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Alternatives to the Hamiltonian and Lagrangian

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Abstract
The feasibility of using in physics of relativistically invariant Newtonians of the free inertial rest energy of matter and Keplerians of the ordinary rest energy of matter, respectively, instead of relativistically non-invariant Hamiltonians and Lagrangians, has been shown. And this is in good agreement not only with relativistically invariant thermodynamics, but also with the equations of the dynamic gravitational field of both the Solar System and flat galaxies.

1. Introduction

Relativistic invariance of thermodynamics indicates the fundamental impossibility of slowing down of the rate of intrinsic time of the matter that moves by inertia in surrounding gravitational field at any speed. And it is the mistaken consideration in Etherington's identity of the unrealistic dilation of the own time of distant galaxies that led to the mistaken refutation of the invariance in time of the fundamental Hubble constant H_E [1-13]. After all, it is the fundamental invariance in time of the Hubble constant that ensures the continuity of the spatial continuum in rigid frames of references of spatial coordinates and time (FR). In addition, this led to the mistaken need for a dark energy Universe [14]. So, the simple Lorentz transformations (and not the more general conform-Lorentz transformations of the increments of spatial coordinates and time are not inherent in the motion of matter by inertia in the gravitational field, provided that its motion is described using Hamiltonians and Lagrangians [4,6,15]. They are inherent only in the uniform motion of matter and, first of all, in the process of evolutionary self-contraction of its microobjects in comoving with expanding Universe FR (CFREU). However, simple Lorentz transformations of increments of spatial coordinate and time can still ensure the absence of dilation of proper time of matter moving in a gravitational field by inertia. But this can only be the case if its motion is described using Newtonians [GT-Hamiltonians] and Keplerians [GT-Lagrangians] [16]. But they (like Hamiltonians and Lagrangians) also require taking into account the presence of not only gravitational pseudo-forces, but also pseudo-forces of evolutionary self-contraction of matter to the center of gravity [16]. It was these pseudo-forces that could have caused the anomalous motion of the "Pioneer" spacecraft, which was at the edge of the Solar System [17-19].

2. The Feasibility of Using Newtonians and Keplerians

In the Relativistic Gravithermodynamics (RGTD), unlike General Relativities (GR), bodies that move by inertia in a gravitational field, influence (by their movement) the configuration of the dynamic gravitational field surrounding them [4,6,16]. At the same time, in equilibrium processes, along with the usage of ordinary Hamiltonians H and Lagrangians L, in RGTD (which is just an improved version of the GR) it is also advisable to use Newtonians N and Keplerians K [16]. Therefore, in RGTD for matter that cools quasi-equilibrially the Hamiltonian (or Newtonian) four-momentum is formed not by the Hamiltonian of enthalpy, but by the Hamiltonian (or Newtonian) of the inert free rest energy $E_0 = m_{00} c v_l$, and Lagrangian (or Keplerian) four-momentum is formed by the Lagrangian (or Keplerian) of ordinary rest energy $W_0 = m_{00} c^3 / v_l$ (multiplicative component of thermodynamic Gibbs free energy) of matter of astronomical object.

The Keplerian [GT-Lagrangian] of the ordinary rest energy of the matter:

$$\mathrm{K} = W_0 c / v_{lc} = m_{gr0} c^2 (1 + v^2 v_l^{-2})^{-1/2} =$$
$$= m_{gr} c^2 = m_{00} c^3 / v_{lc} = \mathrm{N} / b (1 + v^2 v_l^{-2}) = \mathrm{N} / b_c$$

forms the four-momentum not with the Newtonian [GT-Hamiltonian] momentum:

$$\mathbf{P}_{\mathrm{N}} = m_{in0} c^2 v_l^{-2} v = m_{00} c v / v_l ,$$

but with the Keplerian [GT-Lagrangian] momentum:

$$\mathbf{P}_K = m_{gr0} v(1+v^2 v_l^{-2})^{-1/2} = m_{00} vc / v_{lc} = $$
$$= m_{00} vc(v_l^2 + v^2)^{-1/2} = m_{00} \hat{v} ,$$

