FOUNDATIONS OF RELATIVISTIC GRAVITHERMODYNAMICS[1]

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The cardinal difference between relativistic gravithermodynamics (RGTD) and general relativity (GR) is that in RGTD the extranuclear thermodynamic characteristics of matter are used in the tensor of energy-momentum to describe only its quasi-equilibrium motion. For the description of the inertial motion in RGTD only the hypothetical intranuclear gravithermodynamic characteristics of matter(on the basis of which the canonical differential equation of the dynamic gravitational field in RGTD was obtained) are used. Exactly this fact allows avoid the necessity of non-baryonic dark matter in the Universe in principle. Evolutionary self-contraction of microobjects of lower layers of gravithermodynamically bonded matter outpaces the similar self-contraction of its upper layers. This is the exact reason of the curvature of intrinsic space of matter. That is why gravitational field itself should be primarily considered as the field of spatial inhomogeneity of evolutionary decreasing of the size of matter microobjects in the background Euclidean space of expanding Universe. In correspondence to this the gravitational field itself is the field of spatial inhomogeneity of gravithermodynamic state of dense matter of compact astronomical objects, as well as of strongly rarefied gas-dust matter of space vacuum. And, therefore, the gravitational field fundamentally cannot exist without matter. That is why it is not an independent form of matter. It is shown that equations of the gravitational field of GR should be considered as equations of spatially inhomogeneous gravithermodynamic state of only utterly cooled down matter. This matter can only be the hypothetical substances such as ideal gas, ideal liquid and the matter of absolutely solid body. The real matter will be inevitably cooling down for infinite time and never will reach the state that is described by the equations of gravitational field of the GR. Only conditional identity of inertial mass of moving matter to its gravitational mass only by gravity-quantum clock, which is located in the point, from which the matter started its inertial motion, and due to the usage of corrected value of gravitational constant in its pseudo-centric intrinsic frame of reference of spatial coordinates and time, is justified. This is related to the equivalence of inertial mass of matter to the Newtonian (GT-Hamiltonian) of its inert free energy, while the gravitational mass of matter is equivalent to the Keplerian (GT-Lagrangian) of its ordinary rest energy. The identity of the multiplicative component of the Gibbs free energy to the ordinary rest energy of matter, which is equivalent to its gravitational mass, is substantiated. It was proved that values of thermodynamic internal energy and Gibbs free energy of matter of inertially moving body are equal in all global gravithermodynamic frames of references of spatial coordinates and time (GT-FR) that are also inertially moving relatively to matter. The temporal invariance of not only the momentum but also of GT-Lagrangian of ordinary rest energy and of equivalent to it gravitational mass of matter is justified. And that is precisely why there is the temporal invariance and a conformal Lorentz-invariance of thermodynamic potentials and parameters in examined modification of transformations of the special theory of relativity (SR). It is shown that only the GT-Hamiltonian (the Newtonian) and GT-Lagrangian (the Keplerian), which are alternative to Hamiltonian and to Lagrangian respectively, strictly correspond to the orthodox SR. Conformal relativistic transformations of increments of metrical spatial segments and

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metrical temporal intervals (instead of increments of coordinates and coordinate time of SR) were received. Exactly this fact allows avoid not only the twins paradox when twins are inertially moving but also the necessity of the dark energy in the Universe. It is also shown that the tensor of energy-momentum of matter (right side of the gravitational field equation) should be formed not being based on external thermodynamic parameters, but being based exactly on the intranuclear gravithermodynamic parameters. The canonical differential equation of the dynamic gravitational field (that corresponds to matter, which moves in this field only by inertia) is examined. It is this equation that determines the spatial distribution of the average density of mass of matter in the quasi-equilibrium state of its motion by inertia. It is shown that at the edge of the galaxy 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 background Euclidean space of expanding Universe, and not by the weak gravitational pseudo-forces at the edge of the galaxy. The standard value of the average density of matter gravitational mass at the edge of a galaxy is determined by the cosmological constant Λ and the difference between unity and the maximum value of the parameter b_c. And it is a non-zero standard value, despite the local gravitational radius at the edge of a galaxy takes the zero value. It is shown that the decrease in the strength of the gravitational field of flat galaxies is inversely proportional to the radial distance, and not its square, and that the increase in the gravitational "constant" is inversely proportional to the fourth degree of the limit velocity of surface hydrogen individual (separate) motion. Consequently, the presence of dark non-baryonic matter in the Universe is unnecessary. Of course, bodies' free fall in gravitational field is an original realization of their tendency to increase the evolutionary self-contraction of microobjects of their matter, and the realization of the tendency of the whole gravitationally bonded inhomogeneous matter to the minimum of the integral values of its inert free energy and thermodynamic Helmholtz free energy. Bodies that fall accelerate independently in spatially inhomogeneous medium of the outer space or atmosphere. Such bodies transform their continuously released intra-atomic energy into kinetic energy. It is shown that in case of bodies' free fall the gravitational deceleration of the rate of their intrinsic time is completely compensated by the motion due to isotropic all-round conformal gauge self-contraction of the size of falling bodies in the background Euclidean space of the Universe. Clocks that fall free are inertially moving and, therefore, continue to count time at the same rate as when they were in the state of rest. Similarly, the rate of time of astronomical body is not changed in the process of its motion in elliptical orbit. The dilation of intrinsic time of distant galaxies is also absent, which points on the fact that Etherington identity does not correspond to reality. The fact that Hubble's redshift is linearly dependent on transversal comoving distance instead of luminosity distance is justified. It is shown that mentioned above fact corresponds to astronomical observations. According to this the presence of dark energy in the Universe is also unnecessary. For the collective gravithermodynamic Gibbs microstates the connection between all thermodynamic potentials and parameters of matter have been found. This connection is realized with the help of several wave functions that can take arbitrary values with certain probability. The quantum equation of gravitational field have been found, the solutions of which set the spatial distribution of gravitational radius of matter in its every new gravithermodynamic state with the polynomial function with the next more high degree. The indicator of the degree of this function of continuously cooling down matter can successively take only integer and semi-integer values. That is why the process of cooling down of the whole RGTD-bonded matter is the quantum process that is caused by its spontaneous transition to the polynomial function with more high value of degree and, therefore, to the next quantized collective gravithermodynamic state.

Keywords: gravithermodynamics, thermodynamics, gravity, gravitation, GR, SR, vacuum, inert free energy, Helmholtz free energy, field, evolutionary and gravitational conformal gauge self-deformation, all-round isotropic conformal gauge self-contraction of moving matter, collective space-time microstate, Gibbs microstate, Lorentz conformal transformations, the principle of unobservability of the kinematic and gravitational self-contraction of the

size of matter, limit velocity of matter, coordinate velocity of light, internal scale factor, hidden variables, wave functions, quantum gravity, spiral waves, micro-object, outer space, background regular space, photosphere, redshift, flat galaxy, quasar, supernova.

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> But, it is similar to a building, one wing of which is made of fine marble (left part of the equation), but the other wing of which is built of low grade wood (right side of equation). The phenomenological representation of matter is, in fact, only a crude substitute for a representation which would correspond to all known properties of matter.
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> Albert Einstein (*Physics and reality*)

Contents

Preamble (from the author)

Recently besides the epochal misunderstandings such as “Big Bang” of the Universe and “black holes” the two more not less significant misunderstandings appeared: “non-baryonic dark matter” and “dark energy”. This clearly testifies the presence of protracted crisis in theoretical physics. It gradually becomes the simple handicraft industry instead of creative reflection of reality. The gaps that were found in modern interpretations of very harmonious constructions of special (SR) and general (GR) relativities are started to be hushed up or “patched” via the introduction of new material entities (Kantian “things-in- themselves”) instead of reconsidering the physical entities of those theories themselves.

This crisis started right after the discovery of possibility to construct the relativistic theory of thermodynamics alternative to the theory of Planck-Hasenöhrl by Heinrich Ott [1] and independently from him by Heinrich Arsels [2]. Due to heavy debates on this question H. Arsels told about the “modern crisis of thermodynamics” (and not of SR). However the majority of physicists came to the conclusion about relativistic invariance of thermodynamics. And it is so indeed. Despite the principal possibility of relativistic dilation of the intrinsic time of matter the matter that only inertially moves in the gravitational field is not affected in principle by this dilation of intrinsic time. And it is guaranteed by more complex Lorentz-conformal relativistic transformations of increments of spatial coordinates and time. These are why the tensor of energy-momentum being based on the thermodynamic parameters and characteristics of matter can be formed only in frames of references of coordinates and time that is comoving with continuous matter. Unfortunately, the folk wisdom “the simplicity is worse than a theft” has been replaced in modern physics with the statement “everything genius can be only simple”.

The legitimacy of usage in the tensor of energy-momentum of continuous matter of extranuclear (thus thermodynamic) parameters and characteristics instead of intranuclear was substantiated by Richard Tolman [3], who proved the mutual consistency (correlation) of extranuclear and intranuclear parameters and characteristics of matter. In the quasi-equilibrium state of matter the product of absolute temperature, that characterizes the intensity of extranuclear thermodynamic processes, and coordinate velocity of light, that characterizes the intranuclear state of matter, is the spatially homogenous magnitude. However, such correlation is absent for the non-continuous matter of the galaxies and that is why the tensor of energy-momentum of non-continuous matter of the galaxy should be formed only based on relativistically non-invariant intranuclear parameters and characteristics of matter. It was for a reason that Albert Einstein himself had doubts that universal structure of tensor of energy-momentum is possible and compared it with the low quality timber in comparison to metrical tensor, which he compared with elegant marble.

All these misunderstandings are caused by a distorted physical interpretation of the theory of relativity itself and by the not deep enough understanding of physical essence of different forms of such main physical concepts as space and time and also by the not having knowledge about physical processes hidden behind the mathematical model of space-time continuum (STC). Both the revealed by Henri Poincaré physical nature of the curvature of intrinsic space of matter and the revealed by Hermann Weyl possibility of non-observable in principle in people's world gauge deformation of matter on the level of its microobjects and, consequently, of corresponding to it STC are de facto ignored. Moreover, not all people understand the united nation of thermodynamic and gravitational properties of matter, according to which the equations of gravitational field of GR are the equations of spatially inhomogeneous gravithermodynamic state of gauge evolving matter. The neglecting of the principal unrealizability of singularities in GR (taking into account the correspondence of zero value of coordinate velocity of light only to infinitely large values of absolute temperature and pressure), as well as the neglecting of possibility of self-organization by matter and antimatter of mirror symmetric configuration of intrinsic space, are responsible not only for the replacement of ultra massive hollow neutron stars by "black holes", but also for the non-understanding of the nature of ultra high luminosity of quasars and supernovas. Non-perception of the fact that the Universe cannot be homogeneous in principle in intrinsic STCs of astronomical objects and the false identity (paralogism) of Etherington (that is based on the imaginary dilation of intrinsic time of inertially moving far galaxies) are responsible for the fictive necessity of phantom "dark energy" in the Universe. Non-understanding of the fact that tensor of energy-momentum should be formed not being based on the external thermodynamic characteristics, but namely being based on the intranuclear gravithermodynamic characteristics of non-continuous matter, is responsible for the fictive necessity of phantom "non-baryonic dark matter" in the Universe. The scientific research made by author, results of which are described in the proposed for consideration work, is dedicated to the justification of everything mentioned above.

Introduction

Clausius's Hypothesis about opportunity of the heat death of the Universe (1865) and also the misconceptions about non-invariance of thermodynamics equations to relativistic transformations led to false conclusion that methods of thermodynamics cannot be applied to the analysis of evolutional processes in megaworld. It is known now that the Universe cannot cool down at any as long as possible finite time period. Self-organization of spatially inhomogeneous thermodynamic states and gravitational fields that correspond to those states prevent matter from complete cooling down. The thing that prevents unlimited growth of entropy in the Universe is the self-organization of different structural formations, the complexity of which grows with every new hierarchy level of self-organization of natural objects that form them. Relativistic generalization of thermodynamics with the invariant absolute temperature is currently considered as the most acceptable generalization [4, 5].

Thermodynamics was already used in this or that manner for analysis of the processes of formation of megascopic Universe objects [6 – 13]. The main researches that should be highlighted: researches on gravitational plasma [13, 14], researches based on the kinetic theory of rarefied gas [15], and also the theory of spatio-temporal evolution of nonequilibrium thermodynamic systems [16]. Recently, being based on the analysis of self-organization processes in nonequilibrium systems [17, 18] and on the more wide usage of the methods of statistical physics, thermodynamics of self-gravitating systems achieved the quite significant success [19 – 21]. However thermodynamic and gravitational descriptions of the self-organization processes of Universe astronomical objects are still not naturally merged. Some authors [22] still continue the search for more weighty purely thermodynamic causes that are responsible for the curvature as well as for the physical inhomogeneity of intrinsic spaces of matter. Another authors [23, 24] identify the gravity force with entropic force[3] not only based on thermodynamics, but also based on extraordinary properties of unreal "black holes"[4] (in astronomical observations the objects that are considered as "black holes" are indeed very massive neutron stars that have the topology of hollow body in background Euclidean space [25] as well as mirror symmetry of intrinsic space). But, of course, gravity can be justified by just the self-organization (by the whole gravithermodynamically bonded matter) of spatially inhomogeneous gravithermodynamic states with gravitational outrunning of evolutionary self-contraction of microobjets of matter in the bowels of astronomical objects [26 – 28]. And this is fundamentally possible due to the fact that the whole matter reaches the minimum

[3] The gravitational pseudo-force that does not perform any work is caused by the non-conservation of the momentum in physically inhomogeneous space. Moments of virtual microobjects (quanta of energy), which are the objects of transfer between mutually interacting real microobjects, are increased in the process of their propagation to the gravitational attraction center and, vice versa, are decreased in the process of their propagation in the opposite direction.

[4] The impossibility of collapse of matter under the Schwarzschild sphere is quite obvious. In any moment of intrinsic time of matter it belongs only to infinitely far cosmological future and its radius in background Euclidean space is equal to zero [37, 42, 43]. And it is related to the fact that the simultaneity of events that take place in different points in cosmological time (but are simultaneous in SF of observer) is not fulfilled. According to mutual solution of equations of gravitational field of GR and equations of thermodynamics [39, 40] the tendency of coordinate velocity of light to zero is possible only when pressure and temperature tend to infinity. And, consequently, the real singular surface, on which coordinate velocity of light is very close to zero, can be only median surface. And it should separate external matter from internal antimatter. In internal space of hollow astronomical body the phenomenon of contraction of internal "Universe" takes place instead of the phenomenon of Universe expansion. And it means that in the internal space of hollow astronomical body the correspondent to antimatter divergent spiral-wave formation (and not the convergent, as in external space) should be placed. Due to the fact that minimal Schwarzschild radius can take quite large values the mass of hollow neutron stars can be arbitrary large.

of integral value of not only extra-nuclear Helmholtz free energy, but also of intranuclear inert free energy. Therefore, phenomenological justification of the united nature of thermodynamic and gravitational properties of the matter [29 – 35] is very important for the studying of megascopic astronomical objects and global processes in the Universe.

Thermodynamic states of matter, examined in General Relativity (GR), are self-inducted by matter spatially inhomogeneous states of this matter. This fact is caused by the presence of gravitational field in matter: Gravitational field is the cause of spatial inhomogeneity of rates of intra-atomic physical processes in matter and, therefore, it inducts not only the curvature, but also physical inhomogeneity of intrinsic space of matter [36, 37]. In rigid frames of reference of time and spatial coordinates (FR) this physical inhomogeneity of the space is in the mutual inequality of values of such hidden thermodynamic property of the matter as coordinate-like velocity v_{cv} of light in different points of this space [38].

The equations of GR gravitational field should be considered as just the equations of spatially inhomogeneous thermodynamic state of utterly cooled down matter. Such matter can be represented only by hypothetical substances such as ideal gas, ideal liquid and matter of absolutely rigid body. Real matter is doomed to cool down infinitely long without reaching the state that is described by the equations of GR gravitational field. This state of gradual quasi-homogeneous cooling down is described by considered here modified tensor equations of GR – equations of relativistic gravithermodynamics (RGTD).

Increasing of coordinate-like velocity of light during the distancing from compact matter of astronomical body can be the consequence of gradual change of thermodynamic parameters of the atmosphere and the outer space that surround this body. In this case spatial distributions of coordinate-like velocity of light, which are set by gravitational field, strictly correspond to concrete spatially inhomogeneous thermodynamic states of matter. Adding of the third independent parameter – coordinate-like velocity of light to any of two mutually independent thermodynamic parameters in GR guarantees only conventional consistency of this theory with objective reality. Indeed, the solutions of equations of gravitational field for any cluster of gravitationally-bounded matter are always examined in conventionally empty Universe. However, the Universe is not empty and, as united solution of equations of gravitational field and equations of thermodynamics for ideal liquid shows [39, 40], values of coordinate-like velocity of light are not vacuum values, but gravity-baric values. They are determined by the values of thermodynamic parameters of ideal liquid accurate to gauge coefficient. Only this coefficient can be considered as pseudo-vacuum value of coordinate-like velocity of light. In the case of presence of both mechanical and thermal equilibriums in ideal liquid this pseudo-vacuum value of coordinate-like velocity of light is the same within the whole liquid, which self-organized its spatially inhomogeneous equilibrium state and gravitational field that corresponds to this state [39, 40]. This fact allows us to consider this vacuum value as gauge parameter that interconnects spatial and temporal metrics and cannot be observed in gravity-quantum proper FRs (GQ-FRs) of matter and in people's world FR in principle.

1. Gravitational nature of the pressure in ideal gas and in conventional emptiness

The space of the Universe is infinite in a comoving with expanding Universe FR (CFREU). In GQ-FR the whole space of the Universe is inside the sphere of the events pseudo-horizon[5] (events on this pseudo-horizon belong to infinitely far cosmological past) [37, 41 – 43]. Therefore in GQ-FR the volume of the whole Universe V_U fundamentally can be finite. Although even infinitely far objects of CFREU are observed in this Universe, the infinitely large number of its astronomical objects is beyond the limits of space-time continuum (STC) of gravithermodynamically bonded matter. And therefore, according to the equation of the state of ideal gas, the pressure in GQ-FR cannot take not only infinitely large values, but also zero values: $p_U \geq RT/V_U$. Taking into account the fact, that not the absolute, but relative measurements of pressure are performed by all devices: $p = p_U - p_{U\min}$, the equation of mechanical equilibrium of matter in gravitational field should be as follows:

$$\frac{dp}{dr} = -(\hat{\mu}_{gr0}c^2 + p + p_e)\frac{d\ln v_{cv}}{dr} = -\frac{(\hat{\mu}_{gr0}c^2 + p + p_e)}{2b}\frac{db}{dr},$$

where: $b = v_{cv}^2/c^2$, $p_e \geq p_{U\min}$ is arbitrary small but still finite value of pressure on the surface of compact physical body that is located in conventionally empty space; $\hat{\mu}_{gr0} = \hat{m}_{gr0}/V = \hat{\mu}_{00}b^{-1/2} = \hat{m}_{00}v_{cV}/cV$ and $\hat{\mu}_{00} = \hat{m}_{00}/V$ are the densities of gravitational rest mass $\hat{m}_{gr0}$ and of mass eigenvalue $\hat{m}_{00}$ of matter not under pressure correspondingly[6];

v_{cv} is coordinate velocity of light GR [38]; *c* is constant of velocity of light (really metrical values of pseudo-vacuum velocity of light); *V* is volume of matter.

Then even in the case of zero density of the mass (μ_{00}) the radial distribution of pressure in conventionally empty space that surrounds the body formally strictly corresponds to the radial distribution of coordinate velocity of light of GR in this space:

$$\frac{dp}{dr} = -p_e\frac{d\ln v_{cv}}{dr} = -\frac{p_e}{2b}\frac{db}{dr}, \qquad p = p_e\left[1 - \ln\left(\frac{v_{cv}}{v_{cve}}\right)\right] = p_e\left[1 - \frac{1}{2}\ln\left(\frac{b}{b_e}\right)\right]. \quad (1)$$

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[5] In equations of gravitational field of GR and RGTD, in contrast to standard cosmology, not the path-like but coordinate time (which can be infinitely big in the past and in the future) is used. That is why the pseudo horizon of events that covers the whole infinite background Euclidean space belongs (in contrast to the real Rindler event horizon) at any moment of intrinsic time of observer only to infinitely far cosmological past [37, 42, 43]. This is related to the relativistic non-fulfillment of simultaneity of events (that happen in different places) in cosmological time, but simultaneous in SF of observer.

[6] The true value of the gravitational mass m_{gr0} of matter under pressure is equivalent to the ordinary rest energy of matter, which is identical to the thermodynamic Gibbs free energy $G = U + pV - TS$.

The tendency of coordinate velocity of light to zero while approaching the fictive singular surface of events pseudo-horizon corresponds to the tendency of pressure to infinity in the same way as it takes place while approaching the real singular surface that separates external matter from internal antimatter in ultra massive neutron stars [29, 30, 37, 39 – 41, 43].

And this, of course, confirms the possibility to use the gradient of pressure in matter and in outer space as the gradient of gravitational field. The pressure in matter and in outer space, which is not caused by electromagnetic interaction of molecules, has namely the gravitational nature.

Conventionally empty space that surrounds such compact matter of The Universe has really never been empty and never will be completely empty. Even the highest cosmic vacuum should be considered as very rarefied gas-dust "incoherent matter", which obey the thermodynamic laws the same as ideal gas of non-interacting molecules[7].

That is why radial distribution of pressure that is set by (1) dependency indeed should correspond not to hypothetical absolute emptiness, but to rarefied gas-dust matter of the outer space that surrounds the compact astronomical body.

In an extremely rarefied substance, one micro-object may correspond to a very large volume of outer space, filled with a very large number of pairs of terminal local sinks and sources of turns of spiral waves (that are now conditionally considered respectively as virtual "particles" and virtual "antiparticles"). Nearby virtual "antiparticles" can annihilate the particles of this micro-object with the de Broglie frequency, and instead of it, a new micro-object similar to it can be actualized at a large distance with a probability that is less, the greater its distance from the original annihilated micro-object is. And this agrees well with quantum mechanics, which states that a micro-object can be detected with a certain probability at any point in space. And besides, this does not at all contradict either classical physics, SR and GR, or RGTD, since such a seemingly instantaneous transposition of a micro-object is not associated with the transfer of energy faster than the speed of light. It is simply replaced by a new micro-object in a new location. Although at any moment in time a new microobject can theoretically take, with a certain probability, any of a large number of microstates, this does not mean that it is simultaneously in several microstates. There is simply a change (with the de Broglie frequency) of microstates of micro-objects (which are similar to and replace the annihilated microobject), depending on many random factors. All this indicates the advisability of considering not the individual behavior of any object, but the changes (with de Broglie frequencies) in the collective spatiotemporal microstates of all gravitermodynamically interconnected micro-objects of both the object under study and the measuring instruments used in the research process. The change of these microstates is carried out by the influx (at superluminal speed) of the next turn of spiral waves of space-time modulation of the

[7] Such "incoherent matter" (in a form of e.g. lonely atom), of course, can interact with the cloud of coherent virtual microobjects in the gravitational field of coherent matter that form collective Gibbs thermodynamic microstates.

dielectric and magnetic permeability of the physical vacuum [37, 43, 44] onto all microobjects. This turn of spiral wave is equivalent to the wave front of formation of gravity-inertial stressed state [45, 46]. And it transfers in the general case not only a new moment of intrinsic time of the matter, but also a quantum of action.

2. Maximum possible velocity of definite matter individual (separate) motion

The limitation of the velocity of physical bodies is indeed exists in rarefied gas-dust matter. However, this limitation is not related to the velocity of light in the matter or in hypothetic absolute vacuum. In airspace, as well as in dense matter, the charged micro objects (protons) can propagate faster than the velocity of light. That is confirmed by the origination of the radiation, found by Cherenkov, in this case. In addition, the value of the coordinate pseudo-vacuum velocity of light v_{cv}, used in the GR as a gravitational potential, can be close to zero in very dense and hot stellar nuclei. And despite this, the nucleus can move at a velocity *v*, which significantly exceeds its inherent value $v_{cvn} << v$. Therefore, this coordinate velocity of light can be considered as the limit velocity only of the relative motion of matter in the nucleus in the FR of the star, and not of its motion in the FR of a distant observer.

On the other hand, hypothetical frequency of intranuclear interaction (alternative to the pseudo-vacuum velocity of light of GR) decreases while approaching the gravitational attraction center unlike the real frequency of electromagnetic interaction in matter, which increases. This is in a good correspondence with the fact that thermodynamic and gravity-evolutionary processes have opposite directions and is related to the fact that frequency of electromagnetic interaction in matter is greater when the temperature of the matter is greater. Due to the same reason the physical processes flow faster not on the surface but in hotter bowels of the astronomical objects despite the gravitational slowing down is predicted by GR for those processes.

The reason for limitation of velocity of physical bodies is indeed the nature of matter movement in the space. Physical vacuum is not carried away by physical body. Matter is only the non-mechanic excitement of physical vacuum (space-time modulations of its physical characteristics). Therefore, the perception of high-frequency discrete movement of the body in the space as the continuous motion is similar to cinematographic perception of discrete change of image frame. The limitation of body velocity can be related to the fact that it is impossible to reach infinitely high frequency of discrete change of Gibbs collective thermodynamic microstate (quantum «hologram») of the whole its RGTD-bonded matter and to the fact that it is impossible to reach the zero value of the length of spatial step shift (quantum micromovement) of the body. This frequency and this micromovement are de facto the de Brogile frequency $\mathbf{v}_B$ and wave length λ_B of the moving body. That is why instead of denying the possibility of moving body to overcome the velocity of light we should state the principal impossibility to reach the extremely big velocity $v_l = \sqrt{v v_B} = v_{B\min}$ of individual (separate) motion of its homogeneous matter. And this corresponds to the tending of $\mathbf{v}_B$ to infinity, and tending of $\lambda_{B\min} = v_l / \mathbf{v}_B = h / m v_l \Gamma = 0$ ($v = v_l$, $\mathbf{v}_B = \infty$, $\Gamma = \infty$) to zero, when phase velocity of de Brogile wave propagation v_B reaches its minimal value, equal to maximal possible velocity $v_{\max}$ of individual motion of the homogeneous matter of the body ($v_{B\min} = v_{\max} \equiv v_l$).

Thus, the greater the gravitational mass $m_{gr0} = m_{00} c / v_l$ of an astronomical body, the greater the frequency with which de Broglie waves run on him, and therefore, the greater the frequency with which step-by-step movement of this body can be carried out. And this means that the inertial mass $m_{in0} = m_{00} v_l / c = m_{gr} v_l^2 c^{-2}$ of an astronomical body, on the contrary, becomes as many times smaller. And therefore, the inertial mass of matter can be identical to its gravitational mass only according to the own clock of matter, when $v_l = c$. According to this, the GR currently actually uses an inertial mass that is equivalent only to the inert free energy $E_0 = m_{in} c^2 = m_{00} c v_l$ of matter, instead of a gravitational mass that is equivalent to the ordinary rest energy $W_0 = m_{gr} c^2 = m_{00} c^3 / v_l$, identical to the multiplicative component of the thermodynamic Gibbs free energy of matter.

In addition, gravitational fields set only the gradients of the intrinsic values of the limit velocity of matter individual (separate) motion, and not the intrinsic values of the limit velocity of matter individual motion themselves, which are determined purely by the thermodynamic parameters of matter. And this also applies to distant galaxies due to the logarithmic potential $\varphi_H = c^2 \ln(v_{lH} / c)$ of the dynamic gravitational field. And, therefore, the thermodynamic parameters and potentials, which are determined purely by the intrinsic values of the limit velocity $v_{lH} = v_l \Gamma_H = c T_{00} / T$ of definite matter individual motion, are not only relativistically, but also gravitationally invariant. Here $\Gamma_H = (1 - v_H^2 v_l^{-2})^{-1/2}$, v_H is Hubble velocity of the radial motion of the galaxy, and T_{00} is a constant that is intrinsic in a definite substance and is independent on external gravitational fields. Since the constant T_{00ind} may be different for different matter, then at the same point in space at the same absolute temperature T they will also have different intrinsic values of the limit velocity v_{lHind} of individual motion of galactic definite substance.

Dense substances, in which the limit velocities of individual (separate) motion are less than the actual velocity, cannot move separately. They must be pushed by substances, in which the limit velocities of individual motion are greater than the actual velocity of their collective motion. Therefore, very dense substances must be contained mainly in the bowels of planets, stars and galaxies, so that they can move at extremely high velocities. And therefore, it is not at all accidental that very dense neutron stars are located only in the centers of galaxies. Because of this, the frequency of de Broglie waves that fall on them corresponds not only to their mass, but to the mass of the entire galaxy.

This is what allows the use of a single limit velocity of motion (in the RGTD for the group motion of many substances), which is inherent, for example, to the most common substance – the hydrogen that is located on the surfaces of the stars (similar to the use of a single coordinate pseudo-vacuum velocity of light, which is supposedly inherent to all substances, in the GR). If such a limit velocity of group motion is known, for example, for a star moving with a known maximum orbital velocity, then the equations of the gravitational field of the galaxy allow us to determine the limit velocities of group motion of a similar substance for stars moving with other orbital velocities.

Thus, not only local spatial features (the presence of own gravitational fields for the stars), but also the non-identity individual constants T_{00ind} for different substances is not taken into account in the universal equations of the galaxy gravitational field. And this takes place both in the GR and the RGTD. After all, according to the solutions of the equations of the gravitational field of the galaxy, the same values of the parameter $b_{lc} = (v_l \hat{\Gamma}_c / c)^2$ correspond to both the matter of the stars and to almost empty space that surrounds them. That is, hydrogen and other substances are supposedly dispersed in the space surrounding stars and planets, rather than concentrated inside them. But these solutions of the equations of the galaxy gravitational field reflect the general tendencies realistically.

In distant galaxies which are not conditionally cooled, as well as in any bodies moving in a gravitational field by inertia, the value $v_{lHind} = cT_{00ind} / T = \mathbf{const}(t)$, corresponding to a particular substance will be the same as in the same substance on Earth only at the same absolute temperature. In the hot matter of distant galaxies, as in the matter in the bowels of the Earth, it is much smaller and gradually increases with a decrease in its temperature. And the much smaller value v_{lH} in the matter of distant galaxies is well consistent with the gradual cooling of the very hot matter of the Universe in the distant past.

Unlike gases, the internal energy of solid matter includes not only thermal energy, but also consists of many products of intensive and extensive thermodynamic parameters. Therefore, it would seem logical to identify gravitational energy, which is equivalent to the gravitational mass of matter, with it. But in fact, it is not this energy at all, and not even enthalpy, which is identified with the energy of an expanded system [5], but only the multiplicative component of Gibbs free energy, which does not include the released thermal energy, can be considered identical to gravitational energy, and therefore equivalent to the gravitational mass of matter. After all, many experiments have proven that heated bodies have a weight that is not at all greater, but, on the contrary, less than a weight of cold bodies [53, 54].

3. Physical essence of gravitational field

Purely gravitational nature of the pressure in ideal gas and also the tendency of coordinate velocity of light (and of equivalent to it maximal possible velocity of objects) to zero value only when pressure tends to infinity is in a good correspondence with the spiral-wave nature of matter [37, 43, 44, 47]. Pressure in matter in the outer space as well as the gradient of the strength of gravitational field increase with the increasing of density of turns of spiral-wave modulation of dielectric and magnetic permeability of physical vacuum. Spiral wave turns approach the physical body with the de Broglie frequency. With each turn that runs over the correspondent to body spiral-wave formation the center of mass of the body can discretely change its position in space. The body itself (correspondent to it spiral-wave formation) is gradually self-shrinkage in CFREU on the level of microobjects of its matter (terminal outlets of the turns of the common spiral-wave formation of the Universe). Exactly this fundamentally non-observable self-contraction of matter is responsible for the expansion of the Universe in the FR of people's world.

There is a thermodynamic quasi-equilibrium between gravitationally self-contracted compact matter and surrounding it arbitrary rarefied matter of the outer space. Therefore, pseudo-vacuum value of the hypothetical coordinate velocity of light in this rarefied liquid matter cannot differ from pseudo-vacuum value of the coordinate velocity of light in the space filled in by compact matter. And, consequently, this value should be the same in the whole Universe space, filled by gaseous and liquid matter. Thus, coordinate velocity of light of GR should indeed be considered not as vacuum velocity but as gravity-baric velocity of light [31 – 33, 35, 40]. Thus, vacuum value of the hypothetical coordinate velocity of light, which is a gauge parameter, should be considered as strictly equal to the constant of the velocity of light c in the whole space, filled in by any gaseous and simplest liquid matter that is in quasi-equilibrium thermodynamic (thermal and mechanical) state. And then, due to isotropy of radial distribution of the pressure in such matter we can reach the following conclusion. The fact that the rates of coordinate (gravity-quantum) time of the homogeneous matter differ in the points of matter, where values of gravitational potential are different, is caused only by inequality of the pressure and other thermodynamic parameters of this gaseous or liquid matter, which fills the whole space, in those points. And, therefore, all such homogeneous matter is not only in the state of mechanical and thermal equilibrium, but also on the same stage of evolutional decreasing of the level of improper value of its intranuclear energy. Of course, the closer is the matter to gravitational attraction center the smaller is its value of limit velocity of its individual motion (alternative to gravity-baric coordinate velocity of light in partially modernized GR [35, 39, 40]) and, therefore, the smaller is its inert free energy and the smaller is the size of its microobjects in background Euclidean space of CFREU. However, this spatial inhomogeneity of evolutionary-gravitational self-shrinkage of matter in CFREU strictly corresponds to the spatial inhomogeneity of its thermodynamic state. And that is why all effects that take place in such gaseous or liquid matter and that are considered as gravitational are indeed purely thermodynamic.

Anisotropy of radial distribution of the pressure in matter is the characteristic for solid matter. That is why solid matter and liquid matter, located above the world Ocean level, are on the certain stage of lagging of evolutionary-gravitational decreasing of the level of improper value of its intranuclear energy. The water of world Ocean is also on the certain stage of lagging of this process since it covers the rigid body. However, gravitational reduction of the level of improper value of its intranuclear energy is in advance of the similar reduction for the objects that are above the world Ocean level. It means that gravitational field is the field of non-equal (spatially inhomogeneous) advance of evolutional decreasing of improper value of intranuclear energy of solid and any liquid matter. And such advance for solid and liquid matter cannot be smaller that the advance of evolutionary reduction of improper value of intranuclear energy of gaseous matter that is in contact with it. Thus, the stepped layer-by-layer realization of gravitational advance of evolutionary reduction of improper value of intranuclear energy of multilayer inhomogeneous matter takes place. The overall gravitational advance of evolutionary self-shrinkage of the whole upper layer of grvithermodynamically bonded gaseous matter is de facto increasing due to advancing evolutionary-gravitational self-shrinkage of solid body covered by this matter. Moreover, radial gradient of the real velocity of light in such gaseous matter can be significantly smaller than the gradient of conventional gravity-thermo-baric velocity of light. And this, of course, can significantly reduce the blurring of spectral lines of radiation of such photospheric gaseous matter of stars.

In correspondence with all this, significant gravithermodynamic redshift of emission radiation spectrum can take place only for astronomical objects with a solid photosphere, as well as for liquid and gaseous astronomical objects, which have solid nucleus or are in non-equilibrium thermodynamic states. And, of course, gravithermodynamic redshift of radiation spectrum is the consequence of advance of evolutionary reduction of the intranuclear energy of lower layers of matter (the consequence of lagging of evolutional decreasing of intranuclear energy of radiating matter). Frequencies of emission radiations are determined only by the differences between energy atomic levels, values of which are not changed in atoms at quasi-equilibrium thermodynamic processes. Radial changes of matter RGTD-parameters, when liquid or gaseous matter is in hypothetical equilibrium thermodynamic state, lead to the change of only the frequency f_G of quantum interactions in atomic nuclei. And it is not accompanied by redshift of its spatially homogeneous emission radiation and by widening of spectral lines of that emission radiation.

Due to all mentioned above the introduction of the count of unified thermodynamic time in atmospheric layer of the Earth instead of the counts of coordinate (gravity-quantum) times (time rates of which are decreasing while approaching the gravitational attraction center) does not break the general covariance of equations and laws of physics.

4. Thermodynamic nature of the majority of gravitational effects

Analysis of solutions of the equations of GR gravitational field [29, 30, 39, 40] specifies the thermodynamic nature of majority of gravitational effects. All gravitational phenomena, except the phenomenon of curvature of intrinsic space of matter, are strictly thermodynamic in fact. For example, the fact that bodies, more dense than surrounding medium, tend to the gravitational attraction center, as well as the fact that bodies, less dense than surrounding medium, tend from the gravitational attraction center, is caused by the fact that the whole system (which consists from all bodies and the medium surrounding them) tends to the state of the minimum of the integral value of their thermodynamic enthalpy [39, 40]. In the case of presence of heat exchange integral values of Helmholtz and Gibbs thermodynamic free energies also tends to minimum [31 – 35], while integral value of entropy of all matter in the Universe tends to maximum. From the other hand, the pressure in ideal gas and in any other "incoherent matter" is not caused by intermolecular electromagnetic interaction and, consequently, this pressure itself has purely gravitational nature. And, therefore, physical phenomena and properties of matter, which are examined by thermodynamics and theories of gravity in a different phenomenological way, are based on the same fundamental nature of matter micro-objects (elementary pseudo-particles) [37, 43, 44].

In classical physics potential energy of gravitational field was considered as something external for the matter, while in GR potential energy is contained in matter itself. Indeed, free fall of the body is an inertial motion. Released potential energy of intranuclear bonds and intranuclear interactions in the atoms nucleus of matter of falling body together with the energies of nucleons that form these atoms transform into kinetic energy of body motion. And the excessive level of evolutionary lost intranuclear energy of matter, in fact, decreases. As it follows from united solutions of equations of gravitational field and thermodynamics equations [32, 35, 39, 40, 44], all characteristics that determine gravitational properties of matter and phenomenon of Universe expansion are also contained in matter itself and cannot be considered as something external for the matter.

The change of collective spatial-temporal state of the whole gravithermodynamically bonded matter takes place simultaneously in its intrinsic time and in all points of its intrinsic space. That is why the rates of all physical processes in intrinsic STC of gravithermodynamically bond matter should be determined only by its thermodynamic parameters and should not directly depend on spatially inhomogeneous rate of coordinate (gravity-quantum) time. Their rates will be non-equal only in cosmological time, rate of which in intrinsic time of matter is decreasing while approaching the gravitational attraction center.

5. Gravithermodynamic FR of people's world

In classical thermodynamics all intensive thermodynamic parameters of matter are determined via measuring of extensive parameters (which depend on those intensive parameters) of matter itself or matter of measuring instruments that are in thermal equilibrium with this matter. For example, the main method of temperature measuring is in the measuring of volume occupied by thermometer liquid. Pressure is determined via measuring of elastic deformation (caused by this pressure) of any element of recording instrument. Deformation and volume are both extensive parameters. This makes closed system of the pairs of mutually complementary intensive and extensive matter parameters self-consistent and guarantees invariance of intensive thermodynamic parameters to time transformations. And, thus, there is not only temporal invariance, but also Lorentz-invariance of used in thermodynamics proper values of intensive and extensive characteristics of matter. And it is similar to the principal invariance of the value of velocity of light by the intrinsic clock in the point of its dislocation and to the principal invariance of Hubble constant[8]. The majority of measurements of physical characteristics in FR of people's world is purely relative. They are strictly bonded not only to intrinsic clock, but also to other intrinsic instruments of operator who performs measurement. And, therefore, the influence of the instrument on the measurement result takes place not only in quantum, but also in classic physics. In contrast to microworld, in the macroworld the measurement results are only strictly determined.

And, therefore, invariant values of thermodynamic parameters and characteristics of motionless matter, which are used in classical thermodynamics, are self-sufficient and don't need to be a member of any FR. They can be members only of certain tracking system: system that tracks changes of thermodynamic parameters and characteristics of matter. And, from the other hand, global FR can be formed based on this tracking system. The presence of phenomena, for which frequency of their elementary acts depends only on absolute temperature, is necessary for this global gravithermodynamic FR (GT-FR) to be non-artificial in nature. Then, the scale of absolute temperature can be linearly calibrated based on this frequency. The clock, using which the rates of coordinate (gravity-quantum) times can be compared and dependences of these rates on parameters of thermodynamic states of these matters can be analyzed, can be realized based on this phenomenon.

[8] In an comoving FR in expanding Universe the change of velocity of light is proportional to the change of the size of length standard and , therefore, proportional to the velocity of evolutional motion of matter to the center of its self-contraction. The velocity of evolutional motion of the matter obeys the Hubble law in this FR. All this guarantees the principal invariance of not only intrinsic value of velocity of light, but also Hubble constant in people's world FR.

And such phenomenon exists: dependence (obtained by Wien) of electromagnetic wave frequency, which corresponds to the maximum of spectral density of equilibrium thermal radiation, only on absolute temperature and proportionality of this frequency to absolute temperature: $\nu_{\max}=(\alpha k/h)T$, where k is Boltzmann constant, h is the Planck constant, α is the root of the equation: $\alpha/5=1-\exp(-\alpha)$. Therefore, united thermodynamic time is used in people world in fact, instead of gravity-quantum time, rate of which is not similar for different matters and depends on their gravithermodynamic states. Quantum processes in etalon matters can only be used for the counting of this time due to the stability of their rate in this matter when temperature T and pressure p remain unchanged. Thermodynamically invariant atomic characteristics – differences between energy levels ΔE_{ij} in atoms and frequencies of emission radiation $\nu_{ij} = \Delta E_{ij} / h$ corresponding to them also can be used for this time counting. Energy levels are defined by radiuses of allowed orbits of electron shells in the atom and, similar to intensive thermodynamic parameter, are the characteristic defined by extensive parameter (radius of allowed orbit) and, therefore, dependent on transformations of spatial coordinates not time. Therefore, electrons energy and, thus, energy levels in atoms are, similarly to thermodynamic internal energy of matter U, Lorentz-invariant and does not depend on the level of inert free energy of nucleons as well as on the gravitational potential (and on hypothetical coordinate pseudo-vacuum velocity of light that defines this potential). And, thus, it does not depend also on the rate of coordinate (gravity-quantum) time of matter.

Thus, the wavelength, as well as the frequency of not only thermal, but also emissive radiation, is determined only by individual properties and thermodynamic parameters of matter. Ants their values do not depend on the magnitude of gravitational potential in it as well as on the rate of coordinate (gravity-quantum) time of matter. And this means that real velocity of light in matter is also strictly determined only by its individual properties and thermodynamic parameters. And it cannot be greater than the limit velocity of individual motion of baryonic matter, which is also the function only of the individual properties and thermodynamic parameters of the same matter. And, therefore, hypothetical coordinate vacuum velocity of light of GR, is, of course, the nonsense since absolute vacuum fundamentally cannot exist not only in matter but also in the outer space.

Gravity (similarly to the evolutionary process of Universe expansion) reduces the magnitudes of radiuses of allowed orbits of electron shells in atom in background Euclidean space of CFREU. And, therefore, inside the astronomical objects (which matter is in the state of gravithermodynamic equilibrium) the non-Dopplerian (gravitational) blueshift of the wavelength of emissive radiation in the process of its generation takes place in CFREU instead of the redshift. However, the gravitational shift of the frequency of emissive radiation is absent in GT-FR since neither the radiuses of allowed electron orbits in atom nor the real velocity of propagation of interaction in matter depend on the value of strength of gravitational field on matter and on the spatial distribution of hypothetical coordinate velocity of light that defines this strength. Moreover, it corresponds to the accepted in GR concept of fundamental unobservability of gravitational deformation of matter on the level of its microobjects. And we, of course, should agree with this concept as well as with the fundamental unobsevability of relativistic deformation of moving matter. Otherwise the general covariance of equations and laws of physics would not be fulfilled.

Despite this the observability of deformation of the orbits of electron shells in atoms under the influence of gravitational pressure can take place in GR. However, if we suggest that while approaching the gravitational attraction center the radiuses of allowed orbits of electron shells are reduced very insignificantly (at least in photosphere of stars) then the very insignificant decrease of real velocity of propagation of electromagnetic interaction will compensate the influence of this on the frequency of emissive radiation. And, then, despite the decreasing of limit velocity of individual motion of baryonic matter (alternative to coordinate velocity of light of GR) the frequency of the same emissive radiation will, obviously, remain the same within the whole photospheric matter that is located in the spatially inhomogeneous state of equilibrium (in GT-FR, as well as in any GQ-FR). De facto the "purely gravitational" decreasing and the "purely thermodynamic" increasing of the frequency of emissive radiation of quasi-equilibrium cooling down matter of non-active stars are mutually compensated. And, therefore, gravithermodynamic shift of the frequency of this emissive radiation is absent. It means that widening of spectral lines of emission radiation can be only Dopplerian – can be caused only by the thermal fluctuations of molecules of the matter. This is confirmed by the absence of gravitational and thermodynamic blurring of spectral lines of excited atoms of cold rarefied galaxy medium even when values of their main quantum numbers are $n \approx 1000$ ($\lambda > 20$ m) [48, 49][9].

And, consequently, the significant non-Doplerian redshift of the spectrum of emissive radiation can take place only for those astronomical objects (that do not have a solid nucleus) the liquid and gaseous homogenous matter of which is in non-equilibrium thermodynamic state. And it will be determined exactly by the thermodynamic parameters of matter and not by the values of limit velocity of individual motion of baryonic matter and of correspondent to it gravitational potential. However in GR such astronomical objects are not considered at all since density of the hybrid enthalpy (together with density of the inert free energy at rest $E_0/V = m_{in0}c^2/V = m_{00}cv_{cv}/V = \mu_{00}cv_{cv}$) is used instead of density of the ordinary rest energy $W_0/V = \mu_{gr0}c^2 = \mu_{00}c^3/v_{cv}$, which is identical to the

[9] Their size, in correspondence to Bohr's model, reaches 0,1 mm, while the wave length of the line C766α of carbon is 20 meters. The reason that prevents the existence of more highly excited atoms is the background galactic radio emission that is propagated throughout the whole Galaxy. The brightness temperature of the background increases with the wave length increasing. That is why the density of quanta, capable to cause the induced transitions in the atom, increases with the increasing of the excitement level of the atom *n*. The sections of such transitions increases together

multiplicative component of Gibbs free energy, in the tensor of energy-momentum (where m_{00} is the eigenvalue of the mass of one mole of matter; $\mu_{00}=m_{00}/V$ is the eigenvalue of density of matter mass).

So, all physical properties of such matter do not depend on gravitational field that is formed by its intranuclear characteristics. Gravitational field reveals itself in the presence of spatial gradients of thermodynamic parameters and potentials as well as other known parameters and characteristics of solid homogenous matter. That is why in RGTD, as well as in classic thermodynamics, it is enough to use only two independent parameters for the description of spatially inhomogeneous quasi-equilibrium thermodynamic state of continuous homogeneous matter. Three independent parameters are used in GR. It is considered that physical properties of the same such matter depend also on the magnitude of coordinate velocity of light in it when the values of its two thermodynamic parameters[10] are equal. That is why purely thermodynamic redshift of radiation spectrum in photospheric layer of solid homogeneous liquid of gaseous matter (that is in the state of thermodynamic quasi-equilibrium) is considered in GR as gravitational. Though, of course, in general case it is indeed gravitationally-thermodynamic.

Despite the quite large velocity of motion of Solar system in the Universe (near 370 *km/s*) the anisotropy of namely the real velocity of light (and not the conventional coordinate velocity of light in hypothetical absolute vacuum) is absent in isotropic media. And, therefore, the matter (being adapted to its velocity of motion) not only reduces its size but also (being conformally-gaugely deformed [36, 50]) sets the anisotropy of its physical properties (and of its refractive index of radiation [51]) in FR in which it moves. And this means that relativistic shrinkage of length of moving matter is determined neither by hypothetical coordinate velocity of light nor by alternative to it limit velocity of matter individual (separate) motion. And since not only the limit velocity of matter individual motion defines the magnitude of its relativistic dimensions shrinkage it can be non-equal in the same point of space for different matters. That is why RGTD suggests the possibility of inequality of values of gravitational potentials (that are formed based on the limit velocity of matter individual motion) on the boundary of media and even phases of the same matter. However using the correspondent gauge coefficients the non-equal for different matters (and for

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with the increasing of *n*. As a result, when *n* value is close to 1000 the life time of the atom on current levels becomes so short that one cannot distinguish any spectral lines [48, 49].

[10] The gravitational field sets only the gradients of the limit velocity of individual motion of matter, and therefore, of the coordinate pseudo-vacuum velocity of light identical to it. Therefore, different substances at the same point in space may have different values of this velocity. The greater the molar mass of matter, the smaller its value of this velocity will be (the value which can be identical to the general value of the coordinate pseudo-vacuum velocity of light only in an astronomical body formed only from the same matter). And therefore, the value of the general coordinate pseudo-vacuum velocity of light in an astronomical body containing a inhomogeneous substance in no way affects the thermodynamic parameters and potentials of matter, which depend only on the specific values of the limit velocity of individual motion inherent only to this matter.

their phase states) inranuclear as well as thermodynamic potentials (that are used in logarithmic gravitational potential) still can be lead to some unified logarithmic parameter of gravitational potential (similarly to using of conventional coordinate velocity of light in GR in hypothetical absolute vacuum, based on which the spatial distribution of logarithmic gravitational potentials is formed[11]). Such universal parameters can be e.g. the limit velocities of mutual motion of all RGTD-bonded homogeneous substances, at which all those substances are still able to form common collective Gibbs gravithermodynamic microstates.

And this means that logarithmic gravitational potentials can be formed based on some thermodynamic as well as other physical properties of matter. RGTD admits the usage (as gravitational potential) of not only the logarithm of limit velocity of matter individual motion or logarithm of multiplicative component of its Gibbs free energy (that is inversely proportional to this velocity). Gravitational potential can also be formed in it based on the logarithm of function of internal scale factor of matter [29 – 31, 35] and of refractive index of its radiation (or of the real velocity of propagation of radiation in it v_{cm}) on the standard or chosen frequency of correspondent to it electromagnetic wave. Due to it the purely gravitational redshift of radiation $z_G=(\lambda_G-\lambda_0)/\lambda_0$ can be determined, being based on the fact that:

$$\lambda_G=\lambda_0(n_{hN}/n_{lA})\prod_{i=1}^{k}(n_h/n_l)_i \,,$$

where: n_{hN} is the refractive index of the matter of continuous nucleus of astronomical body on the boundary with the layer (that covers it) of another matter or another phase of the same matter; n_{lA} is the refractive index of the lower layer of atmosphere (photosphere); n_h and n_l are the refractive indexes of intermediate layer of matter on its upper and lower boundaries correspondingly; k – is the number of intermediate layers of matter.

6. Inert free energy of matter

Absolute temperature is an intensive parameter that characterizes only the level of thermal internal energy $U(T,p)$ and enthalpy $H_T(T,p)$, which includes also potential energy of interatomic and intermolecular bonds. Invariance of all thermodynamic parameters and matter characteristics to time transformation denotes that all of them should be relativistic invariants. Therefore, temperatures of phase transitions should remain internal properties of moving matter. This means that the change of thermodynamic parameters and characteristics of matter should have

[11] It is the expediency of using the logarithmic gravitational potential in GR (together with the identity of the inert and gravitational masses of matter only by its own gravity-quantum clock) that allow us to reveal the evolutionary variability of the gravitational "constant" and thereby rid the Universe of dark non-baryonic matter that it does not really need.

indirect influence on the change inert free energy of matter. And, therefore, nonchemical internal potential energy of interatomic and intermolecular bonds can transform into kinetic energy only of chaotic, but not directed, motion of matter molecules.

Not the total thermodynamic internal energy $U=U_0+U_{ad}$ and not the ordinary rest energy $W_0 \equiv G_0 = m_{in0}c^4 v_{cv}^{-2} = m_{gr0}c^2 = m_{00}c^3 / v_{cv}$ of matter, but only the inert free energy at rest of matter $E_0=m_{in0}c^2=m_{00}cv_{cv}$ can be equivalent to the inertial rest mass m_{in0}. Additive compensation $U_{ad} = U - U_0 = G - G_0 > 0$ of multiplicative representation U_0 of thermodynamic internal energy U and Gibbs free energy G of matter is spatially homogeneous and, consequently, does not depend on the strength of gravitational field.

In classical thermodynamics the intranuclear energy considered as one that is not changed in thermodynamic processes. In fact, it is not true. Part of potential intranuclear energy of gas, which pressure is adiabatically increasing, transforms into energy of chaotic[12] state of its nucleons and potential energy of stressed state of matter of the vessel that contains this gas [29, 30]. The release of intranuclear potential energy, which is reserved in deformed shell of the vessel that is in stressed state, takes place during the heating of compressed gas. Solid body freely expands during the process of its heating and the frequency of interaction of its nucleons decreases [29, 30, 37, 43]. Thus, dilation of its gravity-quantum time takes place in a similar way as it happens during body unfree movement. However, increasing of thermal energy of the body, which is accompanied by the increasing of his thermal temperature T, is only non-significantly compensated by the decreasing of its intranuclear energy due to decreasing of intranuclear entropy S_N [13], which corresponds to one mole of matter, and due to decreasing of intranuclear temperature T_N. That is why no essential dependence of molar gravitational mass of matter on thermal component of its[14] can be observed. And it takes place despite the presence of mutual correlation between inert free energy E and thermodynamic internal (free thermal) energy U of matter. During the cooling down of the body non-significant part of its thermodynamic internal energy is spent on replenishment of intranuclear

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[12] It is obvious that chaos is inherent to microworld on all hierarchy levels of self-organization of matter microobjects.

[13] These gravitational parameters, which define the level of intranuclear energy of matter, are conventionally named so here only due to similarity with thermodynamic parameters, which define the level of molecular internal energy of matter. However they, the same as used in GR the pseudovacuum coordinate-like velocity of light and intrinsic time of the matter, can have another physical interpretation that will possibly better correspond to objective reality than considered here their primitive "thermodynamic" interpretation.

[14] The fact that mass of the mater does not depend on its thermal internal energy U has been noticed by many physicists [3], including Einstein and Infeld: "Mass can be measured on the weights, but can we measure the heat? Does a piece of iron have bigger weight when it is heated to red-hot that when it is cold as ice? Experiment shows that no." [52]. In spite of the extra small (for the bodies of laboratory size) predicted by GR temperature-like relative change of gravity force, experiments that have an objective to measure temperature-like dependence of gravity force took place many times. However most of those experiments were not correctly conducted. The most precise measurements gave "paradox" results. The decreasing of the mass of heated bodies was observed instead of the predicted by GR increasing

inert free energy. The similar decreasing of frequency of interaction of nucleons and releasing of intranuclear energy that corresponds to it takes place during the experiments with rotating gyroscope[15].

7. Generalization of RTGD equation

The examined here formalism is the most acceptable for galactic gravitational fields of a big cluster of astronomical objects that are located in the cosmic vacuum and that are held on their trajectories of motion only by centrifugal pseudo-forces. For the continuous matter that resists to gravitational self-contraction due to the presence of internal pressure in it we should also take into account its thermodynamic properties that are described by the equations of thermodynamics.

Inert free energy of matter should be taken into account in generalized differential equations of thermodynamics by means of multiplicative parameter of direct action $q_N = \eta_m N_{RE} v_{lb}/c = \eta_m (1+T_{Ncr}^{-2} T_N^2)^{-1/2} \leq \eta_m$, which is proportional to the limit values of local velocities v_{lb} of homogeneous substances individual motion in CFREU and, therefore, proportional to equivalent to them pseudo-vacuum coordinate-like velocity of light of GR in CFREU ($v_{cvb} \equiv v_{lb}$) [29, 30, 35, 37, 43]. These equations should also contain a multiplicative parameter of reverse action that realizes the negative feedback. Such parameter is obviously the relativistic (longitudinal) external scale factor[16]:

$$N_{RE} = N_E/\Gamma_E = v_l/v_{lb} = \sqrt{1+m_{00}^{-2} c^{-4} p_{Ncr}^2 V_N^2} \geq 1,$$

that increases while approaching the gravitational attraction center (and, therefore, while deepening into cosmological future) and is responsible for the curvature of intrinsic space of matter and together with q_N for the presence of spatial inhomogeneity of intranuclear values of temperature T_N [17], entropy S_N, pressure p_N [18] and pseudo-volume V_N [19]. Here: $\eta_m = c/v_{lcr} = m_{00}/m_{cr}$ is parameter

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of their mass [53, 54]. And this decrease in the gravitational mass of heated bodies is due to its equivalence not to thermodynamic internal (free thermal) energy at all, but actually to Gibbs free energy.

[15] As experiments show [55 – 57], the weight of gyroscope is not increasing with the increasing of kinetic energy of its rotating rotor (as it could be expected when total energy is equivalent to gravitational mass), but, quite the contrary, is decreasing or is not changed at all. It is obvious that rotating movement of the matter when the center of mass is motionless is equivalent to its chaotic movement and, therefore, similar to the thermal motion of the molecules of matter. Therefore observed decreasing of gyroscope weight is possibly caused by the same reason that causes the decreasing of the weight of heated bodies. And it is obvious that the reason is in proportionality of gravity force not to Hamiltonian but to Lagrangian of ordinary rest energy of rotating matter of rotor.

[16] Due to continuous calibration of longitudinal (radial) standard of length in CFREU by its size in GT-FR on the surface of the body ($dR_e = dr_e$) the $N_{RE}=1$ is always on this surface. Due to relativistic non-fulfillment of simultaneity of events in cosmological time measured in the CFREU and events in GT-FR all intrinsic objects of the body belong to cosmological future. Due to this and due to the curvature of intrinsic space of the body $N_{RE}>1$ for all its intrinsic objects.

[17] Conventional intranuclear temperature as well as the temperature of world ensemble consists of identical particles [22], in contrast to thermodynamic temperature, is (similarly to entropy) the really immeasurable parameter.

that corresponds to certain matter and that defines the dependence between q_N and v_{lb}, as well as between other parameters of certain matter; $N_E = r/R \geq \Gamma_E$ is the transverse external scale factor [20], r and R are radial coordinates of matter in GT-FR and CFREU correspondingly; $\Gamma_E > 1$ is relativistic shrinkage of the length of radial segments of the body in GT-FR that happens due to evolutionary isotropic self-contraction of its matter in CFREU; m_{cr}, v_{lcr}, T_{Ncr} and p_{Ncr} are not similar for different phase states of the same matter, as well as for different matters, critical values[21] of eigenvalue of molar mass of matter, limit velocity of its individual motion and also of intranuclear temperature and pressure correspondingly. In correspondence with this, the rate of quantum processes of intranuclear interaction between nucleons in global GT-FR can be characterized by relative average statistic value of frequency of this interaction $f_G = q_N N_{RE} = \eta_m v_l / c = v_l / v_{lcr} \leq \eta_m$, that is proportional to the limit value of local group velocity of matter v_l in GT-FR (and, therefore, proportional to equivalent to it pseudo-vacuum coordinate-like velocity of light of GR[22] in GT-FR $v_{cv} = v_{cvb} N_{RE} \equiv v_l$ [29, 30, 35, 37, 43]). Precisely f_G, similarly to v_{cv} in GR, is responsible for the presence of gravitational pseudo force[23] $\mathbf{F}_G$, that forces matter for free fall. And this pseudo force in GR is proportional to the inertial mass m_{in}, which is equivalent to the Hamiltonian $\mathrm{H} = \hat{E}_0 (1 - v^2 v_{cv}^{-2})^{-1/2} = \hat{m}_{in} c^2 = \hat{m}_{in0} c^2 (1 - v^2 v_{cv}^{-2})^{-1/2} = \hat{m}_{00} c v_{cv} (1 - v^2 v_{cv}^{-2})^{-1/2})$ of the rest energy $\hat{E}_0$ (which is actually inert free energy) of a matter:

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18 Intranuclear pressure is absent on the surface o the body ($N_{RE}=1$) and can reach its critical (limit) value $N_{RE} = (1 - f_N^2)^{-1/2}$ in infinitely far cosmological future, when intanuclear Helmholtz free energy will be already absent ($F_N = 0$) for the matter.

19 Here, the "intranuclear pseudo-volume" is just the distance of intranuclear interaction. When N_{RE} tends to 1, the intranuclear pressure in non-rigid spherical layers of the atoms and the intranuclear pseudo-volumes (distances of interaction) of those layers both tend to zero. If anisotropic mater indeed has non-uniform angular distribution of its weight [52], then external surfaces of non-rigid layers of its atoms can be ellipsoidal and the molar value of its effective gravitational volume can be proportional to the volume of the sphere with radius that is equal to the modulus of radius-vector of ellipsoidal surface.

20 External scale factor, similarly to coordinate-like velocity of light, defines only the space-time configuration of self-organized spatially inhomogeneous state of matter and, similarly to it, does not characterize its properties observed in people's world and so is not a RGTD-parameter or characteristic of matter. They are external factors for closed system of pairs of mutually complementary intensive and extensive RGTD-parameters of matter and, therefore, it is not possible to measure them in people's world. Their values can be determined only indirectly and only with the accuracy limited by gauge coefficient. So not absolute, but their relative values can be determined.

21 Here, under conventional term "critical values" we consider firstly the values of parameters of the same matter on the boundary of its phases or aggregate states.

22 Coordinate-like velocity of light is not the characteristics of matter, but the characteristics of the form of its being – intrinsic space of GTD-bonded matter. Therefore, it cannot be directly used in equations of thermodynamics. Thermodynamic parameters and characteristics of matter are its self-sufficient properties, although they depend implicitly on the values of coordinate velocity of light. This pseudovacuum velocity of light sets only the spatial gradients of their values. The values themselves are determined by the boundary conditions.

23 In GR only the mechanical component of gravitational pseudo-force, which is counterbalanced by the pressure p, is taken into account while the thermal component of gravitational pseudo-force, which is counterbalanced by the pressure of thermal radiation, is ignored [29, 30, 38 – 40, 44].

$$[\mathbf{F}_G]_{GR} = f_G \frac{d(\mathrm{H} v_{cv})}{d\hat{r}} = -\mathrm{H}\frac{d\ln v_{cv}}{d\hat{r}} = -\mathrm{H}\frac{d\ln m_{in0}}{d\hat{r}} = -\mathrm{H}\frac{d\ln E_0}{d\hat{r}} = \mathrm{H}\frac{d\ln W_0}{d\hat{r}}.$$

In RGTD the gravitational pseudo force, in contrast to the pseudo force of inertia, is proportional not to the Hamiltonian of the inert free energy, but to the Lagrangian of ordinary rest energy W_0 (multiplicative component G_0=G-U_{ad}≡W_0 of the thermodynamic Gibbs free energy G of a matter):

$$[\mathbf{F}_G]_{RGTD} = \frac{1}{f_G}\frac{d(\mathrm{L} f_G)}{d\hat{r}} = -\mathrm{L}\frac{d\ln f_G}{d\hat{r}} = \mathrm{L}\frac{d\ln m_{gr0}}{d\hat{r}} = -\mathrm{L}\frac{d\ln E_0}{d\hat{r}} = \mathrm{L}\frac{d\ln W_0}{d\hat{r}}, \text{ where:}$$

$$\mathrm{L} = W_0(1-v^2 v_l^{-2})^{1/2} = m_{gr}c^2 = m_{gr0}c^2(1-v^2 v_l^{-2})^{1/2} = m_{00}(c^3/v_l)(1-v^2 v_l^{-2})^{1/2} =$$

$$= m_{cr}c^4 v_l^{-2} f_g (1-v^2 v_l^{-2})^{1/2} = m_{cr}(\eta_m^2 c^2/f_g)(1-v^2 v_l^{-2})^{1/2}.$$

Lagrangian of ordinary rest energy W_0 of the matter, the same as Hamiltonian inert free energy E_0 of a matter, is conserved in the process of matter free fall ($\mathrm{L} = \mathbf{const}(\hat{r})$), since thermodynamic state of matter and, consequently, its thermodynamic internal energy are invariable during that process[24]. Lagrangian of inert free energy E_0 of a matter tends to the minimum (as befits it) in the process of free fall of matter in the gravitational field. Hamiltonian of ordinary rest energy W_0 of a matter, to which the coordinate mass is equivalent in GR [38], also does not conserve.

According to it, frequency of nucleons intranuclear interaction in GT-FR:

$$f_G = N_{RE}q_N = m_{in0}/m_{cr} = E_0/E_{0cr} = (W_0 - S_N T_N + V_N p_N)/(W_{0cr} - S_{Ncr}T_{Ncr} + V_{Ncr}p_{Ncr})$$

is equal to the division of the inertial mass m_{in0} of one mole of matter by the critical value of this mass m_{cr}=$E_{cr}c^{-2}$, which corresponds to critical equilibrium value W_{0cr}=$m_{cr}c^2$+$S_{Ncr}T_{Ncr}$−$V_{Ncr}p_{Ncr}$ of the ordinary rest energy. Here:

$$W_0 = m_{gr0}c^2 = E_0 + T_N S_N - p_N V_N = \frac{\eta_m^2 m_{cr} c^2}{q_N N_{RE}} = \frac{\eta_m m_{00} c^2}{q_N^* N_{RE}^*} = m_{00}c^2\sqrt{1 - p_{Ncr}^{-2}p_N^2 + T_{Ncr}^{-2}T_N^2} = \frac{m_{00}^2 c^4}{\sqrt{m_{00}^2 c^4 + p_{Ncr}^2 V_N^2 - T_{Ncr}^2 S_N^2}} =$$

$$= \frac{m_{00}^2 c^4}{E_0} = \frac{m_{00}^2 c^4 p_N}{p_{Ncr}^2 V_N} = \frac{m_{00}^2 c^4 T_N}{T_{Ncr}^2 S_N} = m_{00}^2 c^4\sqrt{\frac{1 - p_{Ncr}^{-2}p_N^2}{m_{00}^2 c^4 - T_{Ncr}^2 S_N^2}} = m_0^2 c^4\sqrt{\frac{1 + T_{Ncr}^{-2}T_N^2}{m_{00}^2 c^4 + p_{Ncr}^2 V_N^2}},$$

$$W_0(q_N,N_{RE}) = E_0(q_N,N_{RE}) + S_N(q_N,N_{RE})T_N(q_N) - V_N(N_{RE})p_N(q_N,N_{RE}),$$

$$W_0(q_N^*,N_{RE}^*) = E_0(q_N^*,N_{RE}^*) + S_N(q_N^*)T_N(q_N^*,N_{RE}^*) - V_N(q_N^*,N_{RE}^*)p_N(N_{RE}^*),$$

$$E_0 = m_{00}c^2 q_N N_{RE}/\eta_m = m_{cr}c^2 q_N N_{RE} = m_{cr}c^2 q_N^* N_{RE}^* = \sqrt{m_{00}^2 c^4 + p_{Ncr}^2 V_N^2 - T_{Ncr}^2 S_N^2} = \frac{m_{00}c^2}{\sqrt{1 - p_{Ncr}^{-2}p_N^2 + T_{Ncr}^{-2}T_N^2}} =$$

[24] The thermodynamic internal energy of matter increases and becomes equal to the former enthalpy only at the beginning of the fall of the body due to the disappearance of pressure in its matter in a state of weightlessness. This is accompanied by an increase in the size of the freely falling body along the direction of its motion, and also by a decrease in the molar volume of its matter.

$$=\frac{p_{Ncr}^2 V_N}{p_N}=\frac{T_{Ncr}^2 S_N}{T_N}=\sqrt{\frac{m_{00}^2c^4-T_{Ncr}^2S_N^2}{1-p_{Ncr}^{-2}p_N^2}}=\sqrt{\frac{m_{00}^2c^4+p_{Ncr}^2V_N^2}{1+T_{Ncr}^{-2}T_N^2}},$$

$$H_{N0}=E_0-p_NV_N=\frac{m_{00}c^2[\eta_m^2-(\eta_m^2-q_N^2)N_{RE}^2]}{q_NN_{RE}}=\frac{m_{00}c^2q_N^*}{\eta_mN_{RE}^*}=\frac{V_N(p_{Ncr}^2-p_N^2)}{p_N}=\sqrt{(m_{00}^2c^4-T_{Ncr}^2S_N^2)(1-p_{Ncr}^{-2}p_N^2)}=$$

$$=\frac{(m_{00}^2c^4-T_{Ncr}^2S_N^2)T_N}{T_{Ncr}^2S_N}=\frac{m_{00}^2c^4-T_{Ncr}^2S_N^2}{\sqrt{m_{00}^2c^4+p_{Ncr}^2V_N^2-T_{Ncr}^2S_N^2}}=\frac{m_{00}c^2(1-p_{Ncr}^{-2}p_N^2)}{\sqrt{1-p_{Ncr}^{-2}p_N^2+T_{Ncr}^{-2}T_N^2}}=\frac{m_{00}^2c^4-p_{Ncr}^2V_N^2T_{Ncr}^{-2}T_N^2}{\sqrt{(m_{00}^2c^4+p_{Ncr}^2V_N^2)(1+T_{Ncr}^{-2}T_N^2)}},$$

$$F_{N0}=E_0+T_NS_N=\frac{m_{00}c^2\eta_mN_{RE}}{q_N}=\frac{m_{00}c^2[\eta_m^2-q_N^{*2}(1-N_I^{*2})]}{q_N^*N_I^*}=\frac{S_N(T_{Ncr}^2+T_N^2)}{T_N}=\sqrt{(m_{00}^2c^4+p_{Ncr}^2V_N^2)(1+T_{Ncr}^{-2}T_N^2)}=$$

$$=\frac{(m_{00}^2c^4+p_{Ncr}^2V_N^2)}{p_{Ncr}^2(V_N/p_N)}=\frac{m_{00}^2c^4+p_{Ncr}^2V_N^2}{\sqrt{m_{00}^2c^4+p_{Ncr}^2V_N^2-T_{Ncr}^2S_N^2}}=\frac{m_{00}c^2(1+T_{Ncr}^{-2}T_N^2)}{\sqrt{1-p_{Ncr}^{-2}p_N^2+T_{Ncr}^{-2}T_N^2}}=\frac{m_{00}^2c^4-T_{Ncr}^2S_N^2p_{Ncr}^{-2}p_N^2}{\sqrt{(m_{00}^2c^4-T_{Ncr}^2S_N^2)(1-p_{Ncr}^{-2}p_N^2)}},$$

$$dE_0=p_NdV_N-T_NdS_N,\ dF_{N0}=p_NdV_N+S_NdT_N,\ dH_{N0}=-V_Ndp_N-T_NdS_N,\ dW_0=-V_Ndp_N+S_NdT_N,$$

$$S_N=\frac{m_{00}c^2N_{RE}}{\eta_mT_{Ncr}}\sqrt{\eta_m^2-q_N^2}=\frac{m_{00}c^2}{\eta_mT_{Ncr}}\sqrt{\eta_m^2-(q_N^*)^2}=\frac{m_{00}c^2}{T_{Ncr}}\sqrt{1-\frac{v_l^2}{c^2(N_{RE}^*)^2}}=\frac{ET_N}{T_{Ncr}^2}=\frac{m_{00}c^2T_N}{T_{Ncr}^2\sqrt{1-p_{Ncr}^{-2}p_N^2+T_{Ncr}^{-2}T_N^2}}=$$

$$=\frac{T_N}{T_{Ncr}}\sqrt{\frac{m_{00}^2c^4+p_{Ncr}^2V_N^2}{T_{Ncr}^2+T_N^2}}=\frac{p_{Ncr}^2V_N}{T_{Ncr}p_N}\sqrt{\frac{p_N^2}{p_{Ncr}^2}\left(1+\frac{m_{00}^2c^4}{p_{Ncr}^2V_N^2}\right)-1},$$

$$T_N=T_{Ncr}\frac{\sqrt{\eta_m^2-q_N^2}}{q_N}=T_{Ncr}\frac{\sqrt{\eta_m^2-(q_N^*)^2}}{q_N^*N_{RE}^*}=\frac{cT_{Ncr}}{v_l}\sqrt{1-\frac{v_l^2}{c^2(N_{RE}^*)^2}}=\frac{T_{Ncr}^2S_N}{E}=\frac{T_{cr}^2S_N}{\sqrt{m_{00}^2c^4+p_{Ncr}^2V_N^2-T_{Ncr}^2S_N^2}}=$$

$$=T_{Ncr}^2S_N\sqrt{\frac{1-p_{Ncr}^{-2}p_N^2}{m_{00}^2c^4-T_{Ncr}^2S_N^2}}=T_{Ncr}\sqrt{\frac{p_N^2}{p_{Ncr}^2}\left(1+\frac{m_{00}^2c^4}{p_{Ncr}^2V_N^2}\right)-1},$$

$$V_N=\frac{m_{00}c^2}{p_{Ncr}}\sqrt{N_{RE}^2-1}=\frac{m_{00}c^2q_N^*}{\eta_mp_{Ncr}}\sqrt{(N_{RE}^*)^2-1}=\frac{m_{00}cv_l^*}{p_{Ncr}}\sqrt{1-(N_{RE}^*)^{-2}}=\frac{m_{00}c^2p_N}{p_{Ncr}^2\sqrt{1-p_{Ncr}^{-2}p_N^2+T_{Ncr}^{-2}T_N^2}}=$$

$$=\frac{Ep_N}{p_{Ncr}^2}=\frac{p_N}{p_{Ncr}}\sqrt{\frac{m_{00}^2c^4-T_{Ncr}^2S_N^2}{p_{Ncr}^2-p_N^2}}=\frac{T_{Ncr}^2S_N}{p_{Ncr}T_N}\sqrt{1+\frac{T_N^2}{T_{Ncr}^2}\left(1-\frac{m_{00}^2c^4}{T_{Ncr}^2S_N^2}\right)},$$

$$p_N=p_{Ncr}\frac{\eta_m\sqrt{N_{RE}^2-1}}{q_NN_{RE}}=p_{Ncr}\sqrt{1-(N_{RE}^*)^{-2}}=\frac{cp_{Ncr}}{v_l}\sqrt{N_{RE}^2-1}=\frac{p_{Ncr}^2V_N}{E}=\frac{p_{Ncr}^2V_N}{\sqrt{m_{00}^2c^4+p_{Ncr}^2V_N^2-T_{Ncr}^2S_N^2}}=$$

$$=p_{Ncr}^2V_N\sqrt{\frac{1+T_{Ncr}^{-2}T_N^2}{m_{00}^2c^4+p_{Ncr}^2V_N^2}}=p_{Ncr}\sqrt{1+\frac{T_N^2}{T_{Ncr}^2}\left(1-\frac{m_{00}^2c^4}{T_{Ncr}^2S_N^2}\right)};$$

$$q_N^*=\sqrt{\eta_m^2-N_{RE}^2(\eta_m^2-q_N^2)}=\eta_m\sqrt{1-m_{00}^{-2}c^{-4}T_{Ncr}^2S_N^2},$$

$$N_{RE}^*=r/(R^*\Gamma_E^*)=q_NN_{RE}/q_N^*=q_NN_{RE}[\eta_m^2-N_{RE}^2(\eta_m^2-q_N^2)]^{-1/2}=(1-p_{Ncr}^{-2}p_N^2)^{-1/2}$$

and Γ_E^* are conjugate values of the parameters q_N, N_{RE} and Γ_E that correspond to the points of intrinsic space of hollow astronomical body (separated by singular surface from its external space) where values of Schwarzschild radial coordinates r are the same as in external space.

It is obvious that not only m_{cr}, v_{lcr}, T_{Ncr} and p_{Ncr}, but also W_{0cr} are individual parameters that characterize certain matter and are, possibly, related only to its certain aggregate or phase state[25].

The greater value of internal energy and Gibbs free energy of matter (that corresponds to gravitational potential) is taken by the matter only in the state of the rest, when matter comes to thermodynamic equilibrium with environment. Evolutionary increase of internal energy and Gibbs free energy of matter in CFREU also corresponds to the increase of this energies while approaching its the gravitational attraction center. But, since in CFREU: $N_{Eb} = N_E \exp[H_E(\tau - \tau_0)] = N_E/(1+z)$, $\Gamma_E = \mathbf{const}(\tau)$, $q_{Nb}=q_N\exp[-H_E(\tau-\tau_0)]=q_N(1+z)$, then: $f_G=q_{Nb}N_{Eb}=q_N N_E=\mathbf{const}(\tau)$ and, consequently, in people's world FR the evolutionary increasing of internal energy and Gibbs free energy of matter cannot be observed in principle. Here: H_E is Hubble constant, that sets the speed of evolutional expansion of the Universe, τ is cosmological time, counted in CFREU by metrically homogeneous scale ($d\tau = dt$), z is Dopplerian redshift of the wave length of radiation of astronomical object, characteristics of which are being determined. However in CFREU according to Hubble law both the molar ordinary rest energy W_{0b} and the molar inert free energy E_{0b} are changed. And, therefore, the also equivalent to it molar inertial mass m_{inb} is changed[26]:

$$W_{0b}=W_0 N_b=W_0 N_E\exp[H_E(\tau-\tau_0)]=W_0 N_E/(1+z),$$

$$E_{0b}=m_{in0b}c^2=E_0/N_{Eb}=(E_0/N_E)\exp[-H_E(\tau-\tau_0)]=(E_0/N_E)(1+z).$$

Not only the molar inertial mass itself ([1+z] times), but also its concentration in intrinsic space of the matter ($[1+z]^3$ times) was bigger in that distant time [74]. And it means that the need in "non-baryonic dark matter"[27] can be fictive.

Physical space that is rigidly connected with cooling down body self-contracts not only in CFREU, but also in intrinsic metric space of the body that has non-rigid intrinsic FR [50]:

$$R = \rho\exp[-(H_E + H_{TE})(\tau - \tau_0)], \qquad r = \rho\exp[-H_{TE}(t - t_0)],$$

[25] It is also possible that in case of anisotropic matter those constants have non-equal values for different directions. Then the value of intranuclear energy of those matters will be dependent on their orientation related to the direction of gradient of gravitational field or to the motion direction. Such possibility can be taken into account due to results of experiment where the anisotropy of weight of monocrystal has been revealed [52]. The values of these constants for each certain matter can be determined by experimental dependencies of the change of intranuclear energy on the changes of temperature and pressure and, therefore, on the change of the Gibbs free energy.

[26] Total energy and momentum are saved only when time and space are homogeneous. The stationarity of the Universe is required for evolutionary saving of molar inertial mass of the matter. Gradual decreasing of mass of rotating astronomical bodies in a binary star system was found by Taylor [58] and Hulse, and, possibly, it is not only evolutionary but also kinematic effect. However, it is mistakenly "connected" with the loss of energy of those objects that is carried away by principally non-existent gravitational radiation (gravitational waves).

where: ρ is radial coordinate, which is counted by rigidly connected with body coordinate grid not in metric space but in physical space of gradually cooling down body, H_{TE} is parameter that characterizes the speed of observed shrinkage of the dimensions of cooling down body.

And due to $EW = m_{00}^2 c^4 = \mathbf{const}$ the following situation will take place. The inert free energy and corresponding to it inertial mass of the matter will decrease the same number of times as the ordinary rest energy is increased. Gravitational mass will not be increasing proportionally to the increasing of the ordinary rest energy because of the violation of thermodynamic equilibrium between heated matter and environment. Quite the contrary, it will be decreasing together with inertial mass since by the intrinsic clock of experimenter these masses should be equal one to another. This is in a good correspondence with the results of experiments since for the many heated metallic bodies the decreasing of their mass is observed [52 – 54][28]. And this decrease in the gravitational mass of heated bodies is due to its equivalence not to thermodynamic internal (free thermal) energy at all, but actually to Gibbs free energy. After all, free thermal energy, like the free kinetic energy of matter, has no weight and is not included to the composition of the Gibbs and Helmholtz free energies. But the increments of these two energies are determined by the increments of only the intensive parameters in the Gibbs free energy.

So the correlation of thermodynamic characteristics of matter with its intranuclear gravithermodynamic characteristics takes place only for homogenous continuous matter that is in the quasi-equilibrium state and, therefore, in a thermodynamic equilibrium with environment. That is why the usage only of extra-nuclear thermodynamic characteristics of not continuous matter instead of intranuclear characteristics in the equations of gravitational field id fundamentally impossible when there is no correlation between them.

The presence of correlation between them in quasi-equilibrium state of homogenous continuous matter is found by Tolman [3] in a form of spatial homogeneity of parameter $T_{00} = Tv_{cv}/c = \mathbf{const}(r)$. If coordinate pseudo-vacuum velocity of light v_{cv} characterizes the rate of intranuclear gravity-quantum processes, then the absolute temperature T characterizes the rate of extranuclear thermodynamic processes. And, consequently, in quasi-equilibrium state of matter the slower the

[27] As we can see, the fictive need in "dark energy" and "non-baryonic dark matter" in the Universe is directly related to the phenomenon of Universe expansion in people's world FR and is caused by not understanding of real causes and physical essence of this phenomenon.

[28] Dependencies of molar mass of the liquid on the pressure and temperature can be determined by putting the liquid into the vessel under the randomly loaded vertical piston. The change of inert free energy (weight) of the liquid can be controlled with the help of several pairs of mutually selected by their sensibility load cells that are located above and under (under the piston) the liquid column and are connected according to the differential "bridge" scheme. Firstly, we should reach the zero value of many times ("cascadingly") amplified differential signal from upper and lower load cells with the help of balancing of the "bridge" in initial thermodynamic state of liquid. Secondly, we should increase the pressure in the liquid via loading the piston or increase the temperature via isobaric heating of the liquid. In order to determine the measurement errors, caused by the mutual difference of sensibilities of load cells, we can repeat measurements with swapping the load cells in each of their pairs (swap upper with lower).

rate of intranuclear processes in it the faster the rate of extranuclear processes. Therefore, together with gravity-quantum proper time, in which the intrinsic value of pseudo-vacuum velocity of light $c=\mathbf{const}(r)$ is invariant parameter, it is worth to examine the thermodynamic intrinsic time, in which gravithermodynamic eigenvalue of temperature $T_{00}=\mathbf{const}(r)$ is invariant within the limits of all RGTD-bonded homogeneous matter that is in quasi-equilibrium state.

All thermodynamic potentials of homogeneous continuous matter in a quasi-equilibrium state vary in mutual proportion along the radial coordinate and increase with approach to the center of gravity. The inert free energy, on the contrary, reaches its minimum precisely at the center of gravity of any astronomical body. After all, when approaching the center of gravity the coordinate velocity of light tends to its minimum, while the temperature of matter quite the contrary tends to its maximum.

The equivalence of the ordinary rest energy $\hat{W}_0$, and therefore the gravitational mass of extremely cooled matter, to the multiplicative component $H_{T0} = U + pV - U_{ad} = U_0 + pV \equiv \hat{W}_0$ of enthalpy of extremely cooled matter, and not only to its internal energy, is actually justified in the GR. After all, in the GR, as a rule, the energy of the extended thermodynamic system is used, which takes into account the pressure load of matter and in the four-momentum of the substance, the density of the hybrid enthalpy is used, and not the mass of matter that is not loaded by pressure. The mass of matter that is not loaded by pressure is used in the GR only instead of the inertial mass, which is equivalent in the RGTD to the inert free energy of matter. And in general, in most physical experiments, exactly the mass of matter that is loaded with atmospheric pressure is used[29].

Spatially inhomogeneous equilibrium RGTD-state of liquid and gaseous matter takes place in the case of fulfillment of the following: $W_j=(f_{Gi}/f_{Gj})W_i$. In the case of isotropy of radial distribution of physical parameters and characteristics of homogeneous matter of astronomical object it can be shown in the following way: $W_{00}^*=f_G(r)W(r)=\mathbf{const}(r)$. In the case of radial altitudinal multi-layer distribution of inhomogeneous matter this condition is fulfilled layer by layer, with the break on the boundaries of two media: $W_{00(k+1)}^*=f_{G(k+1)}W_{(k+1)}<W_{00k}^*=f_{Gk}W_k$, where $(k+1)$ is serial number of the less dense and, therefore, more distanced from the Galaxy center matter.

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[29] You can check whether the pressure in a gas has weight, and therefore whether the gravitational mass of a gas depends on its enthalpy, as follows. It is necessary to place a closed cavity on high-precision scales together with a cylinder with compressed gas. Having opened the cylinder valve remotely with an electric drive, it is necessary to fill the closed cavity, which has a sufficiently large volume, with compressed gas. It is advisable to use the cavity of a vacuum installation as a closed cavity so that the compressed gas can be injected exactly into a vacuum. Only this will ensure that the number of gas molecules in both measurements of its weight remains the same.

In equations of GR gravitational field the hybrid thermodynamic enthalpy $\hat{H}_{Th} = \hat{E}_0 + pV = E_{00}v_{cv}/c + V_{00}p_{00}c/v_{cv}$ ($d\hat{H}_{Th} = (\hat{E}_0 - pV)d\ln v_{cv}$)[30] is de facto used. This hybrid enthalpy is based on the fact that the density of internal energy $U/V = (U_{00}c/v_{cv} + U_{ad})/V$ is changed to completely inert free energy $\hat{\mu}_{in0}c^2 = \hat{\mu}_{00}v_{cv}c = \hat{E}_0/V$ of hot matter that is not under pressure. And this is due to the erroneous identification in GR of the ordinary rest energy[31] of matter with its thermodynamic internal energy U instead of identifying it with the multiplicative component of Gibbs free energy $G_0 \equiv W_0$ or even with the enthalpy H_{T0}, only which can truly be considered as the complete rest energy $\hat{W}_0 \equiv H_{T0} = W_0 + TS = U_0 + pV = (\hat{m}_{th00}c^2 + p_{00}V_{00})c/v_{cv}$ of matter, and not simply as the energy of an extended thermodynamic system. Equilibrium state of ideal liquid in GR is reached only in case of mutual absence of radial gradients in proper gravity-quantum time of matter of not only eigenvalue of temperature $T_{00}=Tv_{cv}/c=\mathbf{const}(r)$, but also of its eigenvalue of hybrid enthalpy $H^*_{00} = \hat{H}_{Th}v_{cv}/c = \mathbf{const}(r)$, and of entropy $S = \mathbf{const}(r)$ [3, 30, 35, 40]. These conditions fulfill the more general condition of equilibrium state of liquids and gases – spatial homogeneity of gravithermodynamic eigenvalue of Gibbs free energy:

$$G^*_{00}=(v_{cv}/c)G=H^*_{00}-ST_{00}=\mathbf{const}(r),$$

where: $dG^*_{00}=(U/c)dv_{cv}+Vdp_{00}-SdT_{00}=0$, $p_{00}=pv_{cv}/c$. This implies:

$$(U/Vc)dv_{cv}=-dp_{00}+(S/V)dT_{00}=-[(p-TS/V)dv_{cv}+v_{cv}dp-(v_{cv}S/V)dT]/c,$$

$$dp=-(U/V+p)d\ln v_{cv}+(S/V)dT_{00},$$

and when $T_{00}=\mathbf{const}(r)$ and in the case of replacement of density of internal energy by the density of inert free rest energy $\mu_{in0}c^2 = \mu_{00}v_{cv}c = (\hat{\mu}_{00} + p_{00})v_{cv}c = E_0/V$ the following dependency could be used in GR:

$$\frac{dp}{dr} = -\mu_{in0}c^2\frac{d\ln v_{cv}}{dr} = -\frac{\mu_{in0}c^2}{2b}\frac{db}{dr} = -\frac{\hat{\mu}_{00}c^2 + p_{00}}{2\sqrt{b}}\frac{db}{dr},$$

where: $b=v^2_{cv}/c^2$.

However, indeed not the values in FR (ordinary values) but eigenvalues of the density of pressure p_{00} and the density of mass $\hat{\mu}_{00}$ (which, unlike the eigenvalue value of the true density of mass $\mu_{00} = \hat{\mu}_{00} + p_{00} - T_{00}S/V$, is the eigenvalue value of the density of mass of hot matter that is not under pressure) are used in the tensor of energy-momentum of GR [38]. Being based on this the

[30] While the increment of inert free energy (when we differentiate by coordinate velocity of light) is positive the increment of the product of pressure and molar volume is negative.

dependence that corresponds not to the value in FR but to the eigenvalue $\hat{E}_{00} = \hat{\mu}_{00}c^2V = \hat{E}/\sqrt{b}$ of inert free rest energy of hot matter (that is not under pressure) is used in GR:

$$\frac{dp_{00}}{dr} = -\hat{\mu}_{00}c^2\frac{d\ln v_{cv}}{dr} = -\frac{\hat{\mu}_{00}c^2}{2b}\frac{db}{dr}. \qquad (2)$$

Equilibrium RGTD-states of matter, in which external gravitational pressure of upper layers of matter is counterbalanced not only by intrinsic pressure inside matter, but also by radiation (thermal) pressure (T_{00}≠**const**(r)), are not considered at all in GR, in contrast to RGTD. And, therefore, GR not only reflect physical reality in more simple way, but also is applied to equilibrium states of only cooled down to the limit homogeneous matter (T_{00}=**const**(r)). That is why the reflection of physical reality in GR should be considered only as the special case of its reflection in RGTD.

Internal energy U of real gases, liquids and solid matters depends on many pairs of their intensive A_i and extensive a_i thermodynamic specific hidden parameters. And there are a very large number of those parameters in solid substances, and therefore the internal energy in these substances is very significant. Those facts prompt us (in the GR) to falsely identify the inert free energy $\hat{E}_0 = \hat{m}_{00}cv_{cv}$ of matter with the multiplicative component $U_0 = U_{00}c/v_{cv}$ of its thermodynamic internal energy due to the use (in the GR) of the eigenvalue of the hybrid enthalpy $\hat{H}_{T00} = \hat{m}_{00}c^2 + p_{00}V_{00} = \hat{H}_{T0}v_{cv}/c = \mathbf{const}(r)$ that is invariant along the radial coordinate r (in the gravitational quantum time of the matter). Similarly, in RGTD, the ordinary rest energy $W_0 = m_{00}c^3/v_l \equiv G_0$ of matter is identified with the multiplicative component G_0 of the Gibbs thermodynamic free energy G. Here: $\hat{m}_{00}$ and m_{00} are the eigenvalues of the mass of matter that is not under pressure and the true mass of the matter, respectively; $p_{00}V_{00} = pVv_{cv}/c = \mathbf{const}(r)$; $U_{00} = \mathbf{const}(r)$, $p_{00} \neq \mathbf{const}(r)$ and $V_{00} \neq \mathbf{const}(r)$ are eigenvalues of the multiplicative component U_0 of the internal energy U, of the pressure p and of the molar volume V of the matter, respectively; v_{cv} and v_l are the coordinate pseudo-vacuum velocity of light of the GR and the equivalent (but not identical) limit velocity of individual (separate) motion of matter (which at the same point in space may be different in the RGTD for different matters) respectively.

However, what is considered here are not at all specific hidden parameters characterizing thermodynamic macrostates of matter, but rather non-specific hidden variables that are mutually related to thermodynamic natural parameters (pressure, molar volume, temperature, and entropy).

[31] However, the possibility of equivalence of the gravitational mass of hot matter, and hence its rest energy, to the Gibbs free energy is not excluded. This is what the decrease in the gravitational mass of matter during its heating may indicate [53, 54].

In addition, non-specific hidden variables that form Gibbs microstates, unlike specific internal macroscopic parameters, can instantly take any values with a certain probability.

Internal energy can also be shown as a sum of internal energy of hypothetic ideal gas (liquid) U_{id} and output of multiplication of resulting intensive $A_\rho(r) = TS / R_T(t) = T^2 S / pV$ and extensive $a_\rho(t) \equiv R_T = pV / T$ thermodynamic parameters:

$$U = U_{id} + \sum_{i=2}^{n} A_i a_i = U_{id} + A_\rho a_\rho ,$$

$$dU = T_{id} dS_{id} + A_\rho da_\rho - pdV = TdS - pdV ,$$

where: $T_{id}{=}TR_T/R_{UT}$, $S_{id}{=}SR_{UT}/R_T$, $A_\rho a_\rho = T_{id} S_{id} = TS$. For gases: $a_i{=}R_{UT}B_i V^{1-i}$, B_i is virial coefficients that depend on both temperature and individual gas properties [5], while R_{UT} is universal gas constant and $R_T(r){=}pV/T{=}\mathbf{const}(t)$ is spatial thermodynamic parameter of a gas, that determines the compressibility coefficient $Z = R_T / R_{UT}$ of a gas and does not vary in space at conditions of quasi-equilibrium cooling down of matter (is the same on any radial distance *r* from the gravitational attraction center in the comoving to it frame of reference of spatial coordinates and time *t*). And exactly this invariability in space of $R_T(t)$ is responsible for the fact that properties of real gases that gradually cools are close to properties of hypothetical ideal gas.

"Ideal" component U_{id} of internal energy is de facto identical to Helmholtz free energy F_T, while "ideal" component H_{Tid} of enthalpy is identical to the Gibbs free energy *G*:

$$U_{id} = U - a_\rho A_\rho = U - ST = F_T , \qquad H_{Tid}{=}H_T{-}a_\rho A_\rho{=}H_T{-}ST{=}G ,$$

$$dU_{id} = T_{id} dS_{id} - a_\rho dA_\rho - pdV = (TdS - \frac{TS}{R_T} dR_T) - (SdT + TdS - \frac{TS}{R_T} dR_T) - pdV = -SdT - pdV = dF_T ,$$

$$dH_{Tid}{=}T_{id}dS_{id}{-}a_\rho dA_\rho{+}Vdp{=}{-}SdT{+}Vdp{=}dG .$$

This, of course, is caused by the absence of binding energy ($\sum_{i=2}^{n} A_i a_i = A_\rho a_\rho = 0$) in ideal gas and ideal liquid due to the absence of electromagnetic interaction of their molecules and atoms. Self-organization of hierarchically more complicated interactions and interconnections in matter is in the tendency of Helmholtz and Gibbs free energies to their minimum.

Lower layers of matter, loaded by its upper layers form the extended system. The energy of such extended system [5] that consists of the whole RGTD-bonded matter is indeed equivalent to enthalpy of a supercooled matter. Therefore, to obtain integral values of the ordinary rest energy and the equivalent to it gravitational mass of any astronomical body, integration must be performed using the spatial distribution of the density of the true mass (equivalent in GR to the enthalpy and in RGTD to the Gibbs free energy of matter), and not at all using the spatial distribution of the density of the "thermal" mass, which is equivalent only to the thermodynamic internal energy of hot matter.

Moreover, as it is shown further, parameter a_ρ (in contrast to A_ρ parameter) takes the same value in the whole space filled by quasi-equilibrium cooling down homogeneous matter ($(\partial a_\rho/\partial r)_t=0$). And, therefore, Gibbs energy "behaves" as it is expected: it only changes in space along the radial coordinate r together with the gravitational potential. And when Gibbs energy changes in time together with the gravitational potential, it "behaves" like multiplicative component of enthalpy (like the energy of thermodynamic extended system).

This is quite logical and reflected in static equations of GR gravitational field. However, in dynamics, the four-momentum should be formed not even by enthalpy, but by the ordinary rest energy of hot matter (which is identical to the multiplicative component the Gibbs free energy[32] in a thermodynamic extended system of matter that gradually gets colder).

Thus, if the GR gravitational field equations are intended to obtain solutions corresponding only to ideal (cooled to the limit) matter, then the use of hybrid enthalpy in these equations instead of ordinary rest energy, which is equivalent to Gibbs free energy, is perhaps justified. However, to obtain solutions corresponding to cooling astronomical objects in quasi-equilibrium state, in these equations instead of hybrid enthalpy, which also includes thermal energy, one should still use ordinary rest energy, which is equivalent to Gibbs free energy and, therefore, does not include the actually released thermal energy.

Ordinary rest energy of matter has an influence on all physical processes. However, due to the fact that in various physical processes the part of its energy is bonded differently the different free energies are formed – inert free energy, Helmholtz free energy, Gibbs free energy and other more exotic free energies. And namely the free energies define the specifics of the flow of correspondent to them physical processes.

In thermodynamics only the increments of internal energy, enthalpy and Gibbs free energy of matter are usually examined. At the same time the theoretically possible in general (and not in some particular conditions of usage) values of their multiplicative components does not have any special importance. On the other hand the ordinary rest energy of matter in mechanics and in the theories of gravity is considered as not reached but reachable in principle in specific conditions its value, when matter receives it from the surrounding environment after the reaching of the state of thermodynamic quasi-equilibrium with it. As it will be shown further, the gravitational-mechanical rest energy of matter W_0 is identical in the same real conditions to the multiplicative component G_0

of its Gibbs free energy, since both of them are described by identical mathematical expressions. However, these identical total energies of matter, as well as free energies that are their components, show themselves differently in different physical processes.

During the quasi-equilibrium self-contraction of cooling down matter the decreasing of its inert free energy is accompanied not by the increasing of velocity of its molecules (in contrast to its free fall in gravitational field) but by the its gradual deceleration. Therefore, the released intranuclear free energy is transformed not into the kinetic energy but into the energy of thermal radiation. During the free fall of the matter in gravitational field (that is not accompanied by the change of its thermodynamic state in principle) the decreasing of its inert free energy is equivalent to an increase in its future rest energy.

Moreover, during the motion of the matter along the elliptic orbit the change of its inert free energy is not accompanied by the change of its thermodynamic state. The change of coordinate velocity of light along the trajectory of orbit, as well as possible decrease of the frequency of interaction of elementary particles due to matter motion, is completely compensated by relativistic shrinkage of distances of interaction. That is why during such inertial motion of matter not only the dilation of intrinsic time does not happen, but also the correlation between intranuclear and extranuclear physical characteristics of matter will not arise. And, consequently, in this case the formation of tensor of energy-momentum of matter based on its extranuclear thermodynamic characteristics is impossible in principle. This tensor can be formed based only on the intranuclear characteristics of matter or on the values of the density of the gravitational and inertial masses of matter dependent on these characteristics.

In addition, according to the GR and the RGTD equations, the configuration of the dynamic gravitational field of a galaxy in a quasi-equilibrium state is standard (canonical in RGTD). Because it is not determined at all by the spatial distribution of the average mass density of its non-continuous matter. After all, this spatial distribution of the average mass density of the galaxy's matter is itself determined by the standard configuration of its dynamic gravitational field:

$$b_c' / a_c b_c r - r^{-2}(1 - 1/a_c) + \Lambda = \kappa(T_N S_N - p_N V_N)/V = \kappa(m_{gr} - m_{in})c^2 / V = \kappa m_{00} c^2 (1/\sqrt{b_c} - \sqrt{b_c})/V ,$$

$$a_c' / a_c^2 r + r^{-2}(1 - 1/a_c) - \Lambda = \kappa E / V = \kappa m_{in} c^2 / V = \kappa m_{00} c^2 \sqrt{b_c} / V ,$$

$$[\ln(b_c a_c)]' / a_c r = \kappa W / V = \kappa m_{gr} c^2 / V = \kappa m_{00} c^2 / \sqrt{b_c} V ,$$

$$S' = \frac{d[r / a_c (1 - b_c)]}{dr} = \frac{1 - r_g' - \Lambda r^2}{(1 - b_c)} + \frac{(r - r_g - \Lambda r^3 / 3)}{(1 - b_c)^2} b_c' = -\frac{b_c S}{r(1 - b_c)} + \frac{(1 - \Lambda r^2)}{(1 - b_c)^2} ,$$

32 Obviously, this is why the gravitational mass of a heated body becomes less than the gravitational mass of a cold body [53, 54].

$$S=\frac{r}{a_c(1-b_c)}=\frac{r-r_g-\Lambda r^3/3}{1-b_c}=\exp\int\frac{-b_c dr}{(1-b_c)r}\times\int\left[\frac{(1-\Lambda r^2)}{(1-b_c)^2}\exp\int\frac{b_c dr}{(1-b_c)r}\right]dr.$$

In addition, in RGTD, unlike GR, bodies that move by inertia in a gravitational field, influence (by their movement) the configuration of the dynamic gravitational field surrounding them. At the same time, in equilibrial processes, along with the usage of ordinary Hamiltonians and Lagrangians, in RGTD it is also possible to use GT-Hamiltonians and GT-Lagrangians. Therefore, in RGTD for matter the Hamiltonian (GT-Hamiltonian) four-momentum must obviously be formed system not by the Hamiltonian of the enthalpy, but by the Hamiltonian (GT-Hamiltonian) of the inert free energy, and Lagrangian (GT-Lagrangian) four-momentum must obviously be formed by the Lagrangian (GT-Lagrangian) of the ordinary rest energy (the multiplicative component of thermodynamic Gibbs free energy) of extremely cooled matter of an astronomical object. For a cooling matter in a quasi-equilibrium state, a similar Lagrangian (GT-Lagrangian) four-momentum can also form the Lagrangian (GT-Lagrangian) of the multiplicative component of the Gibbs free energy.

And therefore, in equilibrial processes of orbital motion of astronomical bodies, along with the usage of ordinary Hamiltonians and Lagrangians, in RGTD it is also possible to use GT-Hamiltonians [Newtonians] N and GT-Lagrangians [Keplerian] K of astronomical objects:

$$\mathrm{N}=m_{in}c^2=m_{in0}c^2(1+v^2v_l^{-2})^{1/2}=m_{00}cv_{lc}=\mathrm{K}b(1+\hat{v}^2c^{-2})=\mathrm{K}b(1+v^2v_l^{-2})=\mathrm{K}b_c,$$

$$\mathrm{K}=W_0c/v_{lc}=m_{gr}c^2=m_{gr0}c^2(1+v^2v_l^{-2})^{-1/2}=m_{00}c^3/v_{lc}=\mathrm{N}/b(1+\hat{v}^2c^{-2})=\mathrm{N}/b(1+v^2v_l^{-2})=\mathrm{N}/b_c,$$

$$\mathbf{P}_{\mathrm{K}}=m_{gr0}v(1+v^2v_l^{-2})^{-1/2}=m_{00}cv/v_{lc}=m_{00}vc(v_l^2+v^2)^{-1/2}=m_{00}vc/v_{lc}=m_{00}\hat{v}.$$

When $b_c=b+v^2v_l^{-2}=(v_l^2+\hat{v}^2)c^{-2}<1$, this is what ensures the absence of slowing down of the flow of the intrinsic time of a moving matter:

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

where: $b=v_l^2c^{-2}$, v_l is the limit velocity of group motion of matter in a hypothetical static gravitational field.

Spontaneous change of RGTD-state of coherent matter and, consequently, its free fall are possible only when they are accompanied by continuous decreasing f_G and thereby decreasing of matter inertial mass at rest.

Since during the free fall of matter in gravitational field the inert free energy is consumed exactly the increments of this energy should be determined by the increments of extensive intranuclear parameters S_N and V_N. According to this, in the process of during matter free fall ($dS=0$, $dV=0$, $d\mathrm{L}\equiv dW=0$, $dW_0>0$, $d\mathrm{H}\equiv dE=0$, $dE_0<0$) evolutionary-gravitational increasing of intranuclear entropy ($dS_N>0$) that is accompanied (as a partial compensation for the effect of its increasing) by increasing of molar value of intranuclear volume ($dV_N>0$) and, thus, by the release of inert free energy E_0 (instead of thermal energy) with its further transformation into kinetic energy of it ordered motion takes:

$$d\mathrm{H} \equiv dE = -T_{RN}dS_N + p_{RN}dV_N + (\tilde{\mathbf{v}}, d\mathbf{P}_{GT}) = 0\,, \quad dE_0 = -T_{RN}dS_N + p_{RN}dV_N = -(\tilde{\mathbf{v}}, d\mathbf{P}_{GT}) < 0\,,$$

$$d\mathrm{L} \equiv dW = S_N dT_{RN} - V_N dp_{RN} - (\mathbf{P}_{GT}, d\tilde{\mathbf{v}}) = 0\,, \quad dW_0 = S_N dT_{RN} - V_N dp_{RN} = (\mathbf{P}_{GT}, d\tilde{\mathbf{v}}) > 0\,.$$

So in the process of body free fall in gravitational field the evolutionary-gravitational increasing of intranuclear entropy takes place, in the same way as it also takes place in the theory of entropic gravitation [22]. Namely this guarantees the increasing of internal energy[33] of the whole gravithermodynamically bonded matter after the recovery of its mechanical equilibrium and, thus, also guarantees its infinitely long existence in the Universe.

In addition, the increments of the ordinary energy W and the ordinary rest energy W_0 of matter are determined, like the increments of the Gibbs free energy, by the increments of only the intensive parameters. That is why the ordinary rest energy of matter can be considered identical only to the multiplicative component of the thermodynamic Gibbs free energy, and the gravitational mass of matter can be considered equivalent to the multiplicative component of the Gibbs free energy. The inert free energy that can be released in the process of free fall of matter can be considered only similar to the thermodynamic internal (free thermal) energy that can be released in the process of cooling of matter.

8. Non-identity of inertial and gravitational masses

In classical mechanics and in SR the inert free energy of rest $E_0 = m_{in0}c^2 = m_{00}cv_{cv}$[34], which tends to the minimum and transforms into kinetic energy in the process of the fall of body in gravitational field, is the equivalent to the thermodynamic internal energy, which tend to the minimum in the process of cooling of matter [59, 60]. The conservation of Hamiltonian of the inert free energy of rest of matter $\mathrm{H} \equiv m_{in}c^2 = E\Gamma = m_{in0}c^2\Gamma = m_{00}cv_{cv}(1 - v^2 v_{cv}^{-2})^{-1/2} = \mathbf{const}(r)$ ($v_{cv}\Gamma = \mathbf{const}(r)$) is guaranteed due to the decreasing of inertial mass of rest $m_{in0} = m_{00}v_{cv}/c$ of matter in the process of

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[33] There is no violation of the law of energy conservation here since according to Noether theorem [61] this law works in time and not in the process of interaction of nucleons. The rate of time of gravity-quantum clock of body that falls free is invariable only in the process of its fall, while starts to decrease in the process of deceleration of the motion. At the same time the increasing of gravitational radius of the whole gravithermodynamically bonded matter and, consequently, the decreasing of rates of time of all its gravity-quantum clocks takes place. That is why it makes no sense to make statements about the action of the law of energy conservation in the moment of the change of rate of time of gravity-quantum clock. Moreover, at the same time the negative energy of bond of nucleons of fallen body is increasing. And, consequently, in the process of deceleration of body not only its kinetic energy, but also its released intranuclear energy are converted into thermal energy.

[34] Here, only the cooled down matter is considered ($\Gamma_m = 1$).

its free fall. The Hamiltonian momentum $\mathbf{P}_{\mathrm{H}} = -(\partial \mathrm{L}_{in}/\partial v)_{Vcv} = m_{00}c(v/v_{cv})(1-v^2v_{cv}^{-2})^{-1/2} = m_{gr0}v\Gamma$, which is proportional to gravitational mass $m_{gr0} = m_{00}c/v_{cv}$, is derived from Lagrangian $\mathrm{L}_{in} = E/\Gamma = m_{00}cv_{cv}\sqrt{1-v^2v_{cv}^{-2}}$ of namely inert free energy of matter. The magnitude of matter momentum, according to Noether's theorem [61] and Heisenberg uncertainty principle, is invariant (in relation to the transformation of time) characteristic of moving matter and, consequently, is invariant for all observers despite the different rates of time of their gravity-quantum clocks.

Coordinate pseudo-vacuum velocity of light $v_{cvj}(r)=cb_j^{1/2}$ is determined for certain point j in unified (for all gravithermodynamically bonded matter of the Earth) coordinate astronomical time t_E. It is identical to the limit velocity of individual (separate) motion of definite substance in RGTD [31, 35, 62] and its value depends on Schwarzschild radial coordinate r of that point. It decreases in GT-FR while approaching the pseudo-horizon or the gravity center. The spatial distribution of the gravithermodynamic values of the coordinate velocity of light in the intrinsic pseudocentric ^{ic}FR of point i is not identical to it in other pseudocentric ^{ic}FRs or even in truly centric FR_0: ${}^iv_{cvj} = c(v_{cvj}/v_{cvi}) \neq {}^iv_{cv0j} = c(v_{cv0j}/v_{cv0i})$.

The thing identical in different pseudocentric ^{ic}FRs is the spatial distribution of only the gravity-quantum values $^{ic}\mathrm{v}_{cv}$ of the coordinate velocity of light, which also depends on the coordinate velocity of light v_{cvi} at point i of the disposition of the real or supposed observer:

$$ {}^i\vec{v}_{cvj} = c(\vec{v}_{cvj}/\vec{v}_{cvi}) = c(v_{cvj}/v_{cvi})^{(v_{cvi}/c)^2} = c(v_{cv0j}/v_{cv0i})^{(v_{cv0i}/c)^2}, $$

$\left[{}^{ic}b_j = {}^cb_j/{}^cb_i = (b_j/b_i)^{b_i} = (b_{0j}/b_{0i})^{b_{0i}} = \mathbf{invar}\right]$. Here: v_{cv00j} and v_{cv00i} are the values of coordinate velocity of light in intrinsic centric $^{ic}\mathrm{FR}_0$ of prospective observe in a far away galaxy.

Metric eigenvalue of velocity of light is the spatio-temporal invariant (gauge-invariant and Lorentz-invariant constant) by intrinsic clock. This eigenvalue (proper value in Special Relativity) is equal to the constant of velocity of light in any point of space: ${}^iv_{cvi} = {}^jv_{cvj} = c$.

Obviously, the momentum $\mathbf{P}_j = m_{00}v_jc(v_{cvj}^2 - v_j^2)^{-1/2} = \mathbf{invar}\,(t_i)$ of matter does not depend on the rate of gravity-quantum time, which is not equal in the points with different gravitational potential. Therefore, the values in FR of inertial and gravitational mass will be expressed via proper rest mass (eigenvalue of mass) m_{00} in the following way $m_{in0j} = m_{00}v_{cvj}/c = m_{00}b_j^{1/2}$ and $m_{gr0j} = m_{00}v_{cvj}/cb_j = m_{in0j}/b_j = m_{00}c/v_{cvj}$. And their gravity-quantum values will be as follows:

$$ {}^{ic}m_{in0j} = m_{00}\,{}^{ic}v_{cvj}/c = m_{00}(v_{cvj}/v_{cvi})^{c^{-2}v_{cvi}^2} = m_{00}(b_j/b_i)^{b_i/2}, $$

$$ {}^{ic}m_{gr0j} = m_{00}c/{}^{ic}v_{cvj} = m_{00}(v_{cvi}/v_{cvj})^{c^{-2}v_{cvi}^2} = m_{00}(b_i/b_j)^{b_i/2}. $$

Obviously, proper rest mass m_{00} can be equal for homogeneous matter in gravitational field only in case of presence of its thermodynamic quasi-equilibrium.

As it was shown by Tolman [3] and as it follows from the Schwarzschild internal solution for extremely cooled and incompressible ideal liquid [38], the gravitational forces in it are proportional to ordinary enthalpy $H_{T0}=U_0+pV=H_{T00}c/v_l$ (where: $H_{T00}=\mathbf{const}(r)$), that does not decrease, unlike the inertial free energy *E*, but on the contrary, increases like the Gibbs free energy with approach to the center of gravity. And since for quasi-equilibrium cooling down matter $(pV-TS)/U_0=\mathbf{const}(r)$, then the multiplicative component $G_0=G-U_{ad}=G_{00}c/v_l$ ($G_{00}=\mathbf{const}(r)$) of Gibbs free energy *G* of matter is also inversely proportional to the limit velocity of the matter individual motion. Here *p* is the pressure, *V* is the molar volume, and $U_{ad}=\mathbf{consnt}(r)$ is the additive compensation of multiplicative representation of multiplicative component $U_0=\hat{m}_{gr0}c^2=\hat{m}_{00}c^3/v_l$ of thermodynamic internal energy *U* of matter.

And, consequently, it is quite obvious that inertial mass of moving matter is conventionally equivalent to its gravitational mass only by the intrinsic clock of the point, from which matter started its inertial motion, in case of the correction of the value of gravitational constant, which guarantees the conventional absence of bound energy of matter in centric or pseudo-centric intrinsic FR of matter. And this is related with the equivalence of inertial mass of matter to the Hamiltonian of its inert free energy, while the gravitational mass of matter is equivalent to the Lagrangian of its ordinary rest energy[35]. And the ratio of these masses is invariant due to the conservation in time of Hamiltonians of inert free rest energy and of Lagrangians of ordinary rest energy of inertially moving gravity-quantum clock of observed matter and of observer:

$$m_{gr0}=m_{in0}\frac{\mathrm{H_i\,L_j}}{\mathrm{L_i\,H_j}}=m_{in0}\frac{v_{lri}^2}{v_{lrj}^2}\equiv m_{in0}\,{}^{i}v_{lrj}^{-2}c^2=\mathbf{const}\ (t),$$

where: ${}^{i}v_{lrj}=cv_{lrj}/v_{lri}=(cv_{lj}/v_{li})(1-v_j^2v_{lj}^{-2})^{-1/2}(1-v_i^2v_{li}^{-2})^{1/2}$ is the value of limit velocity of matter individual (separate) motion in the points *r* of its hypothetic rest relatively to hypothetic observer of the motion.

Of course, it could be assumed that such concept as Hamiltonian is excessive for GR and especially for RGTD. The conservation of Lagrangian of ordinary rest energy and the tendency to zero of the Lagrangian of inert free energy of matter take place in GR and RGTD. However, the usage of only Lagrangian does not allow to reflecting the reality using the local pseudo-Euclidean

[35] The absence of inert bound energy in matter in its own gravity-quantum time takes place even in the state of rest of the matter. After all, according to the own gravity-quantum clock of the molecules of a homogeneous matter, the bound energy of its other molecules is positive in its lower layers and negative in its upper layers. In the common astronomical time of the entire matter, the inert bound energy of all its molecules is fundamentally only positive.

space-time. Moreover the decreasing ($m_{gr0}/m_{in0}=v_{lrj}^{-2}v_{lri}^{2}=c^{2}/{}^{i}v_{lr}^{2}=b_{ri}/b_{rj}$ times) of required average density of mass of astronomical objects in the galaxy will not be guaranteed. That is why we have to rely on namely this hypothesis.

Possibly we should also consider the mass only as the measure of quantity of matter, and we should characterize inertial and gravitational properties of matter by Hamiltonian of inert free energy and Lagrangian of ordinary rest energy of matter correspondingly.

9. Gravity-temporal invariance of really metrical values of mechanical and thermodynamic parameters of matter

In contrast to the momentum the forces that act on the matter, as all types of its energies, formally depend on the rate of time gravity-quantum clock. During the transition from unified gravithermodynamic (astronomical) time to gravity-quantum proper times of matter the magnitudes of these forces, as well as magnitudes of non-centric values of all energies, are increasing c/v_l times. In intrinsic FR of r point, from which the matter started its fall:

$${}^{r}\mathbf{F}_{in}=\mathbf{F}_{in}c/v_{lr}={}^{r}m_{in0r}\,{}^{r}\widehat{a}_{r}=m_{00}a_{r}=\frac{c}{v_{lr}}\frac{d\mathbf{P}}{dt}=\frac{d\mathbf{P}}{dt_{r}}=-{}^{r}\mathbf{F}_{gr}\,,$$

$${}^{r}\mathbf{F}_{gr}=\mathbf{F}_{gr}c/v_{lr}={}^{r}m_{gr0r}\,{}^{r}g=m_{gr0r}gc/v_{lr}=m_{00}gc^{2}v_{lr}^{-2}={}^{r}m_{gr0r}v_{lr}^{-2}c^{2}\frac{d\ln(v_{l}/v_{lr})}{d\widehat{r}}=m_{00}\frac{c^{3}G_{00}M_{gr0}}{v_{lr}^{3}r^{2}}\frac{dr}{d\widehat{r}}=m_{gr0}\frac{{}^{r}G_{0}M_{gr0}}{r^{2}}\frac{dr}{d\widehat{r}}\,,$$

and the eigenvalues (that were corrected to eigenvalue of gravitational constant (centered)) of Hamiltonian of inert free energy and of Lagrangian of ordinary rest energy of matter in its pseudocentric ${}^{rc}FR_0$ will be as follows:

$${}^{rc}\mathrm{H}\equiv{}^{r}\mathrm{H}=\mathrm{H}c/v_{lr}=m_{00}\,{}^{r}v_{l}c(1-\widehat{v}^{2}c^{-2})^{-1/2}=m_{00}c^{2}\,,$$

$${}^{rc}\mathrm{L}=(G_{00}/{}^{r}G_{0})\;{}^{r}\mathrm{L}=(G_{00}/{}^{r}G_{0})\mathrm{L}c/v_{lr}=m_{00}c^{4}v_{l}^{-2}(1-\widehat{v}^{2}c^{-2})G_{00}/{}^{r}G_{0}=m_{00}c^{2}\,,$$

where: $\widehat{v}=vc/v_l$ is the really metrical value of velocity of matter motion [62 – 64]; v is the coordinate velocity of motion of matter in background regular space, where its local kinematic curvature (that is contributed by the moving matter itself) is not taken to account; ${}^{r}\widehat{a}_{r}\equiv\widehat{a}_{r}=\mathbf{invar}(t)$ and $\widehat{a}_{r}=(c/v_{lr})(d\widehat{v}/dt)=d\widehat{v}/dt_{r}=a_{r}v_{lr}^{-2}c^{2}=\mathbf{invar}(t)$ are the really metrical values of accelerations of body free fall in the proper gravity-quantum time of the point r and in the gravithermodynamic time correspondingly; a_r is coordinate acceleration of motion of matter in background regular space; ${}^{r}g_{r}={}^{r}a_{r}=a_{r}=g_{r}v_{lr}^{-2}c^{2}={}^{r}G_{0}M_{gr0}r^{-2}$ and g_r are the gravitational accelerations in the point r by its proper gravity-quantum clock and in gravithermodynamic time (world time of GR [38]) correspondingly; ${}^{r}m_{gr0r}\equiv m_{00}$, since ${}^{r}m_{gr0j}=m_{gr0}v_{lr}/c=m_{00}v_{lr}/v_{lj}$;

${}^{r}m_{in0r}{=}m_{00}v_{lr}^{2}c^{-2}$, since ${}^{r}m_{in0j}{=}m_{in0}v_{lr}/c{=}m_{00}v_{lj}v_{lr}c^{-2}$; ${}^{r}v_{l}{=}cv_{l}/v_{lr}{=}\sqrt{c^{2}-\widehat{v}^{2}}$ is the limit velocity of individual (separate) motion of matter in arbitrary point in the proper gravity-quantum time of the point *r*; ${}^{r}G_{0}=G_{00}c^{2}v_{lr}^{-2}$ is the value of gravitational constant by the proper clock of point *r*; $dt_{r}{=}(v_{lr}/c)dt$ is the value of the increment of proper gravity-quantum time of point *r*.

So, by the gravity-quantum clock of any point *i* inertial and gravitational rest masses of matter will be determined in the following way[36]:

$${}^{ic}\widetilde{m}_{in0j}=m_{00}{}^{i}v_{lj}/c=m_{00}v_{lj}/v_{li}, \qquad {}^{ic}\widetilde{m}_{gr0j}=m_{00}c/{}^{i}v_{lj}=m_{00}v_{li}/v_{lj}.$$

However, with the help of examined here transformations the transition happens only to coordinate (and not to metrical) values of inertial and gravitational mass. And these values of masses in pseudo-centric ${}^{rc}\mathrm{FR}_0$ do not correspond to real values of internal energy of matter and to its thermodynamic states in general. And inert bound energy is absent at all in a new center of coordinates. That is why they cannot be considered as really metrical values of inertial and gravitational masses.

As we can see, the pseudo force of inertia is increased only due to the increasing of inert free energy and equivalent to it inertial mass c/v_{l} times. The metric value of acceleration of free fall of the body, as well as the metric value of velocity of its fall, is not changed. The equations of free fall of matter $v_{l}/v_{lr}{=}\sqrt{1-\widehat{v}^{2}c^{-2}}$, as well as of any other its movements, are equally formulated with the usage of any gravity-quantum clocks. Not the absolute values but the relative values of parameters of motion are used in these equations. So the gravity-quantum clock of matter has only the hidden influence on its mass and does not have an influence on really metrical values of parameters of matter motion, which do not depend on the rate of time of gravity-quantum clock at all. And this is, of course, due to the fact that quantum change of collective microstate of the whole gravithermodynamically bonded matter takes place simultaneously and, consequently, with the same frequency. The limit velocity of matter individual motion ${}^{i}v_{lj}{=}cW_{0i}/W_{0j}{=}cE_{0j}/E_{0i}$, as well as the equivalent to it coordinate velocity of light of GR, are the hidden mechanical and thermodynamic parameter and is already taken into account in its parameters and characteristics that are practically used. And, that is why it fundamentally cannot directly influence on the majority of mechanical and thermodynamic parameters of matter. Its value only characterizes the difference between multiplicative components of thermodynamic Gibbs free energy ${}^{i}v_{lj}=cG_{0i}/G_{0j}$ in different points of gravitational field because in those points matter is in not the same

[36] Here, only the readings of gravity-quantum clocks proportionally synchronized with gravithermodynamic (astronomical) time are used, and not gravity-quantum time itself, according to which the spatial distribution of relative

thermodynamic states. The minimum possible value of Gibbs free energy $G_{\min} = G_{00} + U_{ad}$ ($G_0 = G_{00}c/v_l + U_{ad}$) is, as other thermodynamic parameters, the intrinsic characteristics of matter. Moreover, the multiplicative component of Gibbs free energy of matter is identical to its mechanical ordinary rest energy ($G_0 \equiv W_0$) and, therefore, similarly to it, cannot depend on the rate of time of gravity-quantum clock of the observer (of course, if their rate of time is calibrated by the rate of uniform gravithermodynamic time of the whole gravithermodynamically bonded matter). And, consequently, all other thermodynamic potentials also do not depend on it. And, not only extensive but also intensive thermodynamic parameters a fortiori do not depend on it.

We cannot exclude the possibility that the limit velocity of substance individual (separate) motion at the same point in space may be different for different substances. After all, the gravitational field actually only specifies the gradients of gravitational potentials, not their absolute values. Therefore, inside real substances, gravitational potentials are obviously expedient to be specified as logarithms of real radiation propagation velocities with wavelengths at which, according to Wien's law, there are temperature maxima of energy in the radiation spectrum in equilibrium state.

So the usage of formalism of gravity-quantum time helps to perform only the relative measurements of mechanical and thermodynamic parameters and characteristics of matter. In order to determine (based on it) their really metrical values for observed matter we also need to know – to what values the readings of gravity-quantum clock of the observer correspond to. And only in this case the observed values of mechanical and thermodynamic parameters of matter will be equal for all observers. For example, taking into account that for quasi-equilibrium cooling down gases and simplest liquids:

$$m_{gr0j}{=}m_{00}c/v_{lj}\ (m_{gr0i}{=}m_{00}c/v_{li}),\ U_{0j}{=}U_{00}c/v_{lj}\ (U_{0i}{=}U_{00}c/v_{li}),$$

$$G_{0j} = G_{00}c/v_{lj}\ (G_{0i} = G_{00}c/v_{li}),\ T_{0j}{=}T_{00}c/v_{lj}\ (T_{0i}{=}T_{00}c/v_{li}),$$

we will receive really metrical values (that are observed by gravity-quantum clocks of point *i* in point *j*) of such characteristics of matter as gravitational mass, internal energy, thermodynamic Gibbs free energy and temperature that are identical to their coordinate values in GT-FR:

$${}^i\widehat{m}_{gr0j}{=}(c/{}^iv_{lj})m_{gr0i}{\equiv}m_{gr0j},\quad {}^i\widehat{U}_{0j}{=}(c/{}^iv_{lj})U_{0i}{\equiv}U_{0j},\quad {}^iG_{0j} = (c/{}^iv_{lj})G_{0i} \equiv G_{0j},\quad {}^i\widehat{T}_{0j}{=}(c/{}^iv_{lj})T_{0i}{\equiv}T_{0j}.$$

That is why it is expedient to use not the gravity-quantum clock of the observers, but universal (common for the whole gravithermodynamically bonded matter) gravithermodynamic clock. It is possible that the gravity-quantum clocks, which are located in specially created for them standard thermodynamic conditions, can be used as those clocks. However, it is required for this that in all

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gravity-quantum values of the coordinate velocity of light is the same for all observers, and therefore, is invariant to any spatiotemporal transformations.

points of space, which is filled with gravithermodynamically bonded matter, the same intranuclear gravithermodynamical parameters and characteristics of matter should correspond to the same standard thermodynamic conditions, as it takes place for homogeneous ideal liquid [40].

Of course, the inertial mass of rest of matter became equal to its gravitational mass of rest by the proper gravity-quantum clock of point r and to the eigenvalue of mass. Moreover, by the intrinsic clock of this point the strength of gravitational field is increased more significantly than based only on the usage of logarithmic gravitational potential [62, 65]. And the velocities and accelerations of object remained the same as in proportionally adjusted gravithermodynamic (astronomical) time.

In addition to this in proper gravity-quantum time of any arbitrary point i the ratio of values of inert free energy to values of ordinary rest energy of matter remains the same ${}^{i}E_{0i}/{}^{i}W_{0i} = v_{li}^2 c^{-2}$, as in common for all gravithermodynamically bonded matter gravithermodynamic time. After all:

$$ {}^{i}E_{0i} = \frac{{}^{i}\mathbf{F}_{ini}}{\mathbf{F}_{ini}} E_{0i} = \frac{{}^{i}m_{in0i}}{m_{in0i}} \frac{{}^{i}a_i}{a_i} m_{in0i} c^2 = \frac{m_{in0i} c^3}{v_{li}} = m_{00} c^2, \qquad {}^{i}m_{in0i} \equiv m_{00}, $$

$$ {}^{i}W_{0i} = \frac{{}^{i}\mathbf{F}_{gri}}{\mathbf{F}_{gri}} W_{0i} = \frac{{}^{i}m_{gr0i}}{m_{gr0i}} \frac{{}^{i}g_i}{g_i} m_{gr0i} c^2 = {}^{i}m_{gr0i} v_{li}^{-2} c^4 = \frac{m_{gr0i} c^3}{v_{li}} = m_{00} v_{li}^{-2} c^4 = \frac{{}^{i}G_0 m_{00} c^2}{{}^{ic}G_{0i}}, \qquad {}^{i}m_{gr0i} \equiv m_{00}, $$

where: ${}^{i}a_i = {}^{i}v_i^2 / r_i = v_i^2 v_{li}^{-2} c^2 / r_i = a_i$ and a_i are the centrifugal accelerations in gravity-quantum time of the i point and in common for all gravithermodynamically bonded matter gravithermodynamic time correspondingly; ${}^{i}g_i = g_i v_{li}^{-2} c^2$ and g_i are the accelerations of motion and gravitational accelerations in gravity-quantum time of the i point and in gravithermodynamic time correspondingly; ${}^{i}G_0 \neq \mathbf{const}(r)$ and ${}^{ic}G_{0i} \equiv {}^{E}G_{00} = {}^{i}G_0 v_{li}^2 c^{-2} = \mathbf{const}(r)$ are the values of the gravitational constant, respectively, in the gravity-quantum time of the i point and in gravithermodynamic (astronomical) time of the Earth.

But the identical to each other (in the gravity-quantum time of any arbitrary point i) inertial and gravitational masses of matter are no longer equivalent, respectively, to the inert free energy and ordinary rest energy of matter. And therefore, the gravitational mass of matter is erroneously considered identical to its inertial mass in the general astronomical time of all gravithermodynamically bound matter due to the impossibility of experimental detecting of the spatial variability of the gravitational “constant” in Earth conditions.

Thus, in pseudo-centric ${}^{ic}\mathrm{FR}_0$ of i point we will have the similar thing that is accepted in both classical physics and GR. Namely, due to the correction of gravitational constant we will receive in the i point not only the equality of the velocity of light to the constant c, but also the equality of gravitational mass to inertial mass. Therefore, with the exception of the gravitational "constant" and the coordinate vacuum velocity of light of the GR, all other truly metric mechanical and thermodynamic parameters and characteristics of matter do not depend on the readings of gravity-quantum clocks, and therefore are temporally invariant in the general astronomical time of all gravithermodynamically bound matter. After all, the coordinate vacuum velocity of light of the GR is an internal hidden parameter of most parameters and characteristics of matter.

Within the limits of atmosphere and outer space of the Earth this value of gravitational constant not essentially depends on the height above its surface. While on the edge of the Solar system namely this could cause the abnormal movement of spacecrafts “Pioneer” [66 – 68]. If we go deeper in the distant outer space, where v_{li} is the maximum possible value of limit velocity of group motion of matter in the outer space, then we will receive the quite essential difference between the value gravitational constant there and its value on the Earth. Moreover, for the distant galaxies, this will already be not the pseudo-centric but real centric galactic FRs.

10. Equations of gravitational field of the RGTD

Obviously, for a non-continuous matter in the tensor of the energy-momentum of GR gravitational field equations we should use intranuclear RGTD-characteristics instead of thermodynamic characteristics. For gradually quasi-equilibrium cooling-down matter we should use the density of ordinary rest energy $W_0/V=m_{00}c^3/Vv_l=m_0c^2\eta_m/Vf_G$ instead of the density of Gibbs free energy.

In CFREU non-zero components of metric tensor are the following:

$$g_{11}=N_E^2(R,\tau)=r^2(R,\tau)/R^2,\qquad g_{22}=r^2(R,\tau),\qquad g_{33}=r^2(R,\tau)\sin^2\theta,$$

$$g_{44}=-f_G^2(R,\tau)\Gamma_E^2(R,\tau)\eta_m^{-2}c^2=-f_{Gb}^2(R,\tau)\eta_m^{-2}c^2=-N_E^2(R,\tau)q_N^2(R,\tau)\eta_m^{-2}=-N_E^2(R,\tau)v_{cb}^2(R,\tau)\,.$$

According to this, the equations of gravitational field for homogeneous matter [31, 35, 37, 43]:

$$M_i^k=G_i^k-Gg_i^k/2-\Lambda g_i^k=-\kappa\mathrm{T}_i^k=-(\kappa/V)[(c^{-2}W_0)U_iU^k+(W_0-E_0)\delta_i^k]=$$

$$=-\frac{\kappa}{V}\left[\left(\frac{m_{00}f_G}{\eta_m}-\frac{p_NV_N}{c^2}+\frac{T_NS_N}{c^2}\right)U_iU^k+(T_NS_N-p_NV_N)\delta_i^k\right]=$$

$$=-\frac{\kappa m_{00}}{V}\left[\frac{\eta_m}{f_G}U_iU^k+c^2\left(\frac{\eta_m}{f_G}-\frac{f_G}{\eta_m}\right)\delta_i^k\right]=-\kappa\mu_{00}\left[\frac{1}{\sqrt{b}}U_iU^k+c^2\left(\frac{1}{\sqrt{b}}-\sqrt{b}\right)\delta_i^k\right] \qquad (3)$$

in pseudo-Euclidean Minkowski space of CFREU are the following (in general case):

$$M_1^1=-\frac{2R^2}{r^3f_{Gb}}\frac{\partial f_{Gb}}{\partial R}\frac{\partial r}{\partial R}-\frac{2\eta_m^2}{rc^2f_{Gb}^3}\frac{\partial f_{Gb}}{\partial\tau}\frac{\partial r}{\partial\tau}+\frac{2\eta_m^2}{rc^2f_{Gb}^2}\frac{\partial^2r}{\partial\tau^2}+\frac{\eta_m^2}{r^2c^2f_{Gb}^2}\left(\frac{\partial r}{\partial\tau}\right)^2-\frac{R^2}{r^4}\left(\frac{\partial r}{\partial R}\right)^2+$$

$$+\frac{1}{r^2}-\Lambda=-\frac{\kappa}{V}\left[(T_NS_N-p_NV_N)-\frac{W_0v_b^2}{v_{lb}^2-v_b^2}\right]=-\frac{\kappa m_{00}c^2}{V}\left[\frac{\eta_m}{f_{Gb}}-\frac{f_{Gb}}{\eta_m}-\frac{\eta_mv_b^2}{f_{Gb}(v_{lb}^2-v_b^2)}\right],$$

$$M_1^4=-\frac{r^2\eta_m^2}{R^2c^2f_{Gb}^2}M_4^1=\frac{2\eta_m^2}{rc^2f_{Gb}^2}\left[\frac{1}{f_{Gb}}\frac{\partial f_{Gb}}{\partial R}\frac{\partial r}{\partial\tau}+\frac{1}{r}\frac{\partial r}{\partial R}\frac{\partial r}{\partial\tau}-\frac{\partial^2 r}{\partial R\partial\tau}\right]=-\frac{\kappa\eta_m^2 m_{00}cv_{lb}v_b r}{f_G^2RV(v_{lb}^2-v_b^2)}=-\frac{\kappa\mu_{00}v_{lb}v_b r^3}{cb^3R^3},$$

$$M_3^3=M_2^2=-\frac{R^2}{r^2f_{Gb}}\frac{\partial^2 f_{Gb}}{\partial R^2}-\frac{R}{r^2f_{Gb}}\frac{\partial f_{Gb}}{\partial R}-\frac{2\eta_m^2}{rc^2f_{Gb}^3}\frac{\partial f_{Gb}}{\partial\tau}\frac{\partial r}{\partial\tau}+\frac{2\eta_m^2}{rc^2f_{Gb}^2}\frac{\partial^2 r}{\partial\tau^2}+\frac{\eta_m^2}{r^2c^2f_{Gb}^2}\left(\frac{\partial r}{\partial\tau}\right)^2-\frac{R^2}{r^3}\frac{\partial^2 r}{\partial R^2}+$$

$$+\frac{R^2}{r^4}\left(\frac{\partial r}{\partial R}\right)^2-\frac{R}{r^3}\frac{\partial r}{\partial R}-\Lambda=-\frac{\kappa m_0c^2}{V}\left(\frac{\eta_m}{f_{Gb}}-\frac{f_{Gb}}{\eta_m}\right)=-\frac{\kappa}{V}(T_NS_N-p_NV_N)=-\kappa\mu_{00}c^2\left(\frac{1}{\sqrt{b}}-\sqrt{b}\right)=-\kappa\mu_{gr0}c^2(1-b),$$

$$M_4^4=\frac{3\eta_m^2}{r^2c^2f_{Gb}^2}\left(\frac{\partial r}{\partial\tau}\right)^2-\frac{2R^2}{r^3}\frac{\partial^2 r}{\partial R^2}+\frac{R^2}{r^4}\left(\frac{\partial r}{\partial R}\right)^2-\frac{2R}{r^3}\frac{\partial r}{\partial R}+\frac{1}{r^2}-\Lambda=\frac{\kappa}{V}\left[\frac{W_0v_{lb}^2}{v_{lb}^2-v_b^2}-(T_NS_N-p_NV_N)\right]=$$

$$=\frac{\kappa m_{00}c^2}{V}\left[\frac{f_{Gb}}{\eta_m}-\frac{\eta_m}{f_{Gb}}+\frac{\eta_m v_{lb}^2}{f_{Gb}(v_{lb}^2-v_b^2)}\right]=\frac{\kappa m_{00}c^2}{V}\left[\sqrt{b}-\frac{1}{\sqrt{b}}+\frac{\sqrt{b}}{b-v_b^2c^{-2}}\right],$$

where: $W_0=\dfrac{\eta_m m_{00}c^2}{f_G}=\dfrac{m_{00}c^2}{\sqrt{b}}=\dfrac{m_{in0}c^2}{b}=m_{gr0}c^2=E_0-p_NV_N+T_NS_N$ and $E_0=m_{00}c^2f_G/\eta_m=m_{00}c^2\sqrt{b}=m_{in0}c^2$ are the gravitational intranuclear energy (ordinary rest energy) and the inert free intranuclear energy of matter correspondingly; $T_NS_N-p_NV_N=m_{00}c^2(1/\sqrt{b}-\sqrt{b})=c^2(m_{gr0}-m_{in0})$;

$\Lambda=3H_E^2c^{-2}$ is the cosmological constant; $v_b=dR/d\tau=-H_ER=-\sqrt{\Lambda/3}cR=\hat{v}_b/N_E=\breve{v}_bv_{lb}/c$ and $\hat{v}_b$ are the velocities of radial motion of microobjects of matter in CFREU, which are determined in cosmological time τ by the united length standard and by their own length standards correspondingly;

$\breve{v}_b=cv_b/v_{lb}=-rc\sqrt{\Lambda/3}\eta_m/f_G=\mathbf{const}(\tau)$ is the relative velocity of radial motion of microobjects of matter; $v_{lb}=(R/r)\sqrt{v_l^2+\Lambda r^2c^2/3}=\sqrt{bc^2+H_E^2r^2}/N_E$ and v_l are the limit velocities of individual motion of definite substance (or the limit velocities of group motion of many substances) in cosmological time and in intrinsic time of matter correspondingly;

$f_{Gb}=\sqrt{f_G^2+\Lambda\eta_m^2r^2/3}=\eta_m\sqrt{b+H_E^2c^{-2}r^2}$ and $f_G=\eta_m\sqrt{b}$ are the frequencies of intranuclear interaction in cosmological time and in intrinsic time of matter correspondingly.

In conventionally empty space $f_{Gb}=(R-R_{ge})/(R+R_{ge})=(1-r_g/r)^{1/2}$, $v_{lb}=f_{Gb}R/r=4cR_{ge}R^2(R-R_{ge})/r_{ge}(R+R_{ge})^3=cR^2(R-R_{ge})(R+R_{ge})^{-3}\exp[-H_E(\tau-\tau_k)]$, while radial coordinates in CFREU and in intrinsic FR of matter are connected with each other with more simple dependencies:

$$R=R_{ge}r\left(1+\sqrt{1-r_{ge}/r}\,\tilde{H}_E/H_E\right)^2/r_{ge},\qquad r=r_{ge}(R+R_{ge})^2/4RR_{ge};\quad R_{ge}=(r_{ge}/4)\exp[-H_E(\tau-\tau_k)].$$

According to these equations for rigid intrinsic FR of matter (r=**const**(t); $f_G(r)$=**cons**t(t), $T_N(r)$=**const**(t); $S_N(r)$=**const**(t); $p_N(r)$=**const**(t); $V_N(r)$=**const**(t)) we can receive by metrically homogeneous scale of cosmological time τ ($d\tau \equiv dt$ when $dr=0$) the following dependencies:

$$b'/abr - r^{-2}(1-1/a) + \Lambda = b'/abr - r_g(r)r^{-3} + 2\Lambda/3 = \kappa m_{00}c^2(b^{-1/2} - b^{1/2})/V = \kappa(T_N S_N - p_N V_N)/V ,$$

$$d'/a^2r + r^{-2}(1-1/a) - \Lambda = d'/a^2r + r_g(r)r^{-3} - 2\Lambda/3 = \kappa\mu_{gr0}bc^2 = \kappa m_{00}c^2\sqrt{b}/V .$$

From where:

$$\frac{1}{a} = \left(\frac{\partial r}{\partial \widehat{r}}\right)^2 = 1 - \left(1 - \frac{1}{a_i} - \frac{\Lambda r_i^2}{3}\right)\frac{r_i}{r} - \frac{\kappa m_{00}c^2}{\eta_m r}\int_{r_i}^{r}\frac{f_G r^2}{V}dr - \frac{1}{3}\Lambda r^2 = 1 - \left(1 - \frac{\Lambda r_0^2}{3}\right)\frac{r_0}{r} - \frac{\kappa m_{00}c^2}{r}\int_{r_0}^{r}\frac{\sqrt{b}r^2}{V(b)}dr =$$

$$= -\kappa m_{00}c^2 b\int_{r_0}^{r}\frac{rdr}{b^{3/2}V(b)} = \zeta(r) - \Lambda r^2/3 = 1 - r_g(r)/r - (1 - r_{ge}/r_c)r^2 r_c^{-2} \qquad (1/a_0 = 0,\ \zeta(r) = 1 - r_g(r)/r),$$

$$\left(\frac{\partial r}{\partial \tau}\right)_R = H_E R\left(\frac{\partial r}{\partial R}\right)_\tau = \frac{\widetilde{H}_E r}{\sqrt{a(1 - v_b^2 v_{lb}^{-2})}} = \frac{\widetilde{H}_E f_{Gb}}{\eta_m\sqrt{ab}},$$

$$\sqrt{b} = \frac{v_l}{c} = \frac{f_G}{\eta_m} = \frac{1}{\sqrt{a}}\left(1 + \frac{\kappa m_{00}c^2}{2}\int_{r_e}^{r}\frac{a^{3/2}r}{V}dr\right), \qquad \tau(r,t) = \tau_k + (t - t_k) - \frac{\widetilde{H}_E}{c^2}\int_{r_k}^{r}\sqrt{\frac{a}{b}\frac{\eta_m r}{f_{Gb}}}dr ,$$

$$R(r,t)_{RGTD} = R(r,\tau_k)\exp[H_E(\tau_k - \tau)] = r_k\exp\left[H_E\left((\tau_k - \tau) + \frac{\eta_m}{\widetilde{H}_E}\int_{r_k}^{r}\frac{\sqrt{ab}}{f_{Gb}r}dr\right)\right],$$

$$R(r,t)_{RGTD} = r_k\exp\left[H_E\left((t_k - t) + \frac{1}{\widetilde{H}_E\eta_m}\int_{r_k}^{r}\sqrt{\frac{a}{b}}\frac{f_{Gb}}{r}dr\right)\right] = r_k\exp\left[H_E\left((t_k - t) + \frac{1}{\widetilde{H}_E}\int_{r_k}^{r}\frac{\sqrt{a}}{\sqrt{1 - v_b^2 v_{lb}^{-2}}\,r}dr\right)\right],$$

where: $\widetilde{H}_E = H_E$ for the area of fundamental space of CFREU $R \in (R_0;\infty)$, in which $\partial r/\partial\widehat{r} > 0$, and $\widetilde{H}_E = -H_E$ for the area $R \in (0;R_0)$, in which $\partial r/\partial\widehat{r} < 0$.

As we see in counted in CFREU cosmological time there is no gravitational as well as relativistic anisotropy of the shrinkage of size of micro-objects of matter in the fundamental space of CFREU. Such relativistic anisotropy appears only because of the non-fulfillment of cosmological simultaneity of events that correspond to the same collective microstate of matter when the comoving with self-contracting matter its intrinsic time is used in this background Euclidean space. Because in conventionally empty space (ab=1, $\widehat{v}_b = \breve{v}_b$):

$$\frac{r}{R}dR(r,\tau)_{\tau}=\frac{\eta_m\sqrt{ab}}{f_{Gb}}dr=\frac{dr}{\sqrt{1-r_g/r}}, \quad \frac{r}{R}dR(r,t)_t=\sqrt{\frac{a}{b}}\frac{f_{Gb}}{\eta_m}dr=\frac{dr}{\sqrt{\zeta(1-\hat{v}_b^2c^{-2})(1-\breve{v}_b^2c^{-2})}}=\frac{\sqrt{1-r_g/r}\,dr}{1-r_g/r-H_E^2c^{-2}r^2},$$

$$\left(\frac{R_G}{R}-\frac{2R_G}{R-R_G}\right)d[R(r,t)/R_G]_t=\left[\frac{1}{r_c(r_c-r_s)(r-r_s)}-\frac{1}{r_s(r_c-r_s)(r-r_c)}+\frac{1}{r_cr_s(r+r_c+r_s)}\right]\frac{c^2}{H_E^2}dr, \quad \frac{4R_GR}{(R-R_G)^2}=\psi_t(r)^{37},$$

$$R(r,t)_t=\left[1+(\widetilde{H}_E/H_E)\sqrt{1+\psi_t(r)}\right]^2R_G/\psi_t(r), \text{ where: } \ln\psi_t(r)=\left[\frac{\ln(r/r_s-1)}{r_c(r_c-r_s)}-\frac{\ln(1-r/r_c)}{r_s(r_c-r_s)}+\frac{\ln[r/(r_c+r_s)+1]}{r_cr_s}\right]\frac{c^2}{H_E^2},$$

$r_s=r_{min}>r_g$ is radius of the Schwarzschild singular surface.

Of course, it is related only to the usage of components of metrical tensor, which guarantee the absence of anisotropy of relativistic shrinkage of size of micro-objects of matter in fundamental space of CFREU. However, the usage of exactly these components allowed to receive a solution that completely corresponds to the Schwarzschild external solution in isotropic coordinates [38, 69].

Moreover, it is taken into account that the Hubble constant H_E, like the length standards and the constant of the velocity of light, is a fundamentally unchangeable quantity in the rigid FRs. And this follows from the condition of continuity of spatial continuum in rigid FRs [70]. The most corresponding to astronomical observations value of Hubble constant is the value determined by the following empiric dependencies of it on the well known physical constants and characteristics:

$$H=c\sqrt{\Lambda/3}=\frac{\pi^4\alpha}{8N_{Dn}}\nu_{Bn}=\frac{2}{3}\pi\alpha\, t_p^2\left(\frac{\pi}{2}\nu_{Bn}\right)^3=\frac{2}{3}\pi Ge^2\left(\frac{m_n}{4\hbar}\right)^3=2{,}018859\cdot10^{-18}[s^{-1}]=62{,}29548\left[\frac{km}{sMpc}\right],$$

where: $N_{Dn}=1{,}5(t_p\nu_{Bn})^2=3\pi chm_n^{-2}/G=0{,}999885\bullet10^{40}$ is the neutron large Dirac number, $\alpha=e^2/c\hbar$ is the fine structure constant, $\nu_{Bn}=m_nc^2/2\pi\hbar$ is the de Broglie wave frequency of the neutron, $t_p=(c^5\hbar G)^{1/2}$ is the Planck time, $\hbar=h/2\boldsymbol{\pi}$ is the Dirac-Planck constant, $G\equiv G_{00}$ is the Newton's gravitational constant, e is the electric charge of the proton and electron, m_n is the mass of neutron [62, 65, 71].

However, the value of Hubble constant $H_E=(\pi^4\alpha/8N_{DH})\nu_{BH}=62{,}16420$ [$km/sMpc$] ($\Lambda=1{,}35457\cdot10^{-52}$ [m^{-2}]), that corresponds to the de Broglie wave frequency of hydrogen atom $\nu_{BH}=m_Hc^2/2\pi\hbar=2{,}270262\cdot10^{23}$ [s^{-1}] ($m_H=1{,}67375\cdot10^{-27}$ [kg], $N_{DH}=1{,}5(t_p\nu_{BH})^{-2}=1{,}001292\cdot10^{40}$), only for small distances guarantees slightly worse correspondence to the data of graphical extrapolation of the results of astronomical observations. It is possible that Hubble constant took "hydrogen" value only after spontaneous transformation of quark or neutron medium of the Universe into hydrogen medium. However, of course, it was impossible before that to metrically characterize its continuous protomatter and, therefore, it is senseless to characterize it by "neutron" Hubble constant. Therefore, the final choice of one of these two close values of Hubble constant can be done based on the more precise results of astronomical observations.

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[37] Since $\tau_s=\infty$, $\psi_t(r_s)=0$ and $R_G\neq0$, therefore $R_s=0$. Also, since $\tau_c=-\infty$ and $\psi_t(r_c)=\infty$, therefore $R_c=R_{Gmax}=\infty$.

It is obvious that supposed need in the presence of dark energy in The Universe is based not only on the taking into account the imaginary (fictive) dilation of the time on distant astronomical objects (postulated by Etherington's identity [72]), but also on the wish to have the linear dependence of redshift of radiation spectrum z on luminosity distance D_L to those objects. In fact, according to GR [37, 43, 62, 65, 73, 74] the redshift is linearly dependent only on the transverse comoving distance D_M:

$$z=\frac{\Delta\lambda_D}{\lambda_0}=\frac{H_E\,R}{c}=\frac{H_E\,D_M}{c}$$

and on the angular diameter distance:

$$\hat{z}=\frac{\Delta\nu_D}{\nu_0}=\frac{z}{1+z}=\frac{H_E\,r}{c}=\frac{H_E\,D_A}{c}.$$

Moreover, the supposed dark energy could not be a certain physical entity at all. It could be just the effect of ubiquitous negative feedback. The deceleration of evolutionary self-contraction of matter in CFREU could take place in the distant past due to the presence of this negative feedback. Thus, evolutionary decrease of the velocity of light in CFREU using metrically homogeneous scale of cosmological time [37, 43, 62, 65, 73, 74] in the distant past would also be decelerated. This deceleration, of the outer space course, could have been the greater the smaller the coordinate velocity of light ${}^{U}v_{cos}$ in the outer space in GT-FR had been in distant past.

However, it is quite probable that Hubble's parameter is indeed unchangeable in time, as we had to make sure of it here. It even can be a spatially-temporal invariant alike the proper value of the velocity of light. The value of Hubble's constant can be precised after the more accurate processing of results of astronomical observations.

In the obtained solutions of equations the density of equivalent to ordinary rest energy gravitational mass and the density of equivalent to inert free energy inertial mass are integrated not by eigenvalues of density of mass $\mu_{00}=m_{00}/V=\mu_{gr0}\sqrt{b}$ and pressure $p_{00}=p\sqrt{b}$, which are determined via different intrinsic clocks as it is in used GR [38][38]. They are integrated by their values $[\mu_{gr0}]_{RGTD}=m_{00}/V\sqrt{b}=\eta_m m_{00}/f_G V$ and $[\mu_{in0}]_{RGTD}=m_{00}\sqrt{b}/V=f_G m_{00}/\eta_m V$ observed using the same clock. In all other means these solutions are formally correspond to the solutions of GR for cooled down to the limit matter ($S=\mathbf{const}(r)$), which is in the state of mechanical equilibrium [39, 40]:

$$dp/dr+(\mu_{gr0}c^2+p)b'/2b=0.$$

[38] Due to this the integral value of gravitational mass of the whole matter, of course, will be significantly larger. And, consequently, there is a chance to avoid the necessity of existence of dark non-baryonic matter in the Universe.

In this case, not only the conditions Tolman conditions for thermodynamic parameters of extremely cooled matter in its proper gravity-quantum time $T_{00}=T\sqrt{b}=\mathbf{const}(r)$ and $H_{00}=H_T\sqrt{b}=\mathbf{const}(r)$ are fulfilled, but also the used in obtained solutions for $U_{ad}=\mathbf{const}(r)$ and $S=\mathbf{const}(r)$ condition $G_{00}=G_0\sqrt{b}=(H_T-TS-U_{ad})\sqrt{b}=\mathbf{const}(r)$ is also fulfilled for a gradually cooling matter:

$$dG_{00}=\sqrt{b}Vdp-\sqrt{b}SdT+(G_0/2\sqrt{b})db=0.$$

Due to mutual proportionality of $f_G(r)=\eta_m\sqrt{b(r)}$ and $\sqrt{b}$ ($\mathbf{grad}\ln f_G=\mathbf{grad}\ln\sqrt{b}$), the matter STC, which is obtained based on the analysis of spatial distribution of Lorentz-noninvariant intranuclear RGTD-characteristics of matter, is identical to STC obtained in GR when ignoring both Lorentz-invariance and gravitational-temporal non-transformability of thermodynamic parameters and characteristics of matter.

It should also be mentioned here that, according to GR and RGTD, the ideal gas ($pV=R_{UT}T$) cannot have gravitational field in principle. Molar energy of ideal gas and, consequently, coordinate-like velocity of light in it are the same at all points of the space filled by this gas:

$$E_0=m_{00}c^2\sqrt{b}=(H_T-pV)\sqrt{b}=(H_T-R_{UT}T)\sqrt{b}=H_{00}-R_{UT}T_{00}=\mathbf{const}(r),\quad v_{cv}=\sqrt{b}c=\mathbf{const}(r).$$

And it means that the phenomenon of gravitation is related to electromagnetic interaction of molecules of matter and, therefore, has purely electromagnetic nature.

11. Solution of the standard differential equation of the dynamic gravitational field of a star cluster

According to the equations of the RGTD, the configuration of the dynamic gravitational field of a star cluster in a quasi-equilibrium state is standard (canonical in the RGTD). Because it is not determined at all by the spatial distribution of the average mass density of the non-continuous matter. After all, this spatial distribution of the average mass density of the matter of the star cluster itself is set by the standard configuration of its dynamic gravitational field:

$$S'=\frac{d[r/a_c(1-b_c)]}{dr}=\frac{1-r_g'-\Lambda r^2}{(1-b_c)}+\frac{(r-r_g-\Lambda r^3/3)}{(1-b_c)^2}b_c'=-\frac{b_cS}{r(1-b_c)}+\frac{(1-\Lambda r^2)}{(1-b_c)^2},$$

$$S=\frac{r}{a_c(1-b_c)}=\frac{r-r_g-\Lambda r^2/3}{1-b_c}=\exp\int\frac{-b_cdr}{(1-b_c)r}\times\int\left[\frac{(1-\Lambda r^2)}{(1-b_c)^2}\exp\int\frac{b_cdr}{(1-b_c)r}\right]dr,$$

where the parameter S can be conditionally considered as the distance from the pseudo-horizon of the infinitely distant cosmological past.

The trivial solution of this equation, which takes place at:

$$b_c = b_{ce}\left(\frac{3-\Lambda r^2}{3-\Lambda r_e^2}\right), \quad S_0 = \frac{r-\Lambda r^3/3}{1-b_c} = \frac{(r-\Lambda r^3/3)(3-\Lambda r_e^2)}{3-\Lambda r_e^2 - b_{ce}(3-\Lambda r^2)}, \quad r_g = \frac{(1-b_c)r_{ge}}{(1-b_{ce})}\exp\int_{r_{ge}}^{r_g}\frac{b_c dr}{r(1-b_c)} =$$

$$= \frac{(1-b_c)r_{ge}}{(1-b_{ce})}\exp\frac{2b_{ce}\ln(r/r_e) - (1-\Lambda r_e^2/3)\{\ln[r^2+(3/\Lambda - r_e^2)/b_{ce} - 3/\Lambda] - \ln[(1/b_{ce}-1)(3/\Lambda - r_e^2)]\}}{2(1-\Lambda r_e^2/3 - b_{ce})}$$

does not correspond to reality. After all, because $b_c' = -2b_{ce}\Lambda r/(3-\Lambda r_e^2) \neq 0$ at $r \neq 0$ it does not assume the presence of the pseudo-horizon of events in the FR of matter. And the parameter b_c, unlike the parameter a_c, does not depend on the gravitational radius r_g. And therefore, in the FR, which corresponds to this trivial solution, there is no gravity.

The solutions that actually correspond to star clusters are:

$$b_c = v_{lc}^2 c^{-2} = b + v_{orb}^2 c^{-2} = 1 - r_{gb(st)}/r + (v_{orb}^2 - v_{evol}^2)c^{-2} = 1 - r_{gb(st)}/r + (r_{gb(st)}/2r - H_E^2 r^2 c^{-2})/b_c - H_E^2 r^2 c^{-2} =$$

$$= \frac{1}{2}\left[1 - \frac{r_{gb(st)}}{r} - \frac{\Lambda r^2}{3} + \sqrt{1 + r_{gb(st)}^2 r^{-2} - 2\Lambda r(r + r_{gb(st)}/3) + \Lambda^2 r^4/9}\right] = 1 - \frac{r_{gb}}{r} - \frac{\Lambda r^2}{3} > \frac{1}{2}(1-\Lambda r^2),$$

$$S = (r - r_g - \Lambda r^3/3)/(r_{gb(st)}/r + \Lambda r^2/3 - v_{orb}^2 c^{-2}) = (r - r_g - \Lambda r^3/3)/(r_{gb}/r + \Lambda r^3/3),$$

$$\frac{\rho'}{\rho} = \frac{r_{gb}' - r_g'}{r_{gb} - r_g} = \frac{r_{gb}' - 1 + \Lambda r^2}{r_{gb} + \Lambda r^3/3} + \frac{r_{gb}' r}{\rho(r_{gb} + \Lambda r^3/3)},$$

$$\mu_{00} = \mu_{in}/\sqrt{b_c} = r_g' c^{-2} r^{-2}/\kappa\sqrt{b_c} = (r_{gb}' - \rho')c^{-2}r^{-2}/\kappa\sqrt{b_c},$$

where: $b = 1 - r_{g(st)}/r - 3r^2/\Lambda = b_c - v_{orb}^2 c^{-2}$ is the parameter of the Schwarzschild solution of the static gravitational field equations of the GR; $r_{gb} = r_g + \rho \neq r_g$ is a parameter similar, but not identical to the gravitational radius r_g, which, unlike r_g, determines not the curvature (parameter a_c) of the intrinsic space of matter, but the maximum possible (limit) value of the velocity v_{lc} of motion of matter (parameter b_c); v_{lc} is the maximum possible (limit) value of the velocity of motion of matter, which in the RGTD is only equivalent, and not identical to the coordinate pseudo-vacuum velocity of light v_{cv} of the GR, because outside the limits of prevailing of the gravitational field of the astronomical body, it continuously decreases when moving away from it; $v_{orb}^2 = (r_{g(st)}/2r - \Lambda r^3/3)c^2/b_c = (c^2 r_{g(st)}/2r - H_E^2 r^2)/b_c = \mathbf{const}(t)$ is the square of the velocity of the hypothetical circular orbital motion of the star, which is fundamentally invariant in time t and, therefore, cannot directly affect the intensity of the dynamic gravitational field in the process of the circular motion of the star due to the absence of real radial acceleration of its motion ($dv_{orb}/dr = 0$);

$v_{evol}^2 = \Lambda c^2 r^2 / 3 = H_E^2 r^2$ is the square of the speed of the evolutionary distancing of the star from the observer; $\mu_{in} = \mu_{00}\sqrt{b_c}$ is the density of the inertial mass of the star cluster.

Thus, using a certain radial dependence of the parameter b_c, it is possible to obtain radial distributions not only of all parameters of the dynamic gravitational field, but also of the average mass density μ_{00} of matter of the star cluster.

In the case of using this primitive solution of the equations of the dynamic gravitational field to reflect the process of falling (with Hubble velocities) of star clusters onto the pseudo-horizon of events, we will have the following. Here, at the Hubble constant H_E=62.29548 *km/sMpc* [Danylchenko, 2020; 2024a] and at the maximum possible radius $r_{\max} = \frac{1}{\sqrt{\Lambda}} = \frac{c}{\sqrt{3}H_E} = 8.5734 \cdot 10^{25} [m] \approx 2.778 \; [Gpc]$ of the star cluster according to the condition:

$$\left(\frac{db_c}{dr}\right)_{r_{\max}} = \frac{r_{g\max}}{r_{\max}^2} - \frac{2\Lambda r_{\max}}{3} = \Lambda r_{g\max} - \frac{2\sqrt{\Lambda}}{3} = 0$$

the maximum possible value of the gravitational radius r_{gb} of the star cluster is:

$$r_{gb\max} = \frac{2}{3\sqrt{\Lambda}} = 5.7156 \cdot 10^{25} [m] \approx 1.852 \; [Gpc].$$

In addition, at $r_{\max}$ we have $b_c = 0$. And this means that such a giant star cluster is actually the entire Universe. And therefore, this dynamic gravitational field can also correspond to the real heliocentric FR, but only outside the predominance of the Sun's own gravitational field. And thus, if in the empty outer space of the Sun the radius of the pseudo-horizon of the infinitely distant cosmological past is equal to $r_{\max} = \sqrt{3/\Lambda} = 1.4850 \cdot 10^{26} [m] \approx 4.812 \; [Gpc]$, then in the space saturated with stars it is $\sqrt{3}$ times smaller.

And precisely because of the absence of real radial acceleration of motion ($dv_{orb}/dr = 0$) of stars moving in the obserber's FR not in convergent spiral orbits, but in stable circular orbits, the gravitational forces formally act in the direction of the observer, despite the gradual decrease in his intrinsic space of the parameter b_c with increasing of radial distance to him. But periodically there are local exceptions to this rule when the Sun or another star appears between the terrestrial observer and the Universe. Then, with sufficient radial approaching to them, the gravitational forces begin to act, of course, in the direction of these astronomical objects, and not in the direction of the observer. And this is confirmed by the fall of galaxies (with Hubble velocities) onto the pseudo-horizon of the infinitely distant cosmological past.

Thus, the primitive solution of the canonical equation of the dynamic gravitational field considered here can correspond only to the simplest star clusters or to the entire Universe (when $r_{gb}=0$ or vice versa when $r_{gb}=2/3\sqrt{\Lambda}$ under the condition of the inverse description of the action of the gravitational field).

To describe more complex star clusters, and therefore galaxies, it is obviously necessary to use more complex mathematical dependencies:

$$\frac{\sqrt{a_c b_c}}{m_{00}}\mathbf{F}_{in}=\frac{v_{gr}^2}{r}=v^2\left(\frac{r}{r_e}\right)^m\frac{d\Phi(r)}{dr}=\frac{\sqrt{a_c b_c}}{m_{00}}\mathbf{F}_{gr}=\frac{c^2}{2}\frac{d(\ln b_c)}{dr}=\frac{c^2 q}{n\sqrt{1+4q^2\Phi^2(r)}}\frac{d\Phi(r)}{dr},$$

$$\Phi(r)=\left(1-\frac{3r_e-\Lambda r_e^3}{3r-\Lambda r^3}\right)^m\ln^k\left(\frac{3r-\Lambda r^3}{3r_e-\Lambda r_e^3}\right),\quad \Phi(r_e)=0,\quad v_e^2\equiv v_{\max}^2=\frac{c^2 q}{n}=\frac{c^2 r_{ge}}{2r_e},$$

$$v^2=\frac{v_e^2}{\sqrt{1+4q^2\Phi^2(r)}}\left(\frac{r_e}{r}\right)^m=v_e^2\left(\frac{r_e}{r}\right)^m\left\{1+4q^2\left(1-\frac{3r_e-\Lambda r_e^3}{3r-\Lambda r^3}\right)^{2m}\ln^{2k}\left(\frac{3r-\Lambda r^3}{3r_e-\Lambda r_e^3}\right)\right\}^{-\frac{1}{2}}=v_e^2\left(\frac{r_e}{r}\right)^m\left\{\frac{1}{2}\left[\left(\frac{b_c}{b_{ce}}\right)^n+\left(\frac{b_{ce}}{b_c}\right)^n\right]\right\}^{-1},$$

$$\hat{v}=\frac{v}{\sqrt{b_c}}=\sqrt{\frac{2\,\mathrm{LH}_e(b_c/b_{ce})^n}{\mathrm{HL}_e[1+(b_c/b_{ce})^{2n}]}}\hat{v}_e=\frac{v_e}{\sqrt{b_c}}\left(\frac{r_e}{r}\right)^{\frac{m}{2}}\left\{1+4q^2\left[\left(1-\frac{3r_e-\Lambda r_e^3}{3r-\Lambda r^3}\right)^m\ln^k\left(\frac{3r-\Lambda r^3}{3r_e-\Lambda r_e^3}\right)\right]^2\right\}^{-\frac{1}{4}}=v_e\left(\frac{r_e}{r}\right)^{\frac{m}{2}}\sqrt{\frac{2(b_c/b_{ce})^n}{b_c[1+(b_c/b_{ce})^{2n}]}},$$

$$\left(\frac{3r-\Lambda r^3}{3r_e-\Lambda r_e^3}\right)^{\left(1-\frac{3r_e-\Lambda r_e^3}{3r-\Lambda r^3}\right)^m}=\exp\left[\pm\frac{1}{2q}\sqrt{r_e^{2m}v_e^4 r^{-2m}v^{-4}-1}\right]=\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]\right\},$$

$$b_c=b_{ce}\left[\left(\frac{r_e}{r}\right)^m\left(\frac{v_e}{v}\right)^2\pm\sqrt{\left(\frac{r_e}{r}\right)^{2m}\left(\frac{v_e}{v}\right)^4-1}\right]^{\frac{1}{n}}=b_{ce}\left[\sqrt{1+4q^2\Phi^2(r)}\pm 2q\Phi(r)\right]^{\frac{1}{n}}=b_{ce}\left[\sqrt{1+4q^2\Phi^2(r)}\mp 2q\Phi(r)\right]^{-\frac{1}{n}}=$$

$$=k_b b_{ce}=b_{ce}\left\{\sqrt{1+4q^2\left(1-\frac{r_e-\Lambda r_e^3/3}{r-\Lambda r^3/3}\right)^{2m}\ln^{2k}\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)}\pm 2q\left(1-\frac{r_e-\Lambda r_e^3/3}{r-\Lambda r^3/3}\right)^m\ln^k\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)\right\}^{1/n},$$

$$b_c'=\frac{db_c}{dr}=\frac{2b_c q}{n\sqrt{1+4q^2\Phi^2(r)}}\frac{d\Phi(r)}{dr}=\frac{2b_c q(1-\Lambda r^2)\Psi(r)}{n(r-\Lambda r^3/3)^{m+1}\sqrt{1+4q^2\Phi^2(r)}}=$$

$$=\frac{2b_c q(1-\Lambda r^2)\{m(r_e-\Lambda r_e^3/3)\ln^k[(r-\Lambda r^3/3)/(r_e-\Lambda r_e^3/3)]+k[r-r_e-\Lambda(r^3-r_e^3)/3]^m\}}{n\left(r-\frac{\Lambda r^3}{3}\right)^{m+1}\sqrt{1+4q^2\left(1-\frac{3r_e-\Lambda r_e^3}{3r-\Lambda r^3}\right)^{2m}\ln^{2k}\left(\frac{3r-\Lambda r^3}{3r_e-\Lambda r_e^3}\right)}}=$$

$$= \frac{4b_c{}^E G_{00} M_{00g} \varsigma (1-\Lambda r^2)\{m(r_e - \Lambda r_e^3/3)\ln^k[(r-\Lambda r^3/3)/(r_e-\Lambda r_e^3/3)] + k[r - r_e - \Lambda(r^3 - r_e^3)/3]^m\}}{c^2 b_{ce}^2 r_e \left(r - \frac{\Lambda r^3}{3}\right)^{m+1}\left[\left(\frac{b_c}{b_{ce}}\right)^n + \left(\frac{b_{ce}}{b_c}\right)^n\right]},$$

$$\Psi(r) = m(r_e - \Lambda r_e^3/3)\ln^k[(r-\Lambda r^3/3)/(r_e - \Lambda r_e^3/3)] + k[r - r_e - \Lambda(r^3 - r_e^3)/3]^m,$$

$$q = b_{ce} r_{ge}/2r_e = {}^E G_{eeff} M_{00g} b_{ce} c^{-2}/r_e = \varsigma M_{grg} m_{gre}{}^E G_{00} c^{-2}/r_e m_{00e} = \varsigma M_{00g}{}^E G_{00} c^{-2}/r_e b_{ce},$$

$$r_{ge} = {}^E G_{00} M_{00g} b_{ce}^{-2} c^{-2}, \quad n = b_{ce}, \quad \frac{b_c'}{b_c a_c r} - \frac{1}{r^2}\left(1 - \frac{1}{a_c}\right) + \Lambda - \frac{\kappa m_{00} c^2}{V}\left(\frac{1}{\sqrt{b_c}} - \sqrt{b_c}\right) =$$

$$= \frac{{}^E G_{00} M_{00g} \varsigma \Psi(r)(1-\Lambda r^2)(r^{-2} - r_g r^{-3} - \Lambda/3)}{c^2 b_{ce}^2 r_e r^m \left(1 - \frac{\Lambda r^2}{3}\right)^{m+1}\left[\left(\frac{b_c}{b_{ce}}\right)^n + \left(\frac{b_{ce}}{b_c}\right)^n\right]} - \frac{r_g}{r^3} + \frac{2\Lambda}{3} - \frac{\kappa m_{00} c^2}{V}\left(\frac{1}{\sqrt{b_c}} - \sqrt{b_c}\right) = 0,$$

$$V = \frac{n\kappa m_{00} c^2 (1-\Lambda r^2/3)^{m+1}\left\{(1/\sqrt{b_{ce}})\left[\sqrt{1+A^2} \mp A\right]^{\frac{1}{2n}} - \sqrt{b_{ce}}\left[\sqrt{1+A^2} \pm A\right]^{\frac{1}{2n}}\right\}\sqrt{1+A^2}}{2q r_e^{-m}\Psi(r)(1-\Lambda r^2)(r^{-2} - r_g r^{-3} - \Lambda/3) - n(1-\Lambda r^2/3)^{m+1}(r_g r^{-3} - 2\Lambda/3)\sqrt{1+A^2}},$$

$$\mu_{grst} = \frac{m_{00}}{\sqrt{b_c}V} = \frac{2\varsigma M_{00g}{}^E G_{00}\Psi(r)(1-\Lambda r^2)(r^{-2} - r_g r^{-3} - \Lambda/3)}{\kappa c^4 b_{ce}^2 r_e^{m+1}(1-b_c)(1-\Lambda r^2/3)\sqrt{1+A^2}} + \frac{2\Lambda/3 - r_g r^{-3}}{\kappa c^2(1-b_c)},$$

$$\mu_{grpst} = \frac{2\Lambda/3}{\kappa c^2(1-b_{c\max})} = \frac{H_E^2}{4\pi{}^E G_{00}(1-b_{c\max})}, \quad A = 2q\left(1 - \frac{r_e - \Lambda r_e^3/3}{r - \Lambda r^3/3}\right)^m \ln^k\left(\frac{r - \Lambda r^3/3}{r_e - \Lambda r_e^3/3}\right),$$

where: $$\mathbf{F}_{in} = \frac{m_{00} v^2}{\sqrt{a_c b_c}}\left(\frac{r}{r_e}\right)^m \frac{d\Phi(r)}{dr} = \frac{m_{00} v^2 (1-\Lambda r^2)\Psi(r)}{r r_e^m (1-\Lambda r^2/3)^{m+1}\sqrt{a_c b_c}} =$$

$$= \frac{m_{00} v^2 (1-\Lambda r^2)\{m(r_e - \Lambda r_e^3/3)\ln^k[(r-\Lambda r^3/3)/(r_e - \Lambda r_e^3/3)] + k[r - r_e - \Lambda(r^3 - r_e^3)/3]^m\}}{r r_e^m (1-\Lambda r^2/3)^{m+1}\sqrt{a_c b_c}}$$

is reduced (evolutionarily weakened) centrifugal pseudo-force of inertia; m=1 and k=1 for elliptical galaxies; m=0 and k=1 for flat (ultrathin) galaxies; m=1 and k=0 for globular star clusters.

When single objects and their aggregates form big collection (cluster) their total mass can essentially exceed the mass of central astronomical body (supermassive neutron star or quasar). The attraction of astronomical objects of the internal spherical layers of the galaxy can be much stronger than the attraction to the central body of the galaxy. Then, their collective gravitational influence can essentially distort the correspondence of the motion of peripheral astronomical objects to

Kepler's laws. And, therefore, according to astronomical observations the velocities of rotation v of galaxy's peripheral astronomical objects required for prevention of joint collapse of all matter of the galaxy are much higher than the velocities of rotation of the separate peripheral astronomical objects required for prevention of the independent fall of those objects onto the central astronomical body.

In addition, in RGTD, unlike GR, bodies that move by inertia in a gravitational field, influence (by their movement) the configuration of the dynamic gravitational field surrounding them. At the same time, in equilibrium processes, along with the usage of ordinary Hamiltonians and Lagrangians, in RGTD it is also possible to use GT-Hamiltonians [Newtonians] and GT-Lagrangians [Keplerian]. 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 energy, and Lagrangian (or Keplerian) four-momentum is formed by the Lagrangian (or Keplerian) of ordinary rest energy (multiplicative component of thermodynamic Gibbs free energy G) of matter of astronomical object.

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

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

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:

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

where: $\mathrm{N} = E_0 v_{lc} / c = m_{in} c^2 = m_{00} c \sqrt{v_l^2 + v^2}$, $E_0^2 = \mathrm{N}^2 - v_l^2 \mathbf{P}_N^2 = m_{00}^2 c^2 v_l^2 = m_{in0}^2 c^4$,

$$W_0^2 = \mathrm{K}^2 + c^4 v_l^{-2} \mathbf{P}_\mathrm{K}^2 = m_{00}^2 c^6 v_l^{-2} / (1 + v^2 v_l^{-2}) + m_{00}^2 c^6 v_l^{-4} v^2 / (1 + v^2 v_l^{-2}) = m_{00}^2 c^6 v_l^{-2} = m_{gr0}^2 c^4 ,$$

$$\hat{v} = v b_c^{-1/2} = vc / v_{lc} = vc / v_l \hat{\Gamma}_c , \quad \hat{\Gamma}_c = (1 + v^2 v_l^{-2})^{1/2} , \quad v_{lc}^2 = b_c c^2 = bc^2 + v^2 = v_l^2 + v^2 = \mathbf{const}(t) ,$$

$$b_c = b \hat{\Gamma}_c^2 = (v_l^2 + v^2) c^{-2} = b + v^2 c^{-2} = v_{lc}^2 c^{-2} = \mathbf{const}(t) .$$

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 and the invariance of their intrinsic time with respect to relativistic transformations:

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

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

The quantum change in the parameters of the gravitational field of the galaxy occurs together with the quantum change in the quasi-equilibrium thermodynamic state of matter, which quantumly cools with the de Broglie frequency. Only the quasi-equilibrium of the thermodynamic state of the cooling matter is caused precisely by the occurrence of short-term equilibrium disturbances in the quantum process of discrete loss of thermal energy by the matter. After all, the energy levels corresponding to the equilibrium are quantized according to the polynomial solutions of the gravitational field equations [60, 106].

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 parameters a_c and b_c (or analogous to them parameters a_s and b_s) in the RGTD is a hidden internal parameters of the moving matter. 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.

A similar dependence of the parameter v_{lc} on the velocity 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:

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

and Keplerians of ordinary rest energy :

$K = W_0 c / v_{lc} = m_{00} c^3 / v_{lc} = m_{00} c^3 / \sqrt{v_l^2 + v^2} \approx m_{00} c^2 / \sqrt{1 - r_g /(r_1 + r_2)} = \mathbf{const}\,(t, r)$ 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 $v_{gr}^2 = (c^2 r \sqrt{ab} / 2) d \ln b / d\hat{r} = (c^2 / \sqrt{b})(r_g / 2r - \Lambda r^2 / 3) \approx c^2 r_g / 2r$, 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:

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

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:

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

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:

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

we can find the gravitational radius of the Sun: $r_g \approx v_1^2 c^{-2} (r_1 + r_2) r_1 / r_2 = v_2^2 c^{-2} (r_1 + r_2) r_2 / r_1$.

Planet	r_1 *mln. km*	r_2 *mln. km*	v_1 *km/s*		v_2 *km/s* theoret.	ε	$(1-b_c)$ x10^{10}	r_g *km* actual
			actual	theoret.				
Mercury	69.82	45.90	38.85	38.88	59.14	0.2067	255.95	2.96
Venus	108.94	107.48	34.78	34.83	35.30	0.0067	136.74	2.95
Earth	152.09	147.10	29.29	29.33	30.32	0.0167	98.92	2.95
Mars	249.23	206.60	21.98	22.00	26.54	0.0935	64.92	2.96
Jupiter	816.62	740.52	12.44	12.45	13.73	0.0489	19.00	2.96
Saturn	1505.4	1353.6	9.10	9.15	10.18	0.0531	10.35	2.93
Uranus	3006	2740	6.50	6.50	7.13	0.0463	5.15	2.96
Neptune	4537	4456	5.39	5.39	5.49	0.0091	3.29	2.96
Pluto	7375	4437	3.68	3.68	6.12	0.2487	2.51	2.96

The table shows that the calculated values of the gravitational radius of the Sun, obtained on the basis of using approximate values of the orbital parameters and actual and theoretical (at r_g=2.96 *km*) velocities of different planets, 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.

The analysis of motion of the planets can also be carried out in a dynamic gravitational field corresponding to the hypothetical circular orbital motion of astronomical objects:

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

where: $v^2 = c^2 r_g / 2r = c^2 r_{gc} / 2$; $r_{gc} = r_g / 2$ is gravitational radius of the dynamic gravitational field of the Sun. In this field, the pseudo-forces $\mathbf{F}_{cev}$ of unobservable evolutionary attraction (towards the Sun) of astronomical objects are centripetal and act on astronomical objects regardless of the trajectory of their motion.

The centripetal pseudo-force of unobservable evolutionary attraction (towards the Sun) of hypothetical astronomical objects that can move in circular orbits in the dynamic gravitational field of the Sun is as follows:

$$-\mathbf{F}_{cev0}=\mathbf{F}_{in0}+\mathbf{F}_{gr}=\frac{m_{00}(v_0^2-v_{cgr}^2)}{r_0\sqrt{a_cb_c}}=\frac{m_{00}c^2}{r_0\sqrt{a_cb_c}}\left[\frac{r_g}{2r_0}-\frac{1}{\sqrt{b_c}}\left(\frac{r_g}{4(r_0-r_g)}-\frac{\Lambda r^2}{3}\right)\right]\approx\frac{m_{00}c^2r_{gc}}{2r_0^2}=\frac{m_{00}v_0^2}{2r_0},$$

where: $r_0=(r_1+r_2)/2$ corresponds to the maximum possible value of the angular momentum of the object ($v^2r^2-v_0^2r_0^2=-c^2r_g(r-r_0)^2/2r_0\le 0$).

Also we obtain the centripetal pseudo-force of unobservable evolutionary attraction of planets in the dynamic gravitational field of the Sun at aphelions and perihelions:

$$-\mathbf{F}_{cev(aph)}\approx m_{00}c^2\left[\frac{2r_2r_{gc}}{r_1^2(r_1+r_2)}-\frac{r_{gc}}{2r_1^2}\right]=\frac{m_{00}c^2r_{gc}(3r_2-r_1)}{2r_1^2(r_1+r_2)}=\frac{m_{00}v_1^2(3r_2-r_1)}{4r_1r_2},$$

$$-\mathbf{F}_{cev(per)}\approx m_{00}c^2\left[\frac{2r_1r_{gc}}{r_2^2(r_1+r_2)}-\frac{r_{gc}}{2r_2^2}\right]=\frac{m_{00}c^2r_{gc}(3r_1-r_2)}{2r_2^2(r_1+r_2)}=\frac{m_{00}v_2^2(3r_1-r_2)}{4r_1r_2}.$$

Thus, if in a dynamic gravitational field the centripetal pseudo-forces of unobservable evolutionary attraction (towards the Sun) of hypothetical astronomical objects that can move in circular orbits are strictly equal to the gravitational pseudo-forces, then the pseudo-forces of unobservable evolutionary attraction of planets moving in elliptical orbits are not equal to them, but for all planets they are precisely centripetal.

The use of the parameter $b_s=b\Gamma_s^2=b/(1-v^2c^{-2}/b)=v_{ls}^2c^{-2}=\mathbf{const}(t)$ [39], built on the basis of relativistic size shrinkage $\Gamma_s=(1-v^2v_l^{-2})^{-1/2}$, in the equations of the dynamic gravitational field of the RGTD is also possible. However, in order to ensure the absence of deceleration of dilation of intrinsic time of matter moving in a gravitational field by inertia, it will be necessary to use conformal Lorentz transformations (instead of the usual Lorentz transformations) of the increments of spatial coordinates and time. The solutions of the equations of dynamic gravitational field of the RGTD do not depend on the usage of the parameter b_c or the parameter b_s in them. The only parameters that will differ are the parameters of hypothetical static gravitational fields (which are reproduced on the basis of those parameters b_c and b_s).

[39] Apparently, this parameter is inherent only to the equilibrial (pseudo-inertial uniform) motion of matter of bodies that are evolutionarily self-contracting in the frame of references of spatial coordinates and time which is comoving with the expanding Universe.

12. Solutions of the standard differential equation of the dynamic gravitational field of a flat (or superthin) galaxy

Due to the fundamental unobservability in the intrinsic FR of matter of the evolutionary decrease of the radius *r* of the star´s orbit, it is the same in all FRs. The orbital velocities of galaxies and their stars that are observed on an exponential physically homogeneous scale of intrinsic time *t* of any observer should also be considered real in the observer´s FR. Taking this into account, a dynamic gravitational field of a flat (or superthin) galaxies is examined here: the field in which the velocities *v* of the hypothetical equilibrium circular motion (*r*=**const**) of astronomical objects do not depend directly on the radial coordinates *r*, but depend only on the values of the coordinate vacuum velocity of light v_{cv} of GR or on the equivalent limit velocity of group motion of matter v_l or $v_{lc} = v_l \hat{\Gamma}_c$ (which correspond in RGTD to the limit velocities v_{lhs} or v_{lchs} of individual (separate) motion of the most common surface hydrogen). After all, in the depths of stars, the limit velocities $v_{lchi} = cT_{00h} / T_{inside} << v_{lchs} = cT_{00h} / T_{surface}$ of individual motion of hydrogen are much lower than on the surface of stars due to the high temperature $T_{inssde.}$ in them. Here T_{00h} is the individual constant of hydrogen, which is much lower in denser substances that can be contained both in the depths of stars and on their planets.

Thus, unlike the modified Newtonian dynamics proposed by Mordechai Milgrom, both in the orthodox GR and in its modification by the RGTD, the speed of orbital motion of astronomical objects in a flat galaxy, albeit indirectly, still depends on their radial distance to the center of the galaxy.

The galaxies that cooled down, and therefore were previously much larger, always had (and still have) non-rigid FRs. The variable function *u*(*v*), which corresponds to a non-rigid FRs, and the value of the certain parameter $n = b_e < 1$, at which there will be no need in dark non-baryonic matter in the galaxy, can be matched for any such galaxy.

The GR gravitational field equations de facto correspond to spatially inhomogeneous thermodynamic states of only utterly cooled down matter. The similar to them equations of RGTD correspond to spatially inhomogeneous thermodynamic states of gradually cooling down matter.

Because of this, the Λ-reduced (evolutionarily weakened) centrifugal pseudo-force of inertia:

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

which “balances” (compensates) the gravitational pseudo-force in a rigid FR of matter, depends in GR and RGTD on the cosmological fundamental constant $\Lambda = 3H_E^2 c^{-2} = \mathbf{const}(t)$ 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 [60, 65, 70]. Here: $\mathbf{F}_{in0} = m_{in}v^2 / b_c r$ is ordinary (unreduced) centrifugal pseudo-force of inertia; $\mathbf{F}_{inE} = -2\Lambda m_{in}\hat{v}^2 r/(3 - \Lambda r^2) = -2H_E^2 m_{in}v^2 r / b_c(c^2 - H_E^2 r^2) \approx -2m_{00}v^2 r / \sqrt{b_c}(r_c^2 - r^2)$ 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 ($r_p \approx \Lambda^{-1/2}$), 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) Euclidean space of comoving with expanding Universe FR, and not by the weak gravitational pseudo-forces at the edge of the galaxy.

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 ${}^{g}G_{00}$ of the gravitational constant in the FR_g of the galaxy. But in the FR_{si} of each of the stars of this galaxy there may be their own values ${}^{S}G_{00i} = {}^{g}G_{00}\,{}^{g}b_{ci}^{-2}$ of the gravitational constant [62, 65], according to which the planets and satellites rotate relative to them. Similarly, in the FR_E of the Earth, each of the distant galaxies may also have its own gravitational constant ${}^{g}G_{00i} = {}^{E}G_{00}\,{}^{E}b_{ci}^{-2}$. The failure to take this into account, together with the failure to take into account the two-dimensional topology of flat galaxies, are the main reasons for the imaginary need for dark non-baryonic matter in the Universe. After all, compensation for the mutual non-identity of the inertial and gravitational masses of only the most distant galaxies does not provide compensation for the mutual non-identity of the inertial and gravitational masses of their stars.

Thus, in the own time of astronomical objects of a distant galaxy, the inertial mass of their matter is actually identical to the gravitational mass of the matter, as it should be. The fact that gravitational mass of objects of a distant galaxy in the FR of the Earth observer is greater is due to a much higher temperature of their matter in the distant past. And this is similar to the much higher temperature of matter in the bowels of the Earth. And therefore, the observed thermodynamic parameters of matter in any distant galaxy strictly correspond to the thermodynamic parameters of the Earth's matter. Therefore, the values of the parameter b_c in a distant galaxy strictly correspond to the values of the absolute temperature of its matter in the observed distant past. And therefore, the Earth's gravitational field strictly corresponds to the thermodynamic state of the matter of the Universe in any distant past.

According to this, in the tensor of energy-momentum of the RGTD not only intranuclear pressure p_N but also intranuclear temperature T_N is taken into account:

$$b_c' / a_c b_c r - r^{-2}(1 - 1/a_c) + \Lambda = \kappa(T_N S_N - p_N V_N)/V = \kappa(m_{gr} - m_{in})c^2 / V = \kappa m_{00} c^2 (1/\sqrt{b_c} - \sqrt{b_c})/V,$$

$$a_c' / a_c^2 r + r^{-2}(1 - 1/a_c) - \Lambda = \kappa E / V = \kappa m_{in} c^2 / V = \kappa m_{00} c^2 \sqrt{b_c} / V,$$

$$[\ln(b_c a_c)]' / a_c r = \kappa W / V = \kappa m_{gr} c^2 / V = \kappa m_{00} c^2 / \sqrt{b_c} V,$$

where: b_c and a_c are the parameters of the dynamic gravitational field equations of the non-continuous matter of the galaxy; $p_N V_N = \tilde{\beta}_{pVN} E = b_c \tilde{\beta}_{pVN} m_{gr} c^2 = \tilde{\beta}_{pVN} m_{in} c^2$, $\tilde{\beta}_{pVN} \neq \mathbf{const}(r)$, $S_N = m_{gr} c^2 / T_N = m_{00} c^2 / T_{00} = \mathbf{const}(r)$, $T_{00N} = T_N \sqrt{b_c} = \mathbf{const}(r)$, $m_{00} = m_{gr} \sqrt{b_c} = m_{in} / \sqrt{b_c} = \mathbf{const}(r)$, $\mu_{00} = m_{00} / V \neq \mathbf{const}(r)$, $\mu_{gr} = m_{00} / \sqrt{b_c} V = \mu_{in} / b_c \neq \mathbf{const}(r)$, $\mu_{in} = m_{00} \sqrt{b_c} / V \neq \mathbf{const}(r)$, $V \neq \mathbf{const}(r)$ and $V_N \neq \mathbf{const}(r)$ are molar and intranuclear volume of matter, respectively.

In addition, according to the GR and RGTD equations, the configuration of the dynamic gravitational field of a galaxy in a quasi-equilibrium state is standard (canonical in RGTD). That is so because it is not determined at all by the spatial distribution of the average mass density of its non-continuous matter. After all, this spatial distribution of the average mass density of the galaxy's matter is itself determined by the standard configuration of its dynamic gravitational field:

$$S' = \frac{d[r / a_c (1 - b_c)]}{dr} = \frac{1 - r_g' - \Lambda r^2}{(1 - b_c)} + \frac{(r - r_g - \Lambda r^3 / 3)}{(1 - b_c)^2} b_c' = -\frac{b_c S}{r(1 - b_c)} + \frac{(1 - \Lambda r^2)}{(1 - b_c)^2},$$

$$S = \frac{r}{a_c(1 - b_c)} = \frac{r - r_g - \Lambda r^3 / 3}{1 - b_c} = \exp\int \frac{-b_c dr}{(1 - b_c) r} \times \int \left[\frac{(1 - \Lambda r^2)}{(1 - b_c)^2} \exp\int \frac{b_c dr}{(1 - b_c) r} \right] dr,$$

where the parameter S can be conditionally considered as the distance from the event pseudo-horizon.

The trivial solution of this equation, which takes place at:

$$b_c = b_{ce} \left(\frac{3 - \Lambda r^2}{3 - \Lambda r_e^2} \right), \quad S_0 = \frac{r - \Lambda r^3 / 3}{1 - b_c} = \frac{(r - \Lambda r^3 / 3)(3 - \Lambda r_e^2)}{3 - \Lambda r_e^2 - b_{ce}(3 - \Lambda r^2)}, \quad r_g = \frac{(1 - b_c) r_{ge}}{(1 - b_{ce})} \exp \int_{r_{ge}}^{r_g} \frac{b_c dr}{r(1 - b_c)} =$$

$$= \frac{(1-b_c)r_{ge}}{(1-b_{ce})} \exp \frac{2b_{ce} \ln(r/r_e) - (1-\Lambda r_e^2/3)\{\ln[r^2 + (3/\Lambda - r_e^2)/b_{ce} - 3/\Lambda] - \ln[(1/b_{ce} - 1)(3/\Lambda - r_e^2)]\}}{2(1-\Lambda r_e^2/3 - b_{ce})},$$

does not correspond to physical reality. After all, because of $b_c' = -2b_{ce}\Lambda r/(3-\Lambda r_e^2) \neq 0$ at $r\neq 0$, the solution does not imply the presence of event pseudo-horizon in the FR of matter. And the parameter b_c, unlike the parameter a_c, does not depend on the gravitational radius r_g. And therefore, gravity is absent in the FR corresponding to this trivial solution.

The gravitational potential of the dynamic gravitational field of the flat (or superthin) galaxies depend on the effective value of the gravitational constant ${}^E G_{eeff} = {}^E G_{0ge}/b_{ce} = {}^E G_{00} b_{ce}^{-2}$ in the observer's FR. Since the thing that depends on this effective value is the density of the inertial mass of matter (equivalent to its inert free energy), which previously (when $r>\Lambda^{-1/2}$, $db_c/dr<0$) gradually increased in cosmological time, but now (when $r<\Lambda^{-1/2}$, $db_c/dr>0$) gradually decreases with approaching the center of gravity. And therefore, flat galaxies, which previously were cooling in quasi-equilibrium state (due to $T\sqrt{b_c} = \mathbf{const}$), and which are now more "hot" when approaching their centers, can have predominantly non-rigid FRs.

According to the mutual non-identity of the gravitational and inertial masses of matter we find the square of the rotation velocity of astronomical object relatively to the galaxy center according to the equations of gravitational field of RGTD:

$$[\hat{v}^2]_{RGTD} = \frac{c^2 r(3-\Lambda r^2) b_c'}{6b_c^2(1-\Lambda r^2)} = \frac{c^2 a_c (3-\Lambda r^2)}{6b_c(1-\Lambda r^2)} \left\{ \left(1 - \frac{1}{a_c}\right) + \left[\frac{\kappa m_{00} c^2}{V} \left(\frac{1}{\sqrt{b_c}} - \sqrt{b_c} \right) - \Lambda \right] r^2 \right\} >> [\hat{v}^2]_{GR}.$$

As we can see, at the same radial distribution of the average density of the mass $\mu_{00} = m_{00}/V$ of baryonic matter the circular velocities of rotation of astronomical objects relatively to the galaxy center are much bigger in RGTD than in GR. And this is, of course, related to the fact that:

$$(T_N S_N - p_N V_N)/V \equiv (m_{gr} - m_{in})c^2/V = \mu_{00} c^2 (1/\sqrt{b_c} - \sqrt{b_c}) >> p.$$

Thus, we can get rid of the imaginary necessity of dark non-baryonic matter in flat (superthin) galaxies (which follows from the equations of GR gravitational field) if we analyze the motion of their astronomical objects using the RGTD equations of gravitational field and diffeomorphically-conjugated forms [75] and if take into account the two-dimensional topology of the galaxies.

Therefore, a strength of the dynamic gravitational field of flat (or superthin) galaxies, according to their two-dimensional topology, will be inversely proportional to the radial distance, not to its square. And this will be the case, despite the inverse proportionality of the strength of individual gravitational fields of all its spherically symmetric astronomical objects exactly to the square of radial distance.

The solution of the equation of the dynamic gravitational field of flat galaxies obtained here may also correspond to other galaxies. After all, spherical and elliptical galaxies can have a multi-sector structure, in which each sector can contain a separate flat microgalaxy. Such a sectoral configuration of the general dynamic gravitational field of the entire galaxy will actually isolate its individual microgalaxies from each other.

In addition, at the edge of the galaxy ($r_p \approx \Lambda^{-1/2}$), the centrifugal pseudo-forces of inertia are compensated mainly by centripetal pseudo-forces (which are proportional to the cosmological constant Λ) of evolutionary self-contraction of matter in the fundamental (background) Euclidean space [25] of comoving with expanding Universe FR.

If we do not take into account local peculiarities of distribution of average density of the inertial mass in galaxies and examine only the general tendency of typical dependence of the orbital velocity of their objects on radial distance to the galaxy center, then the following dependencies of this velocity on the parameters $b_c = v_{lc}^2 c^{-2} = b_{ce}(b_{c0}/b_{ce0})^{n_0/n} = b_{ce}(b_{c0}/b_{ce0})^{b_{ce0}/b_{ce}}$ and $b_{ce} = v_{lce}^2 c^{-2} \approx (1+2z_e)(1+z_e)^{-2}$, and thus on radial distance r, can be matched to them [76]:

$$\widetilde{v} = \frac{v}{\sqrt{b_c}} = \sqrt{\frac{2\,\mathrm{LH}_e (b_c/b_{ce})^n}{\mathrm{HL}_e[1+(b_c/b_{ce})^{2n}]}}\widetilde{v}_e = \sqrt{\frac{2b_{ce}(b_c/b_{ce})^n}{b_c[1+(b_c/b_{ce})^{2n}]}}\widetilde{v}_e =$$

$$= \sqrt{\frac{2}{b_c[(b_{ce}/b_c)^n + (b_c/b_{ce})^n]}}v_e = \frac{v_e}{\sqrt{b_c}}\left\{1+\left[2q\ln\left(\frac{r}{r_e}\right)\right]^2\right\}^{-1/4},$$

$$\widehat{v} = \frac{v}{\sqrt{b_c}} = \sqrt{\frac{2\,\mathrm{LH}_e (b_c/b_{ce})^n}{\mathrm{HL}_e[1+(b_c/b_{ce})^{2n}]}}\widehat{v}_e = \sqrt{\frac{2(b_c/b_{ce})^n}{b_c[1+(b_c/b_{ce})^{2n}]}}v_e =$$

$$= \frac{v_e}{\sqrt{b_c}}\left\{1+4q^2\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right) - u\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right]^2\right\}^{-1/4},$$

where: b_{c0} and b_{ce0} are the parameters of the gravitational field in the galaxy's centric intrinsic $\mathrm{FR_g}$; $(dv/db_c)_e = (dv/dr)_e = 0$, $n={}^E G_{00}/{}^E G_{0ge} = b_{ce} < 1$, $n_0={}^g G_{00}/{}^g G_{0e} = b_{ce0} < 1$; $q = b_{ce} r_{ge}/2r_e = {}^E G_{eeff} M_{00g} b_{ce} c^{-2}/r_e = \varsigma M_{grg} m_{gre}\, {}^E G_{00} c^{-2}/m_{00e} r_e = \varsigma M_{00g}\, {}^E G_{00} c^{-2}/r_e b_{ce}$, ${}^E G_{eeff} = \varsigma\, {}^E G_{0ge}/b_{ce} = \varsigma\, {}^E G_{00} b_{ce}^{-2}$ and ${}^E G_{0ge} = {}^E G_{00}/n = {}^E G_{00}/b_{ce}$ are, respectively, the effective and real values of the gravitational constant of the galactic star e in $\mathrm{FR_E}$; ${}^g G_{00}$ and ${}^g G_{0e}$ are the gravitational constants in $\mathrm{FR_g}$, respectively, of the galaxy and its star e; $\varsigma \geq 1$ is an indicator of the level of zonal anomaly of the gravitational field caused by the location of the galaxy in a cosmosphere with an increased average density of matter or by the high speed of the galaxy's motion on a picture plane; $u(r)$ is the indicator of the presence of non-rigidity of the $\mathrm{FR_{0g}}$ of a galaxy that was cooling in quasi-equilibrium state ($\mathbf{F}_{in}$<-$\mathbf{F}_{gr}$); r_e is the radius of the conventional galactic loose nucleus, on the surface of which of the observed orbital velocity v of objects can take its maximum possible value $v_{\max} \equiv v_e = b_{ce}^{1/2}\hat{v}_e(b_e) = v_{lce}\hat{v}_e / c$; M_{00g} and $M_{grge} = M_{00g} / \sqrt{b_{ce}}$ are the ordinary and gravitational masses of the loose nucleus of the galaxy; m_{00e} and m_{gre} are the ordinary and gravitational masses of a galactic star moving in a circular orbit at the maximum possible speed.

In the first approximate dependence [Danylchenko, 35, 60, 65, 76, 83], the evolutionary self-contraction of matter in infinite fundamental space of CFREU is conditionally not taken into account. And therefore, there is no limitation of the galaxy's intrinsic space by the event pseudo-horizon (on which only the infinitely far cosmological past is always present) in it. After all, according to it, the coordinate velocity of light continuously increases along with the increase in the radial coordinate r.

Herein similarly to diffeomorphically-conjugated forms [76]:

$$v = b_c^{1/2}\hat{v} = \{[(b_{ce}/b_c)^n + (b_c/b_{ce})^n]/2\}^{-1/2} v_{\max} = [1 + 4q^2 \ln^2(r/r_e)]^{-1/4} v_e,$$

$$r = r_e \exp\left[\pm(1/2q)\sqrt{v^{-4}v_e^4 - 1}\right] = r_e \exp\left\{(1/4q)\left[(b_c/b_{ce})^n - (b_{ce}/b_c)^n\right]\right\},$$

$$b_c = k_b b_{ce} = b_{ce}\left[(v_{\max}/v)^2 \pm \sqrt{(v_{\max}/v)^4 - 1}\right]^{1/n} = b_{ce}\left[\pm 2n_g \ln(r/r_e) + \sqrt{1 + [2q\ln(r/r_e)]^2}\right]^{1/n},$$

$$b_c' = \frac{db_c}{dr} = \frac{2qb_c}{nr\sqrt{1 + [2n_g v_e^2 c^{-2} \ln(r/r_e)]^2}} = \frac{4qb_c}{nr[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]} =$$

$$= \frac{4b_c\varsigma M_{00g}\,{}^E G_{00} \exp\left\{\mp(1/4q)\left[(b_c/b_{ce})^n - (b_{ce}/b_c)^n\right]\right\}}{c^2 b_{ce}^2 r_e^2 [(b_c/b_{ce})^n + (b_{ce}/b_c)^n]},$$

$$\frac{b_c'}{b_c a_c r} - \frac{1}{r^2}\left(1 - \frac{1}{a_c}\right) + \Lambda - \frac{\kappa m_{00}c^2}{V}\left(\frac{1}{\sqrt{b_c}} - \sqrt{b_c}\right) = \frac{4q[r^{-2} - r_g r^{-3} - \Lambda/3]}{n[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]} - \frac{r_g}{r^3} + \frac{2\Lambda}{3} - \frac{\kappa m_{00}c^2}{V}\left(\frac{1}{\sqrt{b_c}} - \sqrt{b_c}\right) = 0,$$

$$V = \frac{n\kappa m_{00}c^2(1/\sqrt{b_c} - \sqrt{b_c})[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]}{4q(r^{-2} - r_g r^{-3} - \Lambda/3) - n(r_g r^{-3} - 2\Lambda/3)[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]} =$$

$$= \frac{n\kappa m_{00}c^2\left\{(1/\sqrt{b_{ce}})\left[\sqrt{1+A^2} \mp A\right]^{\frac{1}{2n}} - \sqrt{b_{ce}}\left[\sqrt{1+A^2} \pm A\right]^{\frac{1}{2n}}\right\}\sqrt{1+A^2}}{2q(r^{-2} - r_g r^{-3} - \Lambda/3) - n(r_g r^{-3} - 2\Lambda/3)\sqrt{1+A^2}},$$

$$A = 2q\ln(r/r_e), \qquad 1/a_c = 1 - r_g/r - \Lambda r^2/3, \qquad r_g = \int_{r_{\min}}^{r} r_g' dr, \;\; r_g^* = r_{ge} + \int_{r_e}^{r} r_g' dr$$

and: r_g and r_{ge}[40] are the gravitational radii of any layer of the galaxy and its loose nucleus, respectively [62].

Thus, the gravitational radius r_{ge} of the loose nucleus of the galaxy together with r_e, b_{ce} and M_{00g} is an indicator of the power of galactic gravitational field. Theoretically finding the values of all these indicators is problematic. And it is even impossible in the case of the formation of the loose nucleus of the galaxy by antimatter (i.e. when, due to the mirror symmetry of the antimatter-matter intrinsic space, $r > r_e$ not only outside, but also inside the loose nucleus).

Moreover, even for distant objects in the galaxy $r_g > 2\Lambda r^3/3$, and $b_c < 1-\Lambda r^2 = 1-3H_E^2 c^{-2} r^2$. And therefore, these objects are "affected" by pseudo-forces of repulsion that are three times greater than the Hubble pseudo-forces.

Therefore:

$$V > \frac{n\kappa m_{00} c^2 (1/\sqrt{b_c} - \sqrt{b_c})[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]}{4q(r^{-2} - \Lambda)},$$

$$\mu_{gr} = \frac{m_{00}}{\sqrt{b_c}V} < \frac{4q(r^{-2} - \Lambda)}{n\kappa c^2 (1-b_c)[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]}.$$

Apparently, all this is connected with the simplification of the considered FR of the galaxy. Because in this FR, unlike the FR of galaxies′ individual astronomical objects, there is no the event pseudo-horizon on which b_c=0. After all, the value of b_c can only grow continuously with the growth of the radial coordinate r ($db_c/dr \neq 0$ at all points of its infinite space).

The second dependence, on the contrary, ensures the presence of the event pseudo-horizon. But according to it, more complex mutual dependencies of the gravitational parameters of the galaxy take place and analytical integration of these dependencies is impossible. Due to:

$$\frac{r\sqrt{a_c b_c}}{m_{00}}\mathbf{F}_{in} = \frac{v^2(1-\Lambda r^2)}{(1-\Lambda r^2/3)} = \frac{r\sqrt{a_c b_c}}{m_{00}}\mathbf{F}_{gr} = \frac{rc^2}{2}\frac{d\ln b_c}{dr} = \frac{2c^2 q(1-\Lambda r^2)}{n(1-\Lambda r^2/3)[(b_c/b_{ct})^n + (b_{ce}/b_c)^n]} \quad \text{(when: } u\text{=0)},$$

$$v^2 = \frac{2c^2 q}{n(b_c/b_{ct})^n + (b_{ce}/b_c)^n]}, \qquad v_e^2 = \frac{c^2 q}{n} = \frac{c^2(b_{ce} r_{ge}/2r_e)}{b_{ce}} = \frac{c^2 r_{ge}}{2r_e},$$

we get: $$v = b_c^{1/2}\hat{v} = v_e\left\{\frac{1}{2}\left[\left(\frac{b_c}{b_{ce}}\right)^n + \left(\frac{b_{ce}}{b_c}\right)^n\right]\right\}^{-1/2} = v_e\left\{1+4q^2\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e - \Lambda r_e^3/3}\right) - u(b_c)\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right]^2\right\}^{-1/4},$$

$$\hat{v} = \frac{v}{\sqrt{b_c}} = \sqrt{\frac{2\mathrm{LH}_e (b_c/b_{ce})^n}{\mathrm{HL}_e[1+(b_c/b_{ce})^{2n}]}}\hat{v}_e = \sqrt{\frac{2(b_c/b_{ce})^n}{b_c[1+(b_c/b_{ce})^{2n}]}}v_e = \frac{v_e}{\sqrt{b_c}}\left\{1+4q^2\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right) - u\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right]^2\right\}^{-1/4},$$

[40] The gravitational radius r_{ge}^* corresponds to a loose nucleus, which at $(dr/dR)_e = 0$ contains only antimatter.

where: $$r-\frac{\Lambda r^3}{3}=\frac{(r_e-\Lambda r_e^3/3)(1-b_c)^u}{(1-b_{ce})^u}\exp\left[\pm\frac{1}{2q}\sqrt{v_e^4v^{-4}-1}\right]=\frac{(r_e-\Lambda r_e^3/3)(1-b_c)^u}{(1-b_{ce})^u}\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]\right\},$$

$$b_c=k_bb_{ce}=b_{ce}\left(v_e^2v^{-2}\pm\sqrt{v_e^4v^{-4}-1}\right)^{1/n}=b_{ce}\left(v_e^2v^{-2}\mp\sqrt{v_e^4v^{-4}-1}\right)^{-1/n}=$$

$$=b_{ce}\left\{\sqrt{1+4q^2\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)-u(b_c)\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right]^2}\pm2q\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)-u(b_c)\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right]\right\}^{1/n},$$

$$b_c'=\frac{db_c}{dr}=\frac{q(1-\Lambda r^2)}{n\left(r-\frac{\Lambda r^3}{3}\right)\left\{\frac{1}{2b_c}\sqrt{1+4q^2\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e-r_e^3/3}\right)-u(b_c)\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right]^2}-\frac{u(b_c)}{1-b_c}+\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\frac{du}{db_c}\right\}}=$$

$$=\frac{{}^EG_{00}M_{00g}\varsigma(1-\Lambda r^2)}{c^2r_eb_{ce}^2\left(r-\frac{\Lambda r^3}{3}\right)\left\{\frac{1}{4b_c}\left[\left(\frac{b_c}{b_{ce}}\right)^n+\left(\frac{b_{ce}}{b_c}\right)^n\right]-\frac{u(b_c)}{1-b_c}+\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\frac{du}{db_c}\right\}},$$

$$\frac{b_c'}{b_ca_cr}-\frac{1}{r^2}\left(1-\frac{1}{a_c}\right)+\Lambda-\frac{\kappa m_{00}c^2}{V}\left(\frac{1}{\sqrt{b_c}}-\sqrt{b_c}\right)=$$

$$=\frac{{}^EG_{00}M_{00g}\varsigma(1-\Lambda r^2)(r^{-2}-r_gr^{-3}-\Lambda/3)}{c^2r_eb_{ce}^2\left(1-\frac{\Lambda r^2}{3}\right)\left\{\frac{1}{4}\left[\left(\frac{b_c}{b_{ce}}\right)^n+\left(\frac{b_{ce}}{b_c}\right)^n\right]-b_c\left[\frac{u(b_c)}{1-b_c}-\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\frac{du}{db_c}\right]\right\}}-\frac{r_g}{r^3}+\frac{2\Lambda}{3}-\frac{\kappa m_{00}c^2}{V}\left(\frac{1}{\sqrt{b_c}}-\sqrt{b_c}\right)=0,$$

$$V=\frac{n\kappa m_{00}c^2(1-\Lambda r^2/3)\left\{(1/\sqrt{b_{ce}})\left[\sqrt{1+A^2}\mp A\right]^{\frac{1}{2n}}-\sqrt{b_{ce}}\left[\sqrt{1+A^2}\pm A\right]^{\frac{1}{2n}}\right\}\left(\sqrt{1+A^2}-B\right)}{2q(1-\Lambda r^2)(r^{-2}-r_gr^{-3}-\Lambda/3)-n(1-\Lambda r^2/3)(r_gr^{-3}-2\Lambda/3)\left(\sqrt{1+A^2}-B\right)},$$

$$\mu_{grst}=\frac{m_{00}}{\sqrt{b_c}V}=\frac{2\varsigma M_{00g}\,{}^EG_{00}(1-\Lambda r^2)(r^{-2}-r_gr^{-3}-\Lambda/3)}{\kappa c^4r_eb_{ce}^2(1-b_c)(1-\Lambda r^2/3)\left(\sqrt{1+A^2}-B\right)}+\frac{2\Lambda/3-r_gr^{-3}}{\kappa c^2(1-b_c)},$$

$$\mu_{grpst}=\frac{2\Lambda/3}{\kappa c^2(1-b_{c\max})}=\frac{H_E^2}{4\pi\,{}^EG_{00}(1-b_{c\max})},\qquad r_g=r_{ge}+\int_{r_e}^{r}r_g'dr,$$

$$A=2q\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)-u(b_c)\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\right],\qquad B=2b_c\left[\frac{u(b_c)}{1-b_c}-\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\frac{du}{db_c}\right],$$

μ_{grst} is standard value of the gravitational mass density of the galaxy matter,

μ_{grpst}=4,8596 10^{-27}/ 1-$b_{c\max}$) [kg/m^3] is non-zero standard value at the edge of the galaxy ($r_p=\Lambda^{-1/2}$ =1,1664 10^{26} [m]=3,78 [Gpc]) of the gravitational mass density of the galaxy matter still held by the galaxy in quasi-equilibrium, despite the zero value of the gravitational radius at its boundary (r_{gp}=0, $b'_{cp} = 0$).

Thus, the variation of the gravitational constant does indeed occur not only in time (a possibility suggested by Dirac [77]), but also in space. It varies similarly to the coordinate velocity of light, and therefore a function of it can be used as a gravitational potential. Moreover, the spatial distribution of the potentials of gravitational field of a flat galaxy does not actually depend on the values of local gravitational radii of this galaxy. The values of these local gravitational radii themselves depend on the gravitational field parameter b_c and determine both the curvature of the galaxy's intrinsic space and the spatial distribution of the allowed average mass density of matter. Consequently, new massive astronomical objects captured by the gravitational field of the galaxy will only have to fall onto its loose nucleus. And if the loose nucleus of the galaxy contains antimatter, those objects will be annihilated by it.

The dependence of the local values of the gravitational radii of a galaxy on the radial coordinate is determined from the following differential equation:

$$r'_g = \kappa\mu_{in}c^2r^2 = \frac{\dfrac{2q(1-\Lambda r^2)}{n(1-\Lambda r^2/3)\left(\sqrt{1+A^2}-B\right)}\left(1-\dfrac{r_g}{r}-\dfrac{\Lambda r^2}{3}\right)+\left(\dfrac{2\Lambda r^2}{3}-\dfrac{r_g}{r}\right)}{\dfrac{1}{b_{ce}}\left\{\sqrt{1+4q^2\left[\ln\left(\dfrac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)-u(b_c)\ln\left(\dfrac{1-b_c}{1-b_{ce}}\right)\right]^2}\mp 2q\left[\ln\left(\dfrac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)-u(b_c)\ln\left(\dfrac{1-b_c}{1-b_{ce}}\right)\right]\right\}^{\frac{1}{n}}-1},$$

or using dependent on it parameter S:

$$dS = d\left(\frac{r-r_g-\Lambda r^3/3)}{1-b_c}\right) = -\frac{n}{q}\left\{\frac{1}{4b_c}\left[\left(\frac{b_c}{b_{ce}}\right)^n+\left(\frac{b_{ce}}{b_c}\right)^n\right]-\frac{u(b_c)}{1-b_c}+\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\frac{du}{db_c}\right\}\left(1-\frac{\Lambda r^2}{3}\right)\left[\frac{b_cS}{(1-\Lambda r^2)(1-b_c)}-\frac{r}{(1-b_c)^2}\right]db_c,$$

$$r_g = r-\frac{\Lambda r^3}{3}-(1-b_c)\exp\left[-\int\frac{b_c dr}{(1-b_c)r}\right]\times\int\left\{\frac{1-\Lambda r^2}{(1-b_c)^2}\exp\left[\int\frac{b_c dr}{(1-b_c)r}\right]\right\}dr = r-\frac{\Lambda r^3}{3}-$$

$$-\frac{n(r_e-\Lambda r_e^3/3)(1-b_c)}{4q}\exp\left[-\int\frac{b_c dr}{(1-b_c)r}\right]\times$$

$$\times\int_{b_{ce}}^{b_c}\left\{\frac{[(b_c/b_{ce})^n+(b_{ce}/b_c)^n]}{b_c(1-b_c)^2}-\frac{4u}{(1-b_c)^3}\right\}\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]+\int\frac{b_c dr}{(1-b_c)r}\right\}db_c =$$

$$=\frac{n(r_e-\Lambda r_e^3/3)(1-b_c)}{4q}\exp\left[-\int\frac{b_c dr}{(1-b_c)r}\right]\times\int_{b_{ce}}^{b_c}\left\{\left[1-\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\left(\frac{b_c(1-\Lambda r^2/3)}{1-\Lambda r^2}-1\right)\frac{du}{db_c}\right]\frac{1}{(1-b_c)^2}-\right.$$

$$\left.-\frac{u}{(1-b_c)^3}\left[\frac{b_c(1-\Lambda r^2/3)}{1-\Lambda r^2}-1\right]+\frac{\Lambda[(b_c/b_{ce})^n+(b_{ce}/b_c)^n]}{6(r^{-2}-\Lambda)(1-b_c)^2}\right\}\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]+\int\frac{b_c dr}{(1-b_c)r}\right\}db_c,$$

where: $\int \frac{b_c dr}{(1-b_c)r} = \frac{n}{q}\int \frac{1-\Lambda r^2/3}{(1-\Lambda r^2)(1-b_c)}\left\{\frac{1}{4}\left[\left(\frac{b_c}{b_{ce}}\right)^n + \left(\frac{b_{ce}}{b_c}\right)^n\right] - \frac{b_c u}{1-b_c} + b_c \ln\left(\frac{1-b_c}{1-b_{ce}}\right)\frac{du}{db_c}\right\}db_c$.

At u=-1 ($\mathbf{F}_{in} << -\mathbf{F}_{gr}$) this solution of the standard equation of the dynamic gravitational field of a flat galaxy allegedly degenerates. After all, in this case the value of the gravitational radius of the galaxy becomes proportional to the cosmological constant Λ, and therefore to the Hubble constant:

$$r_g = \frac{2n\Lambda(3r_e - \Lambda r_e^3)(1-b_c)}{9q}\exp\left[-\int \frac{b_c dr}{(1-b_c)r}\right]\times$$

$$\times \int_{b_{ce}}^{b_c} \frac{r^2\{b_c + (1-b_c)[(b_c/b_{ce})^n + (b_{ce}/b_c)^n]/4\}}{(1-\Lambda r^2)(1-b_c)^3}\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n - \left(\frac{b_{ce}}{b_c}\right)^n\right] + \int \frac{b_c dr}{(1-b_c)r}\right\}db_c .$$

But in fact the cosmological constant Λ, like the parameter b_c, is a hidden parameter of almost all physical characteristics of matter. And it is thanks to it that at $b_{ce} > (1-\Lambda r_e^2)/(1-\Lambda r_e^2/3)$ in the non-rigid FR of a cooling flat galaxy in a state of observant self-contraction ($u = -v_e^2 v^{-2}/2$, $\mathbf{F}_{in} << -\mathbf{F}_{gr}$), the radial values of the gravitational radii $r_g(r)$ of a flat galaxy become larger than in the hypothetical rigid FR of a flat galaxy (u=0, $\mathbf{F}_{in} = -\mathbf{F}_{gr}$).

Thus the trivial solution of the equation takes place both at u=0 ($\mathbf{F}_{in} = -\mathbf{F}_{gr}$) and at a negative value of the parameter $u = -\varepsilon(z_e)v_e^2 v^{-2}/2$ ($\mathbf{F}_{in} < -\mathbf{F}_{gr}$), where: $\varepsilon(z_e) \le 1$ is the galactic constant, which determines the rate of contraction of a galaxy and is apparently dependent on the redshift z of the wavelengths of its emission radiation.

Also what is important is that even in an incredibly weak gravitational field (when $\varepsilon(z_e) = 1$, $u = -v_e^2 v^{-2}/2$, $\mathbf{F}_{in} << -\mathbf{F}_{gr}$) and even at large radial distances, astronomical objects will rotate around the center of the galaxy with orbital velocities very close to the maximum possible speed. After all, regardless of the value of the variable function u, the orbital velocities of astronomical objects in a flat galaxy at n=b_{ce}=0 can theoretically be equal to the maximum velocity $v_{max} \equiv v_e$ at all radial distances.

Moreover, it is precisely thanks to $b_{ce} > (1-\Lambda r_e^2)/(1-\Lambda r_e^2/3)$ that this takes place at $u = -v_e^2 v^{-2}/2$ ($\varepsilon(z_e) = 1$, $\mathbf{F}_{in} << -\mathbf{F}_{gr}$) at very large distances from the center of a galaxy. After all, when $u = -v_e^2 v^{-2}/2$ ($\varepsilon(z_e) = 1$, $\mathbf{F}_{in} << -\mathbf{F}_{gr}$), the radial distances from the center to the objects of the cooling galaxy at the same value of the parameter b_c were much greater in the past than the hypothetical radial distances that could be much smaller at u=0 ($\mathbf{F}_{in} = -\mathbf{F}_{gr}$):

$$r-\frac{\Lambda r^3}{3}=\left(r_e-\frac{\Lambda r_e^3}{3}\right)\left(\frac{1-b_{ce}}{1-b_c}\right)^{\frac{v_e^2}{2v^2}}\exp\left[\pm\frac{1}{2q}\sqrt{v^{-4}v_e^4-1}\right]=\left(r_e-\frac{\Lambda r_e^3}{3}\right)\left(\frac{1-b_{ce}}{1-b_c}\right)^{\frac{v_e^2}{2v^2}}\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]\right\}>>$$

$$>>\left(r_e-\frac{\Lambda r_e^3}{3}\right)\exp\left[\pm\frac{1}{2q}\sqrt{v^{-4}v_e^4-1}\right]=\left(r_e-\frac{\Lambda r_e^3}{3}\right)\exp\left\{\frac{1}{4q}\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]\right\},$$

$$\frac{dr}{db_c}=\frac{n(r-\Lambda r^3/3)}{4qb_c(1-\Lambda r^2)}\left\{\frac{1}{1-b_c}\left[\left(\frac{b_c}{b_{ce}}\right)^n+\left(\frac{b_{ce}}{b_c}\right)^n\right]-n\ln\left(\frac{1-b_c}{1-b_{ce}}\right)\left[\left(\frac{b_c}{b_{ce}}\right)^n-\left(\frac{b_{ce}}{b_c}\right)^n\right]\right\}>>$$

$$>>\frac{n(r-\Lambda r^3/3)}{4qb_c(1-\Lambda r^2)}\left[\left(\frac{b_c}{b_{ce}}\right)^n+\left(\frac{b_{ce}}{b_c}\right)^n\right].$$

The transition from the dynamic to the hypothetical static gravitational field of a flat galaxy when u=0 ($\mathbf{F}_{in}=-\mathbf{F}_{gr}$) is carried out as follows:

$${}^s b=\frac{b_s}{2}\left(1+\sqrt{1-\frac{4v^2}{b_s c^2}}\right)=\frac{b_s}{2}\left(1+\sqrt{1-\frac{8v_e^2}{b_s c^2[(b_{se}/b_s)^n+(b_s/b_{se})^n]}}\right),\ {}^s b_e=\frac{b_{se}}{2}\left(1+\sqrt{1-\frac{4v_e^2}{b_{se}c^2}}\right)\quad \text{(in GR and RGTD);}$$

$$b=b_c(1-\hat{v}^2c^{-2})=b_c-v^2c^{-2}=b_c-\frac{2v_{\max}^2(b_c/b_{ce})^n}{c^2[1+(b_c/b_{ce})^{2n}]}=$$

$$=b_c-\frac{v_e^2}{c^2\sqrt{1+\{2q\ln[(r-\Lambda r^3/3)/(r_e-\Lambda r_e^3/3)]\}^2}},$$

$$b_e=b_{ce}(1-\hat{v}_e^2c^{-2})=b_{ce}-v_e^2c^{-2},\quad b'=b_c'+\frac{4q^2v^6(1-\Lambda r^2)}{c^6(r-\Lambda r^3/3)}\ln\left(\frac{r-\Lambda r^3/3}{r_e-\Lambda r_e^3/3}\right)>b_c'\quad \text{(in RGTD).}$$

The gravitational force acting in a static gravitational field on a conditionally motionless body is greater than the gravitational force acting in a dynamic gravitational field on the same body that is moving. And this is not only due to the decrease in the gravitational mass of the body due to its movement. After all, in a space full of rapidly moving bodies, the intensity of the dynamic gravitational field also decreases. That is why it is necessary to use precisely the dynamic gravitational field instead of a static one in calculations of the rotational motion of galactic objects.

Thus, in the equations of the dynamic gravitational field of RGTD, as in the equations of thermodynamics, not only gravitational, but also relativistic indicators are internal hidden parameters of the RGTD-state of matter in motion. And that is why in RGTD, unlike orthodox GR, the use of an external relativistic description of the state of matter in motion is not always required.

The FR practically equivalent the FR of an observed galaxy is galaxy's intrinsic GT-FR$_{g0}$, the transition to which can be reached by transforming the parameters. The invariants of such a transformation are not only the radii of the circular orbits of astronomical objects in the galaxy, but also the following relations:

$$v_0 / v_{e0} = v / v_e = \mathbf{invar}\,, \qquad n_0 \ln k_{b0} = n \ln k_b = \mathbf{invar} \quad [\, b_{ce0} \ln(b_{c0} / b_{ce0}) = b_{ce} \ln(b_c / b_{ce}) = \mathbf{invar}\,].$$

The following dependence of the orbital velocity of objects of galaxies on parameter b_{c0} and, thus on radial distance r, can be applied to these objects in centric intrinsic GT-FR$_{g0}$ (^{ec}FR$_{g0}$) of galaxy [62, 65, 76]:

$$v_0 = v_{e0}\sqrt{\frac{2}{(b_{c0}/b_{ce0})^{b_{ce0}} + (b_{ce0}/b_{c0})^{b_{ce0}}}} = v_{e0}\left\{1 + 4q_0^2\left[\ln\left(\frac{r - \Lambda r^3/3}{r_e - \Lambda r_e^3/3}\right) - u(b_{c0})\ln\left(\frac{1-b_{c0}}{1-b_{ce0}}\right)\right]^2\right\}^{-\frac{1}{4}},$$

where: $q_0 = q b_e / b_{e0}$, $v_{e0}^2 = v_e^2 b_{e0} / b_e$, $b_{c0} = b_{ce0}(b_c / b_{ce})^{\frac{b_{ce}}{b_{ce0}}} = b_{ce0}\left[(v_{e0}^2 v_0^{-2} \pm \sqrt{v_{e0}^4 v_0^{-4} - 1}\right]^{\frac{1}{b_{ce0}}} =$

$$= b_{ce0}\left\{\sqrt{1 + 4q_0^2\left[\ln\left(\frac{r - \Lambda r^3/3}{r_e - \Lambda r_e^3/3}\right) - u(b_{c0})\ln\left(\frac{1-b_{c0}}{1-b_{ce0}}\right)\right]^2} \pm 2q_0\left[\ln\left(\frac{r - \Lambda r^3/3}{r_e - \Lambda r_e^3/3}\right) - u(b_{c0})\ln\left(\frac{1-b_{c0}}{1-b_{ce0}}\right)\right]\right\}^{\frac{1}{b_{ce0}}},$$

$$r - \frac{\Lambda r^3}{3} = \frac{(r_e - \Lambda r_e^3/3)(1-b_{c0})^u}{(1-b_{ce0})^u}\exp\left[\pm\frac{1}{2q_0}\sqrt{v_0^{-4}v_{e0}^4 - 1}\right] = \frac{(r_e - \Lambda r_e^3/3)(1-b_{c0})^u}{(1-b_{ce0})^u}\exp\left\{\frac{1}{4q_0}\left[\left(\frac{b_{c0}}{b_{ce0}}\right)^{b_{ce0}} - \left(\frac{b_{ce0}}{b_{c0}}\right)^{b_{ce0}}\right]\right\}.$$

In the Schwarzschild solution of the GR equations with a non-zero value of the cosmological constant Λ, in addition to the Schwarzschild singular sphere, on which only the infinitely distant cosmological future always lies, there is also a singular sphere of the event pseudo-horizon, on which only the infinitely distant cosmological past always lies. Relativistic non-simultaneity in cosmological time τ of events that take place in different locations but simultaneous in the intrinsic time t of matter turns out to be a mutual agreement of the Schwarzschild solutions of the gravitational field equations in CFREU and FR of matter. And this is due to the use of the physically homogeneous scale of its intrinsic time instead of the metrically and spatially homogeneous scale of intrinsic time of the matter. Otherwise, the values of almost all physical parameters and characteristics of the matter would have to be continuously renormalized. It is because of this that on the singular surface (b_c=0) of the event pseudo-horizon, the gravitational "constant" according to the Dirac hypothesis takes an infinitely large value.

And this corresponds to a very slow rate of physical processes (b_c≈0) in the distant cosmological past near the event pseudo-horizon. Moreover, it actually refutes the incredibly rapid initial rate of physical processes according to the false theory of the Big Bang of the Universe, which localizes the Universe in the distant past at a "point" instead of localizing its distant cosmological past in the observer's FR on a sphere with the maximum possible radius $r_c=(\Lambda/3)^{-1/2}$.

Thanks to: $m_{gre}(d\ln b_c/dr)_e = m_{gre0}(d\ln b_{c0}/dr)_e(n_0/n)^{3/2}$ $[\ln(v_{lc}/v_{lce}) = v_{lce}^{-2}v_{lce0}^{2}\ln(v_{lc0}/v_{lce0})$, $m_{gre} = m_{gre0}v_{lce0}/v_{lce}$, when: $G_{00} = \mathbf{const}(v_{lce})$, $M_{00} = \mathbf{const}(v_{lce})$, $m_{00} = \mathbf{const}(v_{lce})$, $r_e = \mathbf{const}(v_{lce})$], $a_c = a_{c0}$ and $v_e/v_{lce} = v_{e0}/v_{lce0}$, we have the following relations for the centrifugal pseudo-forces of inertia and for the gravitational pseudo-forces in the intrinsic $^{ec}FR_g$ of a distant galaxy and in the ^{E}FR of the observer of this galaxy:

$$^{g}\mathbf{F}_{ine0} = \frac{m_{ine0}c^2v_{e0}^2}{r_e v_{lce0}^2} = {}^{E}\mathbf{F}_{ine}\frac{m_{ine0}}{m_{ine}} = {}^{E}\mathbf{F}_{ine}\frac{v_{lce0}}{v_{lce}} = {}^{E}\mathbf{F}_{ine}\sqrt{\frac{n_0}{n}},$$

$$^{g}\mathbf{F}_{gre0} = \frac{m_{gre0}}{2\sqrt{a_{ce0}}}\left(\frac{d\ln b_{c0}}{dr}\right)_e = {}^{E}\mathbf{F}_{gre}\sqrt{\frac{n_0}{n}} = \frac{m_{gre}}{2\sqrt{a_{ce}}}\left(\frac{d\ln b_c}{dr}\right)_e\sqrt{\frac{n_0}{n}} = \frac{m_{gre0}}{2\sqrt{a_{ce0}}}\left(\frac{d\ln b_{c0}}{dr}\right)_e\frac{n_0^2}{n^2} = {}^{E}\mathbf{F}_{gre0}\frac{^{ge}G_{00}}{^{E}G_{00}},$$

where: $^{g}\mathbf{F}_{gre0} = -{}^{g}\mathbf{F}_{ine0} = -{}^{E}\mathbf{F}_{ine}v_{lce0}/v_{lce} = {}^{E}\mathbf{F}_{gre}\sqrt{n_0/n}$ and $^{g}\mathbf{F}_{ine0}$ are the galactic internal values of the gravitational pseudo-force and the centrifugal pseudo-force of inertia acting on star *e*, respectively; $^{E}\mathbf{F}_{gre} = -{}^{E}\mathbf{F}_{ine} = -{}^{E}\mathbf{F}_{ine}v_{lce0}/v_{lce} = {}^{E}\mathbf{F}_{gre}\sqrt{n_0/n}$ and $^{E}\mathbf{F}_{ine}$ are the observed external values of gravitational pseudo-force and the centrifugal pseudo-force of inertia acting on the star *e* in the observer's ^{E}FR respectively; $^{E}\mathbf{F}_{gre0}$ is the gravitational pseudo-force acting on a similar star in a similar hypothetical galaxy at a distance from the observer $\Lambda^{-1/2}$ ($b_{ce0}\approx 1$).

In the case of using the gravithermodynamic (astronomical) intrinsic time ($b_{c0}=1$) of a distant galaxy, we obtain the galactic value of the gravitational constant $^{g}G_{00} = {}^{E}G_{00}b_{ce}^{-2}$.

Thus, the lack of temporal invariance of the gravitational "constant" refutes not only the Big Bang of the Universe, but also the need for dark non-baryonic matter.

In centric intrinsic GT-FR$_{g0}$ of the galaxy when $u = -v_e^2v^{-2}/2$ the following typical radial distribution of the average density of gravitational mass of the matter in the galaxy takes place:

$$\mu_{grst0} = \frac{m_{00}}{\sqrt{b_{c0}}V} = \frac{2q_0(1-\Lambda r^2)(r^{-2} - r_{g0}r^{-3} - \Lambda/3)}{n_0\kappa c^2(1-b_{c0})(1-\Lambda r^2/3)\left(\sqrt{1+A^2} - B\right)} + \frac{2\Lambda/3 - r_{g0}r^{-3}}{\kappa c^2(1-b_{c0})},$$

$$A = 2q_0\left[\ln\left(\frac{r-\Lambda r^3/3}{r_e - \Lambda r_e^3/3}\right) + \frac{v_{e0}^2}{2v_0^2}\ln\left(\frac{1-b_{c0}}{1-b_{ce0}}\right)\right]$$

$$B = \frac{1}{2}\left\{n_0\ln\left(\frac{1-b_{c0}}{1-b_{ce0}}\right)\left[\left(\frac{b_{c0}}{b_{ce0}}\right)^{n_0} - \left(\frac{b_{ce0}}{b_{c0}}\right)^{n_0}\right] - \frac{b_{c0}}{1-b_{c0}}\left[\left(\frac{b_{c0}}{b_{ce0}}\right)^{n_0} + \left(\frac{b_{ce0}}{b_{c0}}\right)^{n_0}\right]\right\}.$$

According to this distribution, when at the edge of the galaxy ($r_p=\Lambda^{-1/2}$=1,1664 10^{26} [m]=3,78 [Gpc]) the gravitational mass density of matter still held by the galaxy in quasi-equilibrium, despite the zero value of the gravitational radius at its boundary ($r_{g0p}=0$, $b'_{c0p}=0$, $b_{c0p}=b_{c0\max}$, $r_{g0p}r_p^{-3}=\Lambda^{3/2}r_{g0p}=0$), becomes non-zero standard $\mu_{grpst0}=2\Lambda/3\kappa c^2(1-b_{c0\max})=H_E^2/4\pi\,{}^E G_{00}(1-b_{c0\max})$.

It is obvious that the essential time dilation, which is being observed for far galaxies (due to $b_{ce}=1{,}12656\cdot 10^{-6}$), can be considered as evolutionary-gravitational phenomenon that is consistent with the linear Hubble dependence of redshift of wavelength of radiation and that significantly differs from this dependence only for quasars that have very strong gravitational field. