines the range of physical phenomena that can be influenced by this field. This way seems to us more natural (the gravitational field does not distinguish among other fields) and more reliable (the energy-mass conservation law holds undoubtedly) and as will be seen from what follows is much simpler than the "distortion" of the space-time metric as affected by gravitational field, and the account of this "distortion" in physical phenomena via the complicated mathematical apparatus of Riemannian geometry as it is done in the GRT. Account of the influence of the gravitational field on daily rate and length of unit measuring core through the appearance of gravitational mass defect gives an effect twice as small as the GRT does. Nevertheless the new metric leads to experimentally agreeable values of the shift of spectral lines, the motion of Mercury perihelion and deflection of the light rays in the gravitational field of the Sun. The reasons of the discrepancy between the new metric and the GRT metric are discussed.

1. Gravitational Mass Defect

It is obvious that the total mass defect just like in any interaction is equivalent to the potential energy of gravitational interaction. To elucidate the proportion of distribution of this defect between the interacting bodies, we consider mentally the following experiment. Imagine two identical balls with the rest masses m_0 being at infinitely large distance from other masses in the Universe. By the choice of the distance between these balls their initial potential energy of gravitational interaction can be made arbitrarily close to zero ($U(r) \to 0$ at $r \to \infty$). Let then these balls under the action of mutual gravitational attractive forces move to meet one another and colliding with each other lose (in any form) their kinetic energies after which they stop at some distance r (r is the distance between their centres of gravity).

Writing the law of mass-energy conservation before and after collision in a usual way, we obtain:

$$2m_0c^2 = 2m_0c^2 - U(r) + Q \tag{1}$$

where $U(r)$ is the potential energy,

Q – released total kinetic energy of the two balls,

c – velocity of light.

However that very conservation law (1) can be written in a different form:

$$2m'c^2 = 2m_0c^2 - Q = 2m_0c^2 - U(r) \tag{2}$$

where quantity $2m'$ is the rest mass of the system of two balls provided that they are at rest relative to each other at a distance r .

By the mass defect definition and comparing (1) and (2) we obtain:

$$U(r) = 2c^2\Delta m = 2m_0c^2 - 2m'c^2 = Q \tag{3}$$

where Δm is the mass defect for one ball. As long as the energy of gravitational field of any body enters its rest mass [2,3] , then from (3) one can conclude that the potential energy is that maximally possible share of the total rest mass of interacting bodies (total mass defect) which potentially can convert into active (kinetic, thermal, etc.) energy.

Such a definition for potential energy differs from the traditionally ascribed to it status of field origin and pointing to the mass responsible for energy release in gravitational interactions saves us from casuistry of negative mass corresponding to negative potential energy in the equations of energy-mass conservation for the bound systems.

With respect to stated above, after collision of two balls of the same rest mass m_0 , owing to release of total kinetic energy Q to infinity, for the effective rest mass m' for each of the two balls from (2) we obtain up to second-order terms of smallness relative to φ/c^2 , an expression:

$$m' = m_0\left(1 - \frac{\varphi}{2c^2}\right) \tag{4}$$

where φ is a usual Newton potential of one ball at the point of location of the other. For convenience we take it with a positive sign.

From (4) we have $\varphi \to 0$ at $m' \to m_0$, which is natural; it also follows that the gravitational mass defect Δm for one ball is

$$\Delta m = m_0 - m' = \frac{m_0\varphi}{2c^2} = \frac{U(r)}{2c^2} \tag{5}$$

In order to discriminate the generally-adopted rest mass of the bodies, when they are at infinitely large distance from each other and therefore do not interact, from the case when the distance is not large and they interact in the rest state, for the latter case we here introduce a conventional notation of "effective rest mass".

We can readily show that Eq.(5) holds for any relation of masses of two interacting bodies. To do this, we imagine two balls A and B with different rest masses, m_o and Nm_o, respectively. For simplicity we assume N integer. We mentally divide the heavier B ball into N parts with the same masses m_o such that any of the parts would have a spheric shape (N balls inside one another). Obviously, the centres of gravity of all the parts will be in the same point coinciding with the centre of gravity of the B ball.