where: $\mathrm{N} = E_0 v_{lc} / c = m_{in} c^2 = m_{00} c\sqrt{v_l^2 + v^2}$,

$$E_0^2 = \mathrm{N}^2 - v_l^2 \mathbf{P}_N^2 = m_{00}^2 c^2 v_l^2 = m_{in0}^2 c^4 ,$$
$$W_0^2 = \mathrm{K}^2 + c^4 v_l^{-2} \mathbf{P}_K^2 = m_{00}^2 c^6 v_l^{-2} /(1+v^2 v_l^{-2}) +$$
$$+ m_{00}^2 c^6 v_l^{-4} v^2 /(1+v^2 v_l^{-2}) = m_{00}^2 c^6 v_l^{-2} = m_{gr0}^2 c^4 ,$$
$$\hat{v} = v b_c^{-1/2} = vc / v_{lc} = vc / v_l \hat{\Gamma}_c ,$$
$$\hat{\Gamma}_c = (1+v^2 v_l^{-2})^{1/2} ,$$
$$v_{lc}^2 = b_c c^2 = bc^2 + v^2 = v_l^2 + v^2 = \mathbf{const}(t) ;$$
$$b_c = b\hat{\Gamma}_c^2 = (v_l^2 + v^2) c^{-2} = b + v^2 c^{-2} = v_{lc}^2 c^{-2}$$

is the parameter that strictly corresponds to a certain spatially inhomogeneous collective thermodynamic state of matter and whose invariance during its inertial motion in a gravitational field ensures the conservation of both the Newtonian of its inert free energy of rest E_0 and the Keplerian of its ordinary energy of rest W_0; v_l is the maximum possible (limit) velocity of collective motion of all gravithermodynamically bound matter, which is equivalent to the coordinate pseudo-vacuum velocity of light of the GR; m_{00}, and $m_{in} = m_{in0}(1+v^2 v_l^{-2})^{1/2} = m_{00} v_{lc} / c$ are $m_{gr} = m_{gr0}(1+v^2 v_l^{-2})^{-1/2} = m_{00} c / v_{lc}$ the ordinary, inertial and gravitational masses of matter respectively.

And therefore, the condition of quasi-equilibrium precisely in the dynamic gravitational field of the galaxy of all its objects moving by inertia leads to both the absence of relativistic dilation of their intrinsic time t and the invariance of their intrinsic time with respect to relativistic transformations [4–6,15].

$$(ds_c)^2 = v_{lc}^2 (dt)^2 - (d\hat{x})^2 - (d\hat{y})^2 - (d\hat{z})^2 =$$
$$= (bc^2 + v^2)(dt)^2 - (d\hat{l})^2 = bc^2 (dt)^2 = \mathbf{invar} .$$

Here: $(ds_c)^2 = bc^2 (dt)^2 \neq \mathbf{const}(r)$ is the square of the increment of the relativistic interval; $d\hat{l} = vdt = \sqrt{(d\hat{x})^2 + (d\hat{y})^2 + (d\hat{z})^2}$, $d\hat{x} = v_x dt$, $d\hat{y} = v_y dt$, $d\hat{z} = v_z dt$ are increments of metric segments, not increments of coordinates; $b_c c^2 (dt)^2 = \mathbf{const}(r)$.

And thus, only Newtonians [GT-Hamiltonians] and Keplerians [GT-Lagrangians] (and not the alternative Hamiltonians and Lagrangians) of astronomical objects moving by inertia in the surrounding gravitational field can strictly correspond to the standard Special Relativity (SR).

The spatial homogeneity of the rate of intrinsic time in entire gravithermodynamically bound matter is consistent with the single frequency of change of its collective spatially inhomogeneous Gibbs microstates, which is not affected by either a decrease (during approaching gravity center) in the frequency of intranuclear interaction or an increase (during approaching gravity center) in the frequency of extranuclear intermolecular interactions. Moreover, this is ensured even without conformal transformations of the space-time interval s. Therefore, like the parameters v_l, v_{lc}, b and Γ_m in thermodynamics, the parameter b_c in the RGTD is a hidden internal parameters of the moving matter [4-6]. And the usage of this parameter in the equations of the dynamic gravitational field of the RGTD allows us not to additionally use the velocity of matter in those equations, as well as in the equations of thermodynamics.

