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## **«RELAXED, NONLINEAR AND ACOUSTIC OPTICAL PROCESSES AND MATERIALS» (RNAOPM'2026)**

**DEDICATED TO THE MEMORY OF  
NIELS BOHR**

**JUNE 16 - 19, 2026**

**Lesya Ukrainka Volyn National University**

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МАТЕРІАЛИ (РНАОПМ' 2026)

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## ON THE JUSTIFICATION FOR USING A DYNAMIC GRAVITATIONAL FIELD IN AN EXPANDING UNIVERSE

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The feasibility of using the equations of the dynamic gravitational field to reflect the expanding Universe has been proven. Only thanks to this, the Hubble velocity of matter will not exceed the velocity of light at the event horizon of the Universe. The identity of the parameter  $b$  of the Schwarzschild solution of the equations of the gravitational field to the square of the relative frequency of the electromagnetic interaction of micro-objects of matter and the equivalence of the limit velocity of matter to this parameter in its state of immobility has been justified. The falsehood of the association of the parameter  $b$  with the coordinate velocity of light of the General Relativity (GR) has been proven.

**Keywords:** General Relativity, Dynamic Gravitational Field, Expanding Universe, Hubble Velocity.

The Hubble velocity of matter  $m$  at the event horizon of the Universe  $h$  is equal to the constant of velocity of light  $c$ . And this can be real only if dynamic gravitational field [1, 2], according to which the velocity of light  ${}^h v_{cr} = v_{icm} = \sqrt{b_h c^2 + {}^h v_m^2} = c$  at the event horizon of the Universe  $h$  (as well as the limit velocity  $v_{icm} = c\sqrt{b_{cm}} = c\sqrt{b_h + {}^h v_m^2 c^{-2}} = c$  of moving matter  $m$ ) is also equal to the constant of velocity of light  $c$ , corresponds to this matter (similar to galaxies, stars and planets [1, 2]). Here  $b_{cm} = f_{cm}^2 = f_{oh}^2 + {}^h v_m^2 c^{-2} = b_h + {}^h v_m^2 c^{-2} = 1$  and  $b_h = f_{oh}^2 = 0$  are the squares of the relative frequency  $f$  of the electromagnetic interaction between micro-objects of matter  $m$  moving with a velocity  $v$ , and matter conditionally being at rest in a dynamic gravitational field at the event horizon of the Universe  $h$ , respectively.

Therefore, the velocity of matter  $v_m$  increases as does the corresponding relative kinematic frequency  $f_{kin}$  of electromagnetic interaction. It is due to this fact that the further gravitational reduction of this relative frequency is compensated ( $f_{cm}^2 = f_{gr}^2 + f_{kin}^2 = \text{const}(t)$ ). And this is obviously due to the decrease in the distances of electromagnetic interaction between micro-objects of matter in the background Euclidean space of the Universe [3] due to the isotropic kinematic self-contraction of moving matter in it [1, 2, 4]. Thus, the application of the parameter  $c\sqrt{b}$  in the GR (according to the Schwarzschild solution of the gravitational field equation [5]) to space, and not to the matter moving in it, is inappropriate and incorrect.

After all, the identification with this parameter of the so-called coordinate velocity of light [4, 5] leads in the frame of references of spatial coordinates and time (FR) of the observer to an absurd zero value of the velocity of light at the event horizon (due to  $b_h = 0$ ), despite there is the maximum possible value of the Hubble velocity of matter  ${}^h v_m = c$  on the event horizon in the same FR [6]. In addition, this ignores the fact that in fact the gravitational potential is a function of the relative frequency of electromagnetic interaction, and not only of the speed of propagation of electromagnetic waves.