Repeating the arguments that led to formula (5) and taking into account that the gravitational mass defect of the A ball, Δm_A, in interaction with the B ball equals the sum of mass defects with all its N parts separately, we obtain:

$$\Delta m_A = \sum_{i=1}^{N} G\frac{m_o m_o^i}{2\tau c^2} = G\frac{m_o N m_o}{2\tau c^2} = \frac{m_o \varphi_B}{2c^2} = \frac{U(\tau)}{2c^2} \qquad (6)$$

where G is the Newton gravitational constant, m_o^i is the rest mass of the i-th part of the B ball, τ is the distance between the centres of the A and B balls, φ_B is the gravitational potential of the B ball in the point of location of the A ball, $U(\tau)$ is the potential energy of interaction of these balls.

One can readily find the mass defect of the B ball:

$$\Delta m_B = \frac{U(\tau)}{2c^2} = \Delta m_A \qquad (7)$$

Hence, in gravitational interactions of two bodies the total mass defect equivalent to potential energy is shared equally between these bodies irrespective of their mass relation.

2. Variation of Space-Time Metric

In order to understand to what variations in space-time metric will lead the change in mass determined by (6) and (7), we recall that the atomic systems present the best accuracy in measurement of space-time intervals.

It is generally known the dependence of the frequency of the photon emitted by the hydrogen-like atom on the rest mass of the electron m_e:

$$\nu = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right) = \frac{2\pi^2 e^4 m_e}{ch^3}\left(\frac{1}{n^2} - \frac{1}{m^2}\right) \qquad (8)$$

where R is the Rydberg constant, and other quantities are generally known and except m_e are independent of gravitational potential. Using the dependence of m_e on the gravitational potential determined by formula (4) for the frequency of the photon emitted at the point with gravitational potential φ, we obtain:

$$\nu = \nu_o\left(1 - \frac{\varphi}{2c^2}\right) \qquad (9)$$

where ν_o is the frequency of the photon emitted by the same atom in the absence of gravitational field. From here, for the relationship of **time intervals** in the presence and absence of gravitational field we have

$$dt = \left(1 - \frac{\varphi}{2c^2}\right) dt_o \qquad (10)$$

To determine the variation of the space interval, recall that any measuring core of the space interval consists of atoms, and hence it is enough to determine the quantity of variation of Bohr atomic radius versus gravitational potential. For the Bohr atomic radius we have a well-known formula:

$$a = \frac{h^2}{4\pi^2 m_e c^2} \qquad (11)$$

Substituting here the expression for m_e from (4) and discarding the second-order terms of smallness and higher terms in expansion in terms of $\varphi/2c^2$ we obtain:

$$a = a_o\left(1 - \frac{\varphi}{2c^2}\right)^{-1} = a_o\left(1 + \frac{\varphi}{2c^2}\right), \qquad (12)$$

where a_o is the Bohr atomic radius in the absence of gravitational field.

Thus, the comparison of (10) and (12) with the corresponding quantities in the GRT shows that the obtained here variation of the space-time metric in gravitational field is twice as small as in the GRT.

Below we consider to what values of experimental observables the new metric leads.

3. Red Shift of Spectral Lines

It follows from Eq.(9) that the atom in the point with gravitational potential φ will emit a photon with lower frequency, and the frequency shift in the generation of the photon will be

$$\Delta\nu_1 = \nu_o - \nu = \frac{\nu_o \varphi}{2c^2}. \qquad (13)$$

Now we consider what frequency has this photon for an observer locating in the point with gravitational potential $\varphi \to 0$. In order to reach the observer, the photon must spend part of its energy to overcome the gravitational potential φ, which is determined by the expression:

$$\Delta W = \frac{\hbar\nu}{c^2}\varphi. \qquad (14)$$

Repeating backwards the arguments that had led to formulae (5) and (7), one can readily be convinced that this interaction energy, like any other kind of energy, is not lost; shared equally between the interacting bodies it is spent to increase their masses. In the given case these bodies are a photon and the Globe (like in the well-known experiment of Pound and Rebka [6] on red shift measurement).

Thus, half energy determined by formula (14) is spent to increase the rest mass of the Earth. Another half intended to increase the photon mass is spent to enhance the photon energy since the notions of mass and energy are indistinguishable for it. In other words, to overcome the potential barrier φ

by the photon, there occurs an additional shift of its frequency which is equivalent to half energy loss determined by formula (14), i.e.

$$\Delta\nu_2 = \frac{\nu}{2c^2}\varphi. \tag{15}$$

The total red shift effect is thus formed of (13) and (15); so, with respect to (9), discarding $\nu\left(\frac{\varphi}{c^2}\right)^2$ as a small second-order term we obtain:

$$\Delta\nu = \Delta\nu_1 + \Delta\nu_2 = \nu_0\left(1 - \frac{\varphi}{c^2}\right) \tag{16}$$

which is in perfect agreement with experimental data [6] .

It is noteworthy that the red shift is considered to be one of experimental verifications for GRT validity. Is that really the case?

We'll show that within the GRT, if being logically consistent to the end, one can obtain the red shift twice as large as in experiment [6] . Indeed, the deceleration of the daily rate in the gravitational field φ by a factor of $(1-\varphi/c^2)$ as obtained in the GRT implies that the photon emitted in the point with potential φ will have a frequency

$$\nu = \nu_0\left(1 - \frac{\varphi}{c^2}\right) \tag{17}$$

where ν_0 is the frequency of emission of the same atom in the absence of the field, i.e. at $\varphi = 0$.

From (17), for frequency shift at the generation of the photon we'll obtain

$$\Delta\nu_1 = \nu_0 - \nu = \nu_0 \cdot \frac{\varphi}{c^2} \tag{18}$$

Let this photon reach the atom locating in the point without gravitational field, i.e. in the point with $\varphi = 0$. Then it must overcome the gravitational potential φ for which the photon energy is to be decreased by quantity $\hbar\nu/c^2 \cdot \varphi$, which will result in additional frequency shift equal to:

$$\Delta\nu_2 = \frac{\nu\varphi}{c^2} \tag{19}$$

The total shift in the first approximation over φ/c^2 will be

$$\Delta\nu = \Delta\nu_1 + \Delta\nu_2 \simeq \frac{2\nu_0}{c^2}\varphi \tag{20}$$

i.e. twice as large as in experiment [6] .

In order to bypass the evident contradiction with experiment, the sipporters of the GRT claim [7] that in the generation in gravitational field with $\varphi \neq 0$ the photon must have the same frequency ν_0 as with $\varphi = 0$. Then a question arises: how should be treated the GRT conclusion about the deceleration of daily rate in gravitational field? Or atoms do not represent daily rate? If yes, then all periodic processes must slow down, which inevitably will result in the change of frequency of the emitted photon as determined by (20).

Thus, the adopted in the literature "touching agreement" between the GRT-predicted value of red shift and experimental data is illusive.

4. Mercury Perihelion Motion

It is convenient to use a universally applicable in a weak field for various metric theories the Eddington-Robertson expansion [8,9] for the four-dimensional interval ds^2 with "almost usual" spheric coordinates with the origin in the centre of the Sun:

$$ds^2 \simeq \left[1-\alpha\frac{r_g}{r}+\beta\left(\frac{r_g}{r}\right)^2\right]c^2dt^2 - -\left(1+\gamma\frac{r_g}{r}\right)\left[dr^2+r^2(d\theta^2+\sin^2\theta d\varphi^2)\right] \qquad (21)$$

Here we introduced parameters α, β, γ which in the GRT are unity, and $r_g = 2GM_\odot/c^2$; $M_\odot$ is the Sun mass. The calculation of Mercury perihelion motion carried out by metric (21) for the ellipse position angle gives an expression [9,p. 374] :

$$\delta\varphi = \frac{2-\beta+2\gamma}{3} \cdot \frac{6\pi GM_\odot}{a(1-e^2)c^2} \qquad (22)$$

where a and e are respectively a semimajor axis and eccentricity of the ellipse.

For the new metric obtained in this work from (12) it follows that $\gamma = 0.5$. As for the parameter β, to determine it one should calculate the dependence of the frequency of the photon emitted in the field φ, determined by (9) in the approximation $(\varphi/2c^2)^2$. Using expression (7) for the case when $m_A^\circ \ll m_B^\circ$ we find:

$$\Delta m_A = \frac{U(r)}{2c^2} = \frac{G m_A' m_B'}{2rc^2} = = \frac{G}{2rc^2} m_A^\circ\left(1-\frac{\varphi_B}{2c^2}\right) m_B^\circ\left(1-\frac{\varphi_A}{2c^2}\right) \qquad (23)$$

where m_A' and m_B' are the effective rest masses of A and B bodies at a distance r, and φ_A and φ_B are the gravitational potentials created by these bodies.

Using $\varphi_A \ll \varphi_B$, since $m_A^\circ \ll m_B^\circ$ for expression Δm_A in the approximation $(\varphi_B/2c^2)^2$ we obtain:

$$\Delta m_A = m_A^\circ\left[\frac{\varphi_B}{2c^2} - \frac{1}{4}\left(\frac{\varphi_B}{c^2}\right)\right]. \qquad (24)$$

Substituting this in expression (8) instead of (10) we obtain by omitting index B:

$$dt = \left[1-\frac{\varphi}{2c^2}+\frac{1}{4}\left(\frac{\varphi}{c^2}\right)^2\right]dt_\circ . \qquad (25)$$

Substituting here $\varphi = GM_\odot/r$ and $r_g = 2GM_\odot/c^2$ in (21), comparing the time intervals in (21) and (25) we obtain for the new metric $\beta = 1/16 = 0.0625$. Substituting this value of β and the value $\gamma = 0.5$ in (22) for the position angle of Mercury perihelion, using the new metric we obtain a quantity:

$$\delta\varphi = 0{,}98 \cdot \frac{6\pi GM_\odot}{a(1-e^2)c^2} \simeq \frac{6\pi GM_\odot}{a(1-e^2)c^2}, \qquad (26)$$

which is in agreement with experimental data and with the GRT.

One can see that although the post-Newton part of the new metric differs from the similar part of the GRT metric by a factor of two, nevertheless it gives a result agreeing with the GRT with an accuracy to 2%.

5. Deflection of Light Rays Near the Sun

As early as 1801 Soldner considering the light as a corpuscle attracted by the Sun, in the framework of the Newton mechanics for the deflection angle, obtained a value:

$$\alpha_1 = \frac{2GM_0}{c^2 R} \tag{27}$$

where M_0 is the Sun mass, R is the Sun radius.

Soldner's ignorance of the photon mass, $m = \hbar\nu/c^2$, did not impede him to obtain a correct result, since the photon mass drops out of calculations because of equality of inertial and gravitational masses. Soldner's article is reprinted in [10], and the derivation of formula (27) can be found also in [11].

It is left to calculate the relativistic part of the deflection angle α_2 which is related to the new space-time metric obtained in the present paper. With respect to (10) and (12) for the new metric we can write in the approximation φ/c^2:

$$ds^2 \simeq \left(1-\frac{z_0}{z}\right)c^2dt^2 - \left(1+\frac{z_0}{z}\right)dL^2 \tag{28}$$

Here $z_0 = \frac{GM_0}{c^2}$; dL is the space interval. From here, for the coordinate velocity of light c' from the condition $ds = 0$ we obtain an expression:

$$c' = \frac{dL}{dt} \simeq c\left(1-\frac{z_0}{z}\right) \tag{29}$$

where c is the velocity of light in the absence of gravitational field.

The decrease of velocity of light in gravitational field by analogy with the case of its propagation in inhomogeneous refracting medium, according to Huygens' principle, must lead to bending of light rays towards the attractive centre, i.e. towards the increase of angle α_1, determined by (27), by an additional angle α_2 whose value according to [11] and [12] is

$$\alpha_2 = \frac{2GM_0}{c^2 R} \tag{30}$$

The total refraction of light rays in Sun's field will naturally be

$$\alpha = \alpha_1 + L_2 = \frac{4GM_0}{c^2 R}$$

which is in perfect agreement with experiment [9].

Conclusion

The three basic effects of the GRT can be successfully calculated using the new metric based on the account of gravitational mass defect from the energy-mass conservation law, and therefore this metric is beyond doubt. Hence, the good agreement of calculational results with experimental data is not accidental. Note also that the obtained in the present paper result on the decrease of the mass of a test body as other masses approach the latter is opposite to what is claimed by the generally known Mach principle which is substantiated rather philosophically than scientifically.

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Г.Л.БАЯТЯН
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The address for requests:
Information Department
Yerevan Physics Institute
Alikhanian Brothers 2,
Yrevan, 375036
Armenia, USSR