3. Correspondence to Reality of the Newtonian of Inert Free Energy and the Keplerian of Ordinary Energy

A similar dependence of the parameter vlcg on the motion velocity vg also occurs for distant galaxies that are in the state of free fall onto the event pseudo-horizon of the expanding Universe: $v_{lcg}^2 \equiv c^2 = v_{lg}^2 + v_g^2$. After all, according to Hubble's law and the Schwarzschild solution of the gravitational field equations with a non-zero value of the cosmological constant $\Lambda = 3H_E^2 c^{-2}$ and a zero value of the gravitational radius:

$$v_{lg}^2 = c^2 (1 - \Lambda r^2 / 3) = c^2 - H_E^2 r^2 = c^2 - v_g^2 .$$

And for planets that move only by inertia around stars this dependence $v_{lc}^2 = v_l^2 + v^2 = \mathbf{const}(t, r)$ also works.

After all, according to Kepler's laws, which are actually based on Newton's theory of gravity, it is not Hamiltonians and Lagrangians that are conserved in the process of planetary motion, but rather Newtonians of inert free rest energy:

$$\mathrm{N} = E_0 v_{lc} / c = m_{00} c v_{lc} = m_{00} c\sqrt{v_l^2 + v^2} \approx$$
$$\approx m_{00} c^2 \sqrt{1 - r_g /(r_1 + r_2)} = \mathbf{const}(t, r)$$

and Keplerians of ordinary rest energy:

$$\mathrm{K} = W_0 c / v_{lc} = m_{00} c^3 / v_{lc} = m_{00} c^3 / \sqrt{v_l^2 + v^2} \approx$$
$$\approx m_{00} c^2 / \sqrt{1 - r_g /(r_1 + r_2)} = \mathbf{const}(t, r)$$

of the planetary matter. Here r_1 and r_2 are the radii of the planet's elliptical orbit at aphelion and perihelion, respectively, and r_g is the gravitational radius of the Sun.

At the same time, since:

$$b_c = v_{lc}^2 c^{-2} = b + v^2 c^{-2} = 1 - r_g / r + v^2 c^{-2} =$$
$$= 1 - r_g /(r_1 + r_2) = \mathbf{const}(t, r),$$

the squares of the real velocities $v^2 \approx c^2 r_g [1/r - 1/(r_1 + r_2)]$ of the planets significantly differ from their gravitational values:

$$v_{gr}^2 = (c^2 r \sqrt{ab} / 2) d \ln b / d\hat{r} =$$
$$= (c^2 / \sqrt{b})(r_g / 2r - \Lambda r^2 / 3).$$

which allow to compensate for centrifugal pseudo-forces of inertia only with gravitational pseudo-forces. And therefore, the centrifugal pseudo-forces of inertia indeed compensate not only for gravitational pseudo-forces, but also for the pseudo-forces of evolutionary self-contraction of matter in the CFREU, which force planets to move in the observer's NE not in circular, but in elliptical orbits:

$$\mathbf{F}_{ev} \approx \frac{m_{00} c^2}{r\sqrt{ab}} \left[\frac{1}{\sqrt{b}} \left(\frac{r_g}{2r} - \frac{\Lambda r^2}{3} \right) - r_g \left(\frac{1}{r} - \frac{1}{r_1 + r_2} \right) \right] =$$
$$= \frac{m_{00}}{r\sqrt{ab}} (v_{gr}^2 - v^2) \approx \frac{m_{00} c^2 r_g (2r - r_1 - r_2)}{2r^2 (r_1 + r_2)}.$$

These pseudo-forces act in such a way that at perihelion the Sun is a little closer to the planet, and at aphelion, on the contrary, a little further from the planet:

$$\mathbf{F}_{ev(aph)} \approx \frac{m_{00} c^2 r_g \varepsilon}{2 r_1^2} = \frac{m_{00} c^2 r_g}{2 r_1^2} \left(\frac{r_1 - r_2}{r_1 + r_2} \right) =$$
$$= \frac{m_{00}}{r_1} \left(\frac{c^2 r_g}{2 r_1} - v_1^2 \right),$$
$$\mathbf{F}_{ev(per)} \approx -\frac{m_{00} c^2 r_g \varepsilon}{2 r_2^2} = -\frac{m_{00} c^2 r_g}{2 r_2^2} \left(\frac{r_1 - r_2}{r_1 + r_2} \right) =$$
$$= \frac{m_{00}}{r_2} \left(\frac{c^2 r_g}{2 r_2} - v_2^2 \right).$$

Since the compensation of the gravitational and evolutionary pseudo-forces by centrifugal pseudo-forces of inertia occurs only at the aphelions and perihelions of planets, for all planets and other independent objects we obtain a single dependence of the pseudo-forces of evolutionary self-contraction of all matter of the Solar System to its center on the radial distance to the center and on the velocities of orbital motion at aphelions and perihelions:

$$\mathbf{F}_{ev} = -(\mathbf{F}_{gr} + \mathbf{F}_{in}) \approx m_{00} c^2 \left(\frac{r_g}{2r^2} - \frac{2\Lambda r}{3} - \frac{v^2}{c^2 r} \right).$$

The values of the velocities of orbital motion of independent objects of the Solar System at aphelions and perihelions are determined by the initial conditions of their inclusion in the Solar System.

Based on the identity of both the values of the Newtonians and the Keplerians, and the values of angular momentum ($v_2 r_2 = v_1 r_1$) at aphelion and perihelion of the planet:

$$b_c = v_{lc}^2 c^{-2} \approx (1 - r_g / r_2) + v_1^2 r_1^2 r_2^{-2} c^{-2} =$$
$$= (1 - r_g / r_2) + v_2^2 c^{-2} \approx (1 - r_g / r_1) + v_1^2 c^{-2},$$

we can find the gravitational radius of the Sun:

$$r_g \approx \frac{v_1^2 r_1 (r_1 + r_2)}{c^2 r_2} = \frac{v_2^2 r_2 (r_1 + r_2)}{c^2 r_1}.$$

Table 1 shows exactly those known approximate values of the orbital parameters and velocities at aphelion of various planets that allowed us to obtain calculated values of the Sun's gravitational radius with the smallest deviation from its most probable actual value.

Planet	r_1 **mln. km**	r_2 **mln. km**	v_1 **km/s**	r_g **km**
Mercury	69.82	45.90	38.85	2.96
Venus	108.94	107.48	34.78	2.95
Earth	152.09	147.10	29.29	2.95
Mars	249.23	206.60	21.98	2.96
Jupiter	816.62	740.52	12.44	2.96
Saturn	1505.4	1353.6	9.10	2.93
Uranus	3006	2740	6.50	2.96
Neptune	4537	4456	5.39	2.96
Pluto	7375	4437	3.68	2.96

Table 1: Parameters of planets and the Sun

This table shows that the calculated values of the Sun's gravitational radius are almost identical.

And this takes place despite the neglect (in the calculations) of the presence of both a slight evolutionary weakening (Λ-reduction) of centrifugal pseudo-forces of inertia, and the influence of planets on each other. And this confirms not only the correspondence of Newtonians and Keplerians to these planets, but also the absence of relativistic time dilation in them.

Table 2 shows the calculated values of the planetary parameters for the orbital radii of the planets indicated in Table 1 and for the gravitational radius of the Sun r_g = 2.96 km.

Planet	v_1 km/s	v_2 km/s	ε	(1-b_c) x10^{10}
Mercury	38.88	59.14	0.2067	255.9
Venus	34.83	35.30	0.0067	136.7
Earth	29.33	30.32	0.0167	98.92
Mars	22.00	26.54	0.0935	64.92
Jupiter	12.45	13.73	0.0489	19.00
Saturn	9.15	10.18	0.0531	10.35
Uranus	6.50	7.13	0.0463	5.15
Neptune	5.39	5.49	0.0091	3.29
Pluto	3.68	6.12	0.2487	2.51

Table 2: Theoretical Parameters of Planets

By clarifying both the value of the gravitational radius of the Sun and the values of the radii of the planets at aphelion and perihelion, it is possible to obtain corresponding to them more accurate values of the velocities of the planets.

4. The Effect of Evolutionary Docentric Pseudo-Forces on the Stars of Galaxytes

The Λ-reduced (evolutionarily weakened) centrifugal pseudo-force of inertia [16].

$$\mathbf{F}_{in} = m_{in}\hat{v}^2(1-\Lambda r^2)/r(1-\Lambda r^2/3) = \mathbf{F}_{in0} + \mathbf{F}_{inE} \approx$$
$$\approx m_{in}v^2/b_c r - 2m_{in}v^2 r/b_c v^2(r_c^2 - r^2)\,,$$

which "balances" (compensates) the gravitational pseudo-force in a rigid FR of matter, depends in GR and RGTD on the cosmological fundamental constant $\Lambda = 3H_E^2c^{-2} = \mathbf{const}(t)$ and, therefore, on the Hubble fundamental constant $H_E = \mathbf{const}(t)$. The fundamental invariance of these constants in the intrinsic time t of matter ensures the continuity of the intrinsic space of a rigid FR [4,6].

Here: $\mathbf{F}_{in0} = m_{in}v^2/b_c r$ is ordinary (unreduced) centrifugal pseudo-force of inertia;

$$\mathbf{F}_{inE} = -\frac{2\Lambda m_{in}\hat{v}^2 r}{3-\Lambda r^2} = -\frac{2H_E^2 m_{in}v^2 r}{b_c(c^2 - H_E^2 r^2)} \approx -\frac{2m_{00}v^2 r}{\sqrt{b_c}(r_c^2 - r^2)}$$

is centripetal evolutionary pseudo-force, which pushes matter towards the center of the galaxy, thereby compensating within the galaxy (when $r<\Lambda^{-1/2}$) the centrifugal gravitational pseudo-force, which is responsible for the evolutionary distancing of other galaxies from it according to Hubble's law; $r_c \approx c/H_E$ is the radius of the event pseudo-horizon, which covers the entire infinite fundamental space of the Universe in the FR of any matter due to the fundamentally unobservable in FR of people´s world evolutionary self-contraction (in fundamental space) of matter spiral-wave microobjects, which are the so-called elementary particles.

Therefore, astronomical objects in distant galaxies move in stationary, rather than divergent spiral orbits precisely due to the presence (in the observer's FR) of the action on them not only of gravitational, but also of evolutionary centripetal pseudo-force. And it is precisely this evolutionary centripetal pseudo-force that causes these same astronomical objects to move in convergent spiral orbits in the CFREU.

At the edge of the galaxy ($r \approx \Lambda^{-1/2}$), the excessively strong ordinary (unreduced) centrifugal pseudo-forces of inertia are compensated mainly by centripetal pseudo-forces of evolutionary self-contraction of matter in the fundamental (background [20]) Euclidean space of comoving with expanding Universe FR, and not by the weak gravitational pseudo-forces at the edge of the galaxy [16].

The dependence of Λ-reduced centrifugal pseudo-force of inertia exactly on the intrinsic value of the object's velocity $\hat{v} = vc/v_{lc} = v/\sqrt{b_c}$ actually compensates for the non-identity of its inertial mass $m_{in} = m_{gr}b_c$ to the much larger gravitational mass m_{gr} and thereby provides the possibility of using a single galactic value ${}^gG_{00}$ of the gravitational constant in the FR_g of the galaxy [16].

5. Conclusion

Only Newtonians [GT-Hamiltonians] and Keplerians [GT-Lagrangians] (and not the alternative Hamiltonians and Lagrangians) of astronomical objects moving by inertia in the surrounding gravitational field can strictly correspond to the standard SR.

When planets move in circular orbits, the relativistic dilation of their own time is fully compensated by the dynamic components of the gravitational field. When planets move in elliptical orbits, not only the relativistic, but also the gravitational dilation of their own time is fully compensated not only by the dynamic components of the gravitational field, but also by the evolutionary self-contraction of the planets towards the center of gravity. The same thing happens with the free fall of bodies in a gravitational field.

According to Kepler's laws, which are actually based on Newton's theory of gravity, it is not Hamiltonians and Lagrangians that are conserved in the process of planetary motion, but rather Newtonians of inert free rest energy and Keplerians of ordinary rest energy.

It is exactly Newtonians and Keplerians that can also explain the inertial motion of stars in the gravitational field of a galaxy [16].

The centrifugal pseudo-forces of inertia depend also on the cosmological fundamental constant $\Lambda = 3H_E^2c^{-2} = \mathbf{const}(t)$

and therefore on Hubble fundamental constant $H_E = \mathbf{const}(t)$, exactly the invariance of which in the intrinsic time t of matter ensures in principle the continuity of the spatial continuum of a rigid FR [6,8].

Not only the dynamic component of the gravitational field, but also the centripetal evolutionary self-contraction of stars towards the center of gravity of the galaxy provide full compensation for the relativistic dilation of their time even in case of the circular rotation of the stars relative to this center.

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Conflicts of Interest

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