The equivalence of the gravitational interval  $q$  to the astronomical (gravithermodynamic [4]) time  $t$  when  $b_0 = 1$ , and the equivalence of the kinematic (non-relativistic) interval  $s_c$  to the intrinsic gravity-quantum time  $t'$  of matter in the dynamic gravitational fields of galaxies and the Solar System must also be taken into account:

$$(dq)^2 = v_{lc}^2 (dt)^2 + (d\hat{l})^2 = (bc^2 + v_{\sigma c}^2)(dt)^2 + (d\hat{l})^2 = (v_l^2 + 2v_{\sigma c}^2)(dt)^2 = c^2 (dt)^2 = \text{invar},$$

$$(ds_c)^2 = (bc^2 + 2v^2)(dt)^2 - (d\hat{l})^2 = v_{lc}^2 (dt)^2 = (bc^2 + v^2)(dt)^2 = b_0 c^2 (dt)^2 = c^2 (dt')^2 = \text{invar}.$$

Here:

$$v_{lc}^2 = b_c c^2 = [(1 - r_g/r - \Lambda r^2/3)c^2 + v^2](dt)^2 \approx [1 - r_g/(r_{\min} + r_{\max})] = \text{const}(t);$$

$v_{\sigma c}^2 = (r_g/r + \Lambda r^2/3)c^2/2$  is the square of the hypothetical circular orbital velocity of astronomical

objects,  $ds_c = cdt'$  is the increment of the kinematic interval;  $d\hat{t} = \sqrt{(d\hat{x})^2 + (d\hat{y})^2 + (d\hat{z})^2}$ ,  $d\hat{x} = v_x dt$ ,  $d\hat{y} = v_y dt$ ,  $d\hat{z} = v_z dt$  are the increments of metric segments, not increments of coordinates.

According to this, it can be conditionally assumed that the ordinary Newtonian  $N = m_{00}c^2(b + v^2c^{-2})^{1/2}$  [1, 2] of the inert free rest energy  $E_0 = m_{00}c^2b^{1/2}$  [4] of matter is the Pseudo-Hamiltonian of the fundamental Newtonian  $N_F = m_{00}c^2(b + 2v^2c^{-2})^{1/2}$ , and the ordinary Keplerian  $K = m_{00}c^2(b + v^2c^{-2})^{-1/2}$  [1, 2] of the ordinary rest energy  $W_0 = m_{00}c^2b^{-1/2}$  of matter is the Pseudo-Lagrangian of the fundamental Keplerian  $K_F = m_{00}c^2(b + 2v^2c^{-2})^{-1/2}$ , which is inherent to matter (with ordinary mass  $m_{00}$ ) in the comoving with expanding Universe FR (CFREU).

Thus, we have a twofold ( $b_F = b + 2v^2c^{-2}$ ) kinematic increase in the relative frequency of electromagnetic interaction between micro-objects of matter (due to the isotropic reduction of the distances of this interaction in the background Euclidean space [3] of the CFREU), compensated by half by the Lorentzian decrease ( $b_c = b_F - v^2c^{-2} = b + v^2c^{-2}$ ) in it. And therefore, the kinematic interval

$S_c$  (as opposed to the relativistic interval) corresponds to the kinematic acceleration of the flow of the proper time of matter instead of its deceleration (dilation). Indeed, unlike the ordinary (usual) Lorentz transformations of the increments of spatial coordinates and time (OLT) the conformal Lorentz transformations of the increments of spatial coordinates and time of matter moving in equilibrium allow not only to get rid of the relativistic dilation of the proper time [4], but also to obtain the relativistic acceleration of the proper time of the matter due to its isotropic self-contraction and self-compaction in the background Euclidean space of CFREU [3]. In this case, the Lorentz transformations of the velocities of equilibrium and quasi-equilibrium motions of matter will be the same [4, 7] as in the case of OLT.

