Gravitational attraction until relativistic equipartition of internal and translational kinetic energies

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Abstract

Translational ordering of the internal kinematic chaos provides the Special Relativity referents for the geodesic motion of warm thermodynamical bodies. Taking identical mathematics, relativistic physics of the low speed transport of time-varying heat-energies differs from Newton's physics of steady masses without internal degrees of freedom. General Relativity predicts geodesic changes of the internal heat-energy variable under the free gravitational fall and the geodesic turn in the radial field center. Internal heat variations enable cyclic dynamics of decelerated falls and accelerated takeoffs of inertial matter and its structural self-organization. The coordinate speed of the ordered spatial motion takes maximum under the equipartition of relativistic internal and translational kinetic energies. Observable predictions are discussed for verification/falsification of the principle of equipartition as a new basic for the ordered motion and self-organization in external fields, including gravitational, electromagnetic, and thermal ones.

Keywords: Internal energy variable, GR principle of equipartition, Equilibrium proximity, Decelerated fall, Accelerated takeoff, Thermal propulsion

1 Introduction

Most scientists, starting in high school, are taught the erroneous notion that Einstein’s relativistic physics in weak fields should reproduce Newtonian physics (while not only identical mathematics) of the point constant mass for the slow motion with $v^2/c^2 \equiv \beta^2 \ll 1$. Despite the fact that Classical Mechanics does not know numerical failures “in the field of its applicability”, Newtonian mass ontology can not be true if real mechanical bodies have internal energy. Indeed, the Einstein inertial particle has the rest energy $M_0c^2$ (due to internal kinetic chaos), while the Newtonian mechanical body has no internal energy content. Different degrees of freedom divorce in principle Newton and Einstein approaches to low speed physics [1]. The weight and inertia stay the same after warming of bodies in the Newton theory, but not in the Einstein relativity. The goal of this paper is to criticize the constant mass notion and argue in favor of the internal heat-energy variable. We tend to comment quantitatively why “Einstein’s theory can be accepted only with the recognition that Newton’s was wrong” [2]. Today this still remains a minority view despite General Relativity (GR) is a metric theory for chaos-order transformations and structural self-organizations of extended matter, while Newton’s point mass dynamics can only describe quantitative changes in the inertial system.
The equal inertial and gravitational charges in Einstein’s physics are both defined by the full relativistic energy \( M_{\circ}c^2/\sqrt{\gamma_{oo}/\sqrt{1 - \beta^2}} \) ([3], for example). This energy counts thermal variations of the internal heat-energy of real thermodynamical bodies. The internal heat content, \( Q = Q_{\circ}\sqrt{1 - \beta^2} \), and the internal temperature, \( T = T_{\circ}\sqrt{1 - \beta^2} \), of a moving body obey the same law provided by a pupil of Laue [4]. This kinematic rule for heat-energy changes clarifies, for instance, why the quantum particle in wave mechanics carries its frequency as \( \bar{\hbar}\omega = \bar{\hbar}\omega_{\circ}\sqrt{1 - \beta^2} \).

The Laue–Mosengeil law originates, in general, from the Lorentz transformations and their time dilation mechanism in the Minkowski space–time. These fundamental transformations are not inherent in Newtonian dynamics. According to an observer who calculates relativistic energy balances, any inertial body with the rest energy \( M_{\circ}c^2 \) loses under the low speed transport some part of this internal energy, namely \( M_{\circ}c^2/\sqrt{1 - \beta^2} - M_{\circ}c^2 \approx -M_{\circ}v^2/2 \). This counterflow of internal heat-energy losses halves the kinetic energy of spatial translations \( vP = M_{\circ}c^2/\sqrt{1 - \beta^2} \approx M_{\circ}v^2 \approx M_{\circ}c^2 \) at low velocities, because \( (M_{\circ}v^2 - M_{\circ}v^2/2) = M_{\circ}v^2/2 \).

Again, the translational ordering of internal kinematic chaos decreases the internal heat-energy \( \sqrt{1 - \beta^2}M_{\circ}c^2 \). The similar energy content \( kM_{\circ}c^2 \) (with \( 1/2 \leq k \leq 1 \)) was smartly used by Nikolay Umov [4] since 1873. According to Umov, both heat and mechanical energy can form Newton mass flows. He considered energy perturbations in media the primary physical process which defines the corresponding transport of mass from known secondary relations. Contrary to the Umov vector analysis of primary energy flows, the Newton–Euler approach to ideal fluids is based on the scalar mass transport. Here, the balance of energies is derived from secondary relations. But what is the most correct way of describing the mechanical motion in reality?

The Lorentz transformations for the internal heat-energy \( M_{\circ}c^2 = (E - vP)/\sqrt{1 - \beta^2} \) and its zero 3-momentum \( (P - \beta E/c)/\sqrt{1 - \beta^2} = 0 \) reveal two physical parts, \( E = M_{\circ}c^2/\sqrt{1 - \beta^2} + vP \equiv M_{\circ}c^2/\sqrt{1 - \beta^2} + \beta^2E \), in the relativistic structure of the summary kinetic energy \( E = M_{\circ}c^2/\sqrt{1 - \beta^2} \). These inseparable parts have different kinematic origin. They can be colored under computations like inseparable quarks in their proton. The first part \( E_{\circ}\sqrt{1 - \beta^2} \) is the kinetic energy of internal chaotic motions or the internal heat variable of the moving particle. The second part \( M_{\circ}c^2\beta^2/\sqrt{1 - \beta^2} \) is the kinetic energy of ordered spatial translations of all chaotic densities of matter. In other words, the Hamilton form of energy in quantum mechanics, \( H = M_{\circ}c^2/\sqrt{1 - \beta^2} + vP \), obeys the same Lorentz split over internal and external degrees of freedom. It is not quite appropriate to consider the formal Newton model, which mixed independent degrees of freedom and halved the kinetic energy of ordered translations, as a correct physical theory even “in the field of its applicability”. Newton’s physics with only one degree of freedom for two (chaos and order) competing kinds of kinetic energy is unable to provide reliable referents for the relativistic motion and self-organization of real matter with the internal heat variable.
2 Inertia depends on heat contrary to Newton

In general, it is necessary to recognize the model defectiveness of Classical Mechanics with the point mass concept. Contrary to Newton, there is no need at all to trace the conservation and transport of scalar masses in the Einstein theory. The latter incorporates thermodynamics though the common balance of heat and mechanical energies. The time-dilation effect for moving internal energy is well tested due to multi-kilometer tracks of cosmic muons in the atmosphere. Because of the suitable notion of the internal heat variable, $Q(v^2) = Q_o \sqrt{1 - \beta^2} \neq \text{const}$, one could completely abandon the inertial mass notion $M_o = \text{const}$. The constant point mass is independent on variations of the body temperature and the body speed $v$. But mechanical inertia is an energy characteristic since it grows with the absorption of energy of “massless electromagnetic waves”. The traditional preservation of two competing notions (rest energy and mass) for the inertial charge of a real thermodynamic body inevitably leads to physical confusion at first, and then to incorrect mathematical models. Below we demonstrate the inability of the Newtonian theory of “cold” point masses to act as a true limit for Einstein’s General Relativity of inertial energies with the internal heat variable.

We define the full energy of an isolated (or remote from other field centers) particle at rest $M_o c^2 \equiv Q_o$ as its internal heat-energy $Q_o$ associated with the chaotic motion of elementary material densities. The latter can be Ricci metric densities of a continuously extended particle in a Cartesian material space or can be particle’s internal sub-elements (like point quarks) in the empty space alternative of Newton. The internal chaotic motion can correspond to Descartes mechanical vortexes which are shaping particular spatial structures of elementary matter. We admit an equilibrium internal state behind the heat-energy variable $Q(v^2) = Q_o \sqrt{1 - \beta^2}$ despite we associate this kinetic energy with internal relativistic heat or internal chaos. And this internal heat is independent from external fields. The full rest energy at the finite distance $R$ from the center of the radial gravitational field, $E_o(R) = Q_o \sqrt{g_{oo}(R)}$, is defined by both the internal heat $Q_o$ and the metric field contribution from $g_{oo}(r = R) = \text{const} < 1 = g_{oo}(r = \infty)$. The free gravitational fall in a constant radial field from the coordinate $R$, where $v^2(r = R) = 0$, will keep the initial relativistic energy $E(r, t) \equiv Q_o \sqrt{g_{oo}(r, t)} / \sqrt{1 - \beta^2(r, t)} = E_o(R)$ [3]. We decompose this probe body energy into three path-dependent parts

$$E(r, t) = \frac{Q_o \sqrt{g_{oo}(r, t)}}{\sqrt{1 - \beta^2(r, t)}} = Q_o \sqrt{1 - \beta^2(r, t)} \quad \text{[1]}$$

This full relativistic energy is proportional to the value of the total inertial (equal to gravitational) charge $q(r, t) \equiv E(r, t) / \varphi_o$ of the falling body (where $\varphi_o \equiv c^2 / \sqrt{G} = 1.04 \times 10^{27} \text{eB}$). Despite the full charge $q$ is constant in the constant
gravitational field, we will study (in the absence of rotations) its path dependent contributions from the internal heat-energy $Q(r[t]) \equiv Q_o \sqrt{1 - \beta^2(r[t])} > 0$ of the relativistic body, from the kinetic energy of ordered spatial translations $T(r[t]) \equiv vP = Q_o\beta^2(r[t])/\sqrt{1 - \beta^2(r[t])} > 0$ as a whole system, and from the negative potential shift $U(r[t]) \equiv -Q_o[1 - \sqrt{g_{oo}(r[t])}]/\sqrt{1 - \beta^2(r[t])} \leq 0$ in the external gravitational field, with $0 \leq g_{oo}(r[t]) \leq g_{oo}(R)$ and $r[t] \leq R$. Ernst Mach would probably approve our definition of charges, $q \equiv E/\varphi_o$, based on their full energy. Indeed, body’s inertia and gravitation depend on the distribution of all remote bodies through gravitational contributions to a purely mechanical part of the moving body energy, $M(r, t) \equiv T(r, t) + U(r, t) = E(r, t) - Q(r, t) = Q_o[\beta^2(r, t) - 1 + \sqrt{g_{oo}(r, t)}]/\sqrt{1 - \beta^2(r, t)}$. This mechanical part $M(r, t)$ is grouped in (1) inside the square brackets.

The summary kinetic energy of internal (chaotic) and translational (ordered) motions, $K(r, t) \equiv Q(r, t) + T(r, t) = Q_o/\sqrt{1 - \beta^2(r, t)}$, can be also traced in (1). This combination was implemented in Special Relativity only in favor of old referents of Newtonian dynamics. In other words, Special Relativity in its nonrelativistic limit was oriented to the Newtonian kinetic term $Q_o\beta^2/2$ for the net transport of internal and external energies. Contrary to its capabilities, Special Relativity did not recognize internal energy changes in moving thermodynamical bodies. Rapid path variations of the internal heat-energy $Q_o\sqrt{1 - \beta^2}$ reveal collinear counter changes of thermal (chaotic) and translation (ordered) energy flows of the point particle. The model dynamics of Newton’s cold masses should in no way serve as a non-relativistic referent for a continuous relativistic medium with heat-energy flows. These vectors in liquids and gases may have non-collinear options regarding to ordered translations of material densities. Instead of the Lorentz vector transport of two independent and competing energy flows, the Newton–Euler transport of the summary density amplitude (of these non-collinear vectors in continuous media) is declared nonphysically for the (constant) mass transfer along ordered translations, but never along heat exchanges.

3 Metric self-sufficiency of General Relativity with charges of heat-energy

The relevance of Newton’s theory should be revised not only for the slow dynamics of inertial energies with heat in Special Relativity, but also for the search of metric solutions of General Relativity through the Newtonian limit of weak fields. Indeed, the inhomogeneous metric component $g_{oo}(x)$ can be uniquely expressed from the most general balance $E(x) \equiv Q_o\sqrt{g_{oo}(x)}/\sqrt{1 - \beta^2(x)}$ and the universal ratio $U(x)/E(x) \leq 0$ of the negative gravitational contribution $U(x)$ to the full energy content $E(x) \equiv T(x) + U(x)$:

$$\sqrt{g_{oo}(x)} = [T(x) + U(x)] \frac{1 - \beta^2(x)}{Q_o}$$
\[ 1 + \frac{U(x)\sqrt{g_{oo}(x)}}{E(x)} \equiv \frac{1}{1 + (-U(x)/E(x))}. \]

(2)

On the basis of algebraic identities in relations (2), one can formulate the following \( g_{oo} \)-theorem: “The temporal metric component is defined by the gravitational potential \( \varphi(x) \equiv U(x)/E(x) \), with \(-\infty < \varphi(x) \leq 0\), strictly as \( g_{oo}(x) = 1/[1 - \varphi(x)]^2 \leq 1 \).” The static field potential \( U(x)/E(x) = -GE_2/c^4r \) of the large energy integral \( E_2 = \text{const} \gg E(x) \) matches the Newton gravitational potential in the weak field limit and corresponds to peculiarity free metric component \( g_{oo}(r) = (c^4r/(c^4r + GE_2))^2 \) in strong fields. Therefore, the empty space Schwarzschild metric [6] with \( g_{oo}(r) = (c^4r - 2GM_2)/c^2r \) for strong fields does not agree with (2) and with the Einstein–Infeld material fields [7,8] of inertial energies with internal heat. It is unjustifiable to equate the model gravitation of Newton’s cold and point masses in empty space to the Mach–Einstein gravitation of heat-energy variables in a Cartesian non-empty space.

Recall that in 1913 Einstein and Grossmann introduced a gravitational field only into the time section of the Minkowski space–time interval. They also preserved, without variants at that time, the point mass model or localized substance for comparison of relativistic and classical motions in gravitational fields [9]. After the November 1915 correspondence with Gilbert, Einstein had a tensor equation for metric gravitational fields. The space–time interval \( ds^2 = \sqrt{d\tau^2 - dl^2} \) became a combination of two warped sub-intervals, \( d\tau^2 \equiv g_{oo}[cdt + (g_{oi}dx^i/g_{oo})]^2 \) and \( dl^2 \equiv (g_{oo}g_{ij}g_{oo}^{-1/2} - g_{ij})dx^i dx^j \). In this case, the non-geometrized substance in the right hand side of the Einstein Equation [10] again allowed spatial localization and empty space regions in accordance with Newton’s referential presentations of localized inertial masses. But in 1938, Einstein criticized the duality of massive particles and massless fields. He pointed to the non-dual way in the relativistic physics of continuous carriers of energy [7]. After that, the author of General Relativity clearly characterized the Schwarzschild 4-interval with a singularity as “not related to physical reality” [11]. But where is the invisible revolution of new Einstein’s ideas of 1938–1939 after the first shocks of Newtonian gravity in 1913–1916?

4 The non-dual turn of 1938 from the dual gravitation of 1916

The Schwarzschild metric for curved emptiness was rejected for physical reality not only by Einstein. A curved 3-space in the metric solution of 1916 for a constant central field [6] could not suit many opponents. Sommerfeld, Schwinger, Feynman and many other physicists sought to preserve the Euclidean nature of electrodynamics, including its constant Gaussian flux through a two-dimensional closed surface and the strict Bohr–Sommerfeld quantization rule over a closed line contour. In the 1980s, Russian academician A. Logunov suggested the alternative theory of gravitation [12] by returning back to the Minkowski space–time
of 1908. This would return flat space to relativistic physics. According to Logunov, it would eliminate nonphysical black holes in strong fields and would lead to a cyclical state of matter with high and low densities.

Logunov’s program goals should be welcomed, especially since Einstein himself tried to improve the relativistic theory. However, Einstein understood that consistent classical mechanics should be constructed, like quantum mechanics of the spatially distributed particle, in non-dual terms of extended energy densities: “Matter is where the concentration of energy is great, field is where the concentration of energy is small. But if this is the case, then the difference between matter and field is a quantitative rather than a qualitative one. There is no sense in regarding matter and field as two qualities quite different from each other. We cannot imagine a definite surface separating distinctly field and matter.”

The non-dual theory of energy densities can not be transformed into a dual one because of the transition from high concentrations of matter to low. It is unreasonable to expect that non-dual objects in physics of the microworld will begin to change into dual ones due to scaling of space or speed values. The model separation of the continuous energy macrocosm into an allegedly localized substance within weak fields can be explained by the local quantitative observations of nonlocal reality. But any observations can not be justified as true solely with the means of a mathematically correct theory. In 1938, Einstein proposed not to return back to the sum of three main concepts, space–time plus field plus matter, as Logunov chose instead of two main concepts of 1916 (space–time-field plus substance). Contrary to Logunov, Einstein proposed to go ahead and to diminish the number of main physical concepts to one. He qualitatively integrated the continuous density of the extended elementary particle into a united space–time-field-substance. This revolutionary proposal was not accompanied at that time by new formulas and verifiable predictions. But Einstein immediately warned from the non-dual theory of pure fields that a continuous particle must disappear from the auxiliary right-hand side of his 1915 tensor equation. Today everyone can check that the self-sufficient GR interval with \( g_{oo}(r) = r^2/(r+r_0)^2 \) admits 6 inherent metric symmetries for the Euclidean spatial section, \( dl^2 = \delta_{ij}dx^idx^j \), and for the vanishing Einstein curvature \( G_{oo} = 0 \) of the static material field. The static curvature nullification corresponds to the static Einstein Equation, \( R_{oo} = g_{oo}R/2 \neq 0 \). The extended particle belongs to the field part of the Einstein Equation rather than to its right hand side.

5 Turning traffic in the static gravitational center

To predict new testable effects in the Descartes paradigm of the nonempty space of extended energy-charges, it is necessary to firmly reject the Newtonian referents from the point mass physics. It is sufficient to assume that the
relativistic rest energy $E_o$ has the pure kinetic nature due to internal motions of metric material densities within the extended (non-point) elementary particle. Then, the remote probe body at rest will have in (1) a maximum of its internal (kinetic) heat-energy $E(\infty) = Q_o$ under zero mechanical energy: $M(\infty) = T(\infty) + U(\infty) = 0$, with $T(\infty) = U(\infty) = 0$. At any final removal of $R$ from the static gravitational center, the probe body at rest (when $\beta(R) = 0$ and $T(R) = 0$) possesses the diminished full energy $Q_o \sqrt{g_{oo}(R)}$ but the same internal heat-energy $Q_o(r) = Q_o = \text{const}$. The point is that the body ‘gained’ a negative potential energy $M(R) = U(R) = -Q_o[\sqrt{g_{oo}(\infty)} - \sqrt{g_{oo}(R)}] < 0$.

The initial rest energy of the thermodynamic probe body, $Q_o + M(R) = Q_o \sqrt{g_{oo}(R)} \equiv E_o(R) > 0$, stays positive in strong gravitational fields apart from their center, $g_{oo}(0) = 0$. Without the external gravitational potential or other external stimulation, the chaotic equilibrium state of probe matter does not have energy reasons for further spatial self-ordering. Indeed, the positive rate of translational energy changes under spatial self-accelerations cannot be balanced in (1) by the negative rate of internal heat changes only, $\delta[K(v^2) + Q(v^2)] \neq 0$. For the ordered spatial motion with the growth of $v^2$, interacting mechanical bodies have to create mutual gravitational potentials and relevant conditions for mutual rotations.

Let us return to the free fall from a fixed height $R$ on a heavy static center with a large energy $E_2 \gg E_o(R)$. The constant field of this gravitational center keeps the initial energy $E_o = Q_o \sqrt{g_{oo}(R)}$ of the falling thermodynamical body, $E(r[t]) = Q_o \sqrt{g_{oo}(r)/[1 - \beta^2(r)]} = Q_o \sqrt{g_{oo}(R)}$ for $0 \leq r[t] \leq R$. Such a GR energy conservation allows to associate $g_{oo}(r)$ with the relativistic physical speed $v(r) \equiv c dr/dt = dv/dt \sqrt{g_{oo}(r)}$, where $0 \leq v^2(r) < c^2$, as well as with the coordinate speed $dr/dt$. The latter can be measured in practice by a remote observer with the available clock rate $dt \equiv dx^o/c$. Again, we start computations from the known GR equation, $Q_o \sqrt{g_{oo}(r)}/\sqrt{1 - \beta^2(r)} = Q_o \sqrt{g_{oo}(R)}$, for the relativistic energy conservation under radial incidence of a probe charge-energy $Q_o/\varphi_o$ in a constant radial field. This equation reads for the coordinate speed $dr/dt$ as to associate $g_{oo}(r)$ with the relativistic physical speed $v(r) \equiv c dr/dt = dv/dt \sqrt{g_{oo}(r)}$, where $0 \leq v^2(r) < c^2$, as well as with the coordinate speed $dr/dt$. The latter can be measured in practice by a remote observer with the available clock rate $dt \equiv dx^o/c$. Again, we start computations from the known GR equation, $Q_o \sqrt{g_{oo}(r)}/\sqrt{1 - \beta^2(r)} = Q_o \sqrt{g_{oo}(R)}$, for the relativistic energy conservation under radial incidence of a probe charge-energy $Q_o/\varphi_o$ in a constant radial field. This equation reads for the coordinate speed $dr/dt$ as

$$\frac{g_{oo}(r)}{g_{oo}(R)} = 1 - \frac{v^2(r)}{c^2} = 1 - \frac{1}{g_{oo}(r)c^2} \left(\frac{dr}{dt}\right)^2.$$ (3)

Taking into account both directions of the radial motion, the second equality in the strong field equation (3) can be rewritten for the coordinate velocity in
an equivalent form with the introduction of a unit vector $\hat{r} \equiv r/r$:

$$\frac{d\hat{r}}{dt} = \pm \hat{r} c \sqrt{\frac{g_{\infty}(R)}{g_{\infty}(r)}} \left[ 1 - \frac{g_{\infty}(r)}{g_{\infty}(R)} \right].$$  \hspace{1cm} (4)

It turns out from this universal relation of General Relativity that from the viewpoint of the remote observer the body first dials the coordinate speed, $0 \rightarrow d\hat{r}/dt \rightarrow -\hat{r} c \sqrt{g_{\infty}(R)/2}$, in the region of the moderate fields $g_{\infty}(R) \geq g_{\infty}(r \rightarrow r_{eq}) \rightarrow g_{\infty}(R)/2$. Then, with further growth of the field as the probe body moves toward the center in the region $g_{\infty}(R)/2 \geq g_{\infty}(r \rightarrow 0) \rightarrow 0$, this body begins to decelerate to a zero coordinate speed, $-\hat{r} c \sqrt{g_{\infty}(R)/2} \rightarrow d\hat{r}/dt \rightarrow 0$. In this case, the magnitude of the physical speed $v(r \rightarrow 0) = |d\hat{r}/\sqrt{g_{\infty}(r)}|dt \rightarrow c$, the coordinate speed diminishes to zero at the center, $d\hat{r}/dt \rightarrow 0$, where the probe body with completely ordered kinetic energy temporarily stops before the start of its reverse takeoff.

After an unstable stop in the extreme nonequilibrium state with $r = 0$, $Q(0) = 0$, $M(0) = K(0) = U(0) = Q_{\infty}\sqrt{g_{\infty}(R)} = E_0$ in the very center of the radial gravitational field, the probe body starts the reverse accelerated motion toward the equilibrium radial proximity at $r_{eq}(R) < R$. After passing through the equilibrium proximity from the center, $r[t] = r_{eq}(R)$, the probe body continues to increase its vertical height and the internal chaotic energy $Q(v^2[r,t])$. Ultimately, the body returns with Newtonian deceleration to the height $R$, where it stops in the initial nonequilibrium state with the same full energy $E_0 = Q_{\infty}\sqrt{g_{\infty}(R)}$, $Q = Q_{\infty}$, $K(R) = 0$, and $U(R) = -Q_{\infty}[1 - \sqrt{g_{\infty}(R)}]$.

In order to find the observable (coordinate) acceleration of the probe body on the entire trajectory of the free gravitational fall and the reverse takeoff, it is sufficient to differentiate the coordinate velocity (4) over the world (coordinate) time $t = x^0/c$ and to use the regular computation rule $dg_{\infty}(r[t])/dt = (dg_{\infty}/dr)dr[t]/dt$:

$$\frac{d^2\hat{r}[t]}{dt^2} = \hat{r} c^2 \left( \frac{1}{2} \frac{g_{\infty}(r)}{g_{\infty}(R)} \right) \frac{dg_{\infty}(r)}{dr} \hspace{1cm} (5)$$

$$\Rightarrow \begin{cases} \frac{-1}{2} \frac{4r_a}{r} \hat{r} \frac{c^2 r_a}{r^2} \hat{r} & g_{\infty}^{1916} = 1 - \frac{2r_a}{r^2} \\ \frac{-c^2 r_a (r^2 - 2r_a)}{(r + r_a)^2} & g_{\infty}^{2008} = \frac{r^2}{(r + r_a)^2}. \end{cases} \hspace{1cm} (6)$$

We considered the gravitational fall from the infinity in (6), where $R \Rightarrow \infty$, $g_{\infty}(\infty) = 1$, and $g_{\infty}(r_{eq}) = 1/2$. And we employed in (6) both the Schwarzschild metric of 1916 for the empty space around a point source and the metric solution $g_{\infty} = r^2/(r + r_a)^2$ from the algebraic identity (2) with $U/E = -r_a/r$ and
$r_o \equiv GE_2/c^4$ [1]. In both cases, the Newtonian acceleration by the weak field, $-c^2 r_o r/r^3$, smoothly changes the sign for the deceleration at $r > 2r_o$, i.e. above the supposed black hole horizon in conventional dual physics with empty space.

The equilibrium radial level $r_{eq}(R)$ (at which the coordinate acceleration (5) vanishes for the most general case of metric relations $g_{oo}(r_{eq}) = g_{oo}(R)/2$) depends on the initial height $R$ of the radial fall. However, the physical speed parameter $\beta_{eq}^2 = 1/2$ is universal for all equilibrium levels $r_{eq}(R)$ as can be found from the GR equations (3). The derived relation $v_{eq}^2 = c^2/2$ for each and all particles on cyclic geodesic falls-takeoffs maintains the exact equipartition of disordered (internal) and ordered (translational) kinetic energies,

$$Q(r_{eq}) \equiv Q_o \sqrt{1 - \beta_{eq}^2} = \frac{Q_o \beta_{eq}^2}{\sqrt{1 - \beta_{eq}^2}} \equiv T(r_{eq}),$$

at all zero acceleration spheres of radii $r_{eq}(R)$ around the strong field center.

The Newton gravitational fall turns out to be in General Relativity a universal tendency of a rest energy particle toward the equipartition of its disordered and ordered kinetic energies. This universal tendency of each elementary particle to distribute the relativistic kinetic energy equally over internal and external degrees of freedom can be formulated as the GR principle of equipartition. It stands behind the universal capacity of elementary matter to reorganize its internal heat-energy in the environment of external fields. Recall that there are no internal degrees of freedom in Newton’s physics which can employ gravitation only for quantitative changes of mechanical values rather than for qualitative creations of new spatial structures of energies due to chaos-order transformations. Newtonian mass without the internal heat variable would never return back from the strong field region. There are no clear options for the structural evolution of matter in Newtonian reductionism with degenerated energy degrees of freedom. Therefore, Newton’s dynamics maintains only the growth of entropy up to the thermal death. General Relativity maintains both dynamical and structural changes in the chaos vs order balances. The new kinematic tendency of the internal heat-energy to the dynamical equipartition with the ordered kinetic energy allows to accept Einstein’s theory “with the recognition that Newton’s (gravitation and mechanics) was wrong” [2].

6 Conclusions on verifiable predictions

The internal heat variable is important to take into account in mechanics of liquids and gases even for non-relativistic laboratory flows. Contrary to the collinear transport of internal and translational energies in one elementary particle, heat transfer in multiparticle media can not always be directed along the vector of ordered translations. Despite Umov’s vector transport and join conservation of heat and translational flows of energies in tensor thermomechanics [5], Newtonian proponents of the scalar mass transfer still maintain the homogeneous pressure in the radial section of the fully developed laminar flow of liquid
in rectilinear pipes [13]. It is not surprising that they register often unexpected (for them) extra heat and pressure on side boundaries of hydrodynamical energy devices like Ranque–Hilsch vortex tubes, De Laval and Francis turbines, jet engines, etc. But it is surprising that they do not associate turbulence with the kinematic tendency of media to new forms of equilibrium structural organizations under external impacts.

So far we neglected, for simplicity, all wave exchanges of a probe thermodynamic body with third bodies (or with the world thermostat) under the considered free fall with the Laue–Mosengeil cooling of initial thermal energy. But in such an adiabatic approximation, the geodesic decrease in the internal energy variable (due to the increase in the translation energy) must be accompanied by a decrease in temperature and a change in the Stefan–Boltzmann radiation from the cooling body under consideration. Therefore, the interpretation of gravitational events through the internal energy variable can suggest a kinematic self-cooling/self-warming mechanism for geodesically moving asteroids or comets. This thermal geodesic mechanism predicts, for example, rapid heat changes and volcanic activities for small satellites of large planets due to sharp decelerations in the inertial system of distant stars (related nowadays to the cosmic microwave background).

If the kinematic tendency to the energy equipartition between chaos and order is the fundamental property of the mechanical motion, then this tendency should stay behind all spatial accelerations toward new equilibrium states under any renovations of external fields. Any constant dimensionless field $\Theta(r)$, which can change in (1) the initial rest energy, $Q_o \Theta(R) \neq Q_o$, like in $E_o(R) \equiv Q_o \sqrt{g_{oo}(R)}$ for gravitation, could result in a propulsion similar to an accelerated motion in the metric field $g_{oo}(r, t)$. Such an external field can be modeled both from the electric Coulomb potential and from heat exchangers with distributed external sources/absorbers of thermal energy. The external thermal potential can deliver its contribution to the internal energy of the probe body quite rapidly under ideal (very fast) exchanges. Any inertial body at rest tends to drop excess of its internal thermal energy to low temperature bodies and tends to avoid thermal energy from high temperature bodies. In a relevant thought experiment, a small probe body at rest should start to move toward lower thermal potentials like in the case of lower gravitational potentials. For example, the bullet in the barrel without friction should move toward the cold end in tensor thermomechanics for Umov’s energy flows. Such kind of experiments, say on the International Space Station, can maintain or falsify the GR principle of kinetic energy equipartition behind the free spatial motion of matter and its structural self-organizations. The thermal propulsion by the warmed material space in question could be also studied for moving bodies on almost frictionless equipotential surfaces with hot (sunny) and cold (shadow) areas. Tensor thermomechanics of non-empty space might assist to find proper energy approaches to ‘the sailing stones’ at Racetrack Playa, California.

The point mass physics is to be replaced by internal energy physics in many relativistic phenomena as well. The Einstein gravitational theory of 1916 with Newtonian referents for the Schwarzschild metric of strong static fields predicts
the presence of the gravitational horizon at distances $r = 2r_o \equiv 2GE_2/c^4$ before the center of the gravitational charge $E_2/\varphi_o$. However, the similar metric solution of General Relativity in the 1938 Einstein—Infeld paradigm of material fields predicts the smooth decrease of $g_{oo}(r)$ and the observable radial fall/takeoff of probe bodies with internal heat up to $r = 0$. Confirmation or refutation of the black hole horizon in the center of the galaxy can refute or confirm, respectively, the 1938 idea of Einstein and Infeld to redesign the world space continuum in non-dual terms of material fields without the localized particle. The ontological merger of extended substance and strong energy fields can realize the criterion of double unification known since the middle of the last century: to unify a particle with a field and electricity with gravity [8].

The predicted deceleration of vertically falling matter with further takeoff acceleration, as if along a degenerated Keplerian orbit, could, upon detection, clarify the kinematic role of the internal heat variable. The new approach to gravity through the principle of equipartition of relativistic kinetic energies could be examined in relevant cosmic observations. By taking $r \ll r_o$ in the relativistic generalization (6) of the Newton gravitational law one can simulate the accelerated expansion of the Metagalaxy based on the previous cyclic compression with deceleration.

The radial motion to the center of the galaxy from its periphery is characterized by the kinematic cooling of thermodynamic bodies and, therefore, by the non-equilibrium absorption of radiation energy from the world thermostat. This implies the presence of cold (dark) regions for IR and optical observations. Inelastic collisions near the center of the galaxy (as well as near each massive center) lead to the sharp heating of decelerated material densities and to a local thermonuclear reaction for the synthesis of light elements. The thermonuclear energy release next to the center of a star also heats its visible surface. This results in visible luminosity of thermonuclear stars even at the edge of the galaxy, where other falling bodies are cooling according to the Laue–Mosengeil transport of heat.

A small star that is on an elongated elliptical orbit around a massive center should be heated twice per cycle due to sudden decelerations by small circular satellites at minimum star approximations to this center. In this case, rapid losses of translational kinetic energy occur under explosive growth of internal heat energy and temperature. Thus, the relativistic heat variable predicts a double burst of luminosity of stars for each cycle along an elongated orbit. Upon detection, such thermokinetic effects can be modeled for a numerical verification of the internal energy variable in accordance with the relativistic heat transfer law.

Recall again that radiation and absorption of electromagnetic waves change the relativistic full energy of a probe body even in a constant gravitational field. There are no steady mechanical charges in reality and this was stated by Cartesian physics as early as in 1629 [13]. In closing, the Newton mass physics is to be replaced by tensor gravitation and tensor mechanics for vector energy flows of the time-varying internal heat. New non-dual physics of
non-empty warm space \[7\] corresponds to original Cartesian ideas of vortex matter-extensions. Internal relativistic heat controls the visible spatial motion due to the introduced principle of equipartition of kinetic energies. Cartesian physics of time-varying charges can change the Newton world paradigm of localized particles in empty space and can shed some light on how to warm the nonlocal Universe in advanced theories of continuous flows of heat energy.

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