And therefore, the motion of matter actually induces an increase in the relative frequency of electromagnetic interaction between its micro-objects, which leads to compensation for its further gravitational reduction. And this, of course, can be considered only as a compensation for the further gravitational dilation of the proper time of matter, and not as a compensation for the action of the external gravitational field in general. It is precisely due to this compensation that the Hubble velocity of matter is equal to the constant of velocity of light  $c$  at the event horizon of the Universe, despite the zero value of the relative frequency of electromagnetic interaction  $b$  in the hypothetical static gravitational field of the Universe. Therefore, it is only due to the presence of a dynamic gravitational field in the Universe [1, 2, 4, 8] that Hubble law can operate in it.

Although we should not exclude the possibility that the gravitational field is actually weaker, and therefore that the centrifugal pseudo-forces of inertia actually compensate not only for the half-weaker gravitational pseudo-forces, but also for the centripetal pseudo-forces of evolutionary self-contraction of matter towards the center of gravity, which are equal in magnitude to gravitational pseudo-forces [1, 2].

And only from the condition of complete compensation of the comoving change ( $v = \sqrt{a_c} dr / dt \approx -c\sqrt{b_c - 1 + r_g/r} = -c\sqrt{r_g(1/r - 1/r_0)}$ ,

$b_c = 1 - r_g/r + v^2c^{-2} - \Lambda r^2/3 = 1 - r_g/r_0 - \Lambda r_0^2/3 = \text{const}(r, t)$ ,  $b = 1 - r_g/r - \Lambda r^2/3$ ) in gravitational dilation of time by the inertial motion of matter can one obtain Newtonian gravitational acceleration:

$$g = -\frac{c^2}{\sqrt{a_c}} \frac{d \ln(v_{ic}/c)}{dr} = -\frac{c^2}{2b_c\sqrt{a_c}} \left( \frac{db_c}{dr} \right)_v \approx -\frac{c^2 r_{g0}}{2b_c r^2} = -\frac{G_0 M}{b_c r^2} = -\frac{G_0 M}{b_c a_c R^2} = -\frac{GM}{r^2},$$

$$g = \frac{dv}{dt} = \frac{1}{2\sqrt{a_c}} \frac{dv^2}{dr} \approx \frac{c^2}{2} \left( \frac{db_c}{dr} - \frac{r_g}{r^2} \right) = -\frac{GM}{r^2} \quad \left( \frac{db_c}{dr} = 0 \right),$$

where:  $G = G_0/b$ ;  $R = r/\sqrt{a_c} \approx r\sqrt{b_c}$  is radial coordinate in the background Euclidean space [3] of CFREU, which under the condition of hypothetical emptiness of space ( $b_c a_c = 1$ ) takes a zero value  $R_h = 0$  on singular surfaces ( $b_c = b = 0$ ).

And therefore, in the absence of complete compensation of the further gravitational dilation of time by the kinematic acceleration of the flow of time ( $db_c/dr \neq 0$ ), the gravitational acceleration of a freely falling body will not correspond to reality. Therefore, ignoring the invariance of the time dilation of matter moving by inertia in a gravitational field, based on the imaginary relativistic dilation of proper time of matter, is unacceptable. From the same condition follows the necessity of using the logarithmic gravitational potential and the identity of the inertial mass  $m_{in} = m_{00}v_{lc}/c = m_{00}\sqrt{b_c}$  to the gravitational mass  $m_{gr} = m_{00}c/v_{lc} = m_{00}/\sqrt{b_c}$  only according to the proper gravity-quantum clock of matter ( $v_{lci} = c$ ) [1, 2, 4, 6, 8], and the spatial and thus temporal dependence (on the parameter  $b_c = b + v_x^2 c^{-2}$ ) of the gravitational "constant"  $G = G_0 m_{gr}/m_{in} = G_0/b_c \neq \text{const}(r)$  [1, 2, 4], the instability of which in time was predicted by Dirac [9].

The discovery of new relativistic transformations of increments of spatial coordinates and time that comply with Newton's and Kepler's laws is similar to the discovery (by Ott [10] and Arzelies [11]) of the possibility of an alternative relativistic interpretation of thermodynamics, which finally confirmed the relativistic invariance of thermodynamics.

### Conclusion

The gravitational field is a spatial distribution of the relative frequency of electromagnetic interaction between micro-objects of a motionless matter and the equivalent limit velocity of motion of a real or hypothetical matter that could be conditionally at rest at a certain point in space. The vacuum velocity of light is the same at all points of the gravitational field and is equal to the constant  $c$  even on singular surfaces on which the relative frequency of electromagnetic interaction and the equivalent to it limit velocity of the matter are zero. And it is on the basis of the condition of equality of the velocity of light to the constant  $c$  that the metric of the intrinsic space of matter moving at any velocity is formed. Therefore, the entire infinite fundamental space of the CFREU, in which the value of the velocity of light is evolutionary decreasing, is limited by a pseudo-horizon of events (of the infinitely distant cosmological past) in the FR of matter.

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$$g = \frac{dv}{dt} = \frac{1}{2\sqrt{a_c}} \frac{dv^2}{dr} \approx \frac{c^2}{2} \left( \frac{db_c}{dr} - \frac{r_g}{r^2} \right) = -\frac{GM}{r^2} \quad \left( \frac{db_c}{dr} = 0 \right),$$

where:  $G = G_0 / b$ ;  $R = r / \sqrt{a_c} \approx r \sqrt{b_c}$  is radial coordinate in the background Euclidean space [3] of CFREU, which under the condition of hypothetical emptiness of space ( $b_c a_c = 1$ ) takes a zero value  $R_h = 0$  on singular surfaces ( $b_c = b = 0$ ).

And therefore, in the absence of complete compensation of the further gravitational dilation of time by the kinematic acceleration of the flow of time ( $db_c/dr \neq 0$ ), the gravitational acceleration of a freely falling body will not correspond to reality. Therefore, ignoring the invariance of the time dilation of matter moving by inertia in a gravitational field, based on the imaginary relativistic dilation of proper time of matter, is unacceptable. From the same condition follows the necessity of using the logarithmic gravitational potential and the identity of the inertial mass  $m_{in} = m_{00} v_{lc} / c = m_{00} \sqrt{b_c}$  to the gravitational mass  $m_{gr} = m_{00} c / v_{lc} = m_{00} / \sqrt{b_c}$  only according to the proper gravity-quantum clock of matter ( $v_{lci} = c$ ) [1, 2, 4, 6, 8], and the spatial and thus temporal dependence (on the parameter  $b_c = b + v_x^2 c^{-2}$ ) of the gravitational "constant"  $G = G_0 m_{gr} / m_{in} = G_0 / b_c \neq \text{const}(r)$  [1, 2, 4], the instability of which in time was predicted by Dirac [9].

The discovery of new relativistic transformations of increments of spatial coordinates and time that comply with Newton's and Kepler's laws is similar to the discovery (by Ott [10] and Arzelies [11]) of the possibility of an alternative relativistic interpretation of thermodynamics, which finally confirmed the relativistic invariance of thermodynamics.

### Conclusion

The gravitational field is a spatial distribution of the relative frequency of electromagnetic interaction between micro-objects of a motionless matter and the equivalent limit velocity of motion of a real or hypothetical matter that could be conditionally at rest at a certain point in space. The vacuum velocity of light is the same at all points of the gravitational field and is equal to the constant  $c$  even on singular surfaces on which the relative frequency of electromagnetic interaction and the equivalent to it limit velocity of the matter are zero. And it is on the basis of the condition of equality of the velocity of light to the constant  $c$  that the metric of the intrinsic space of matter moving at any velocity is formed. Therefore, the entire infinite fundamental space of the CFREU, in which the value of the velocity of light is evolutionary decreasing, is limited by a pseudo-horizon of events (of the infinitely distant cosmological past) in the FR of matter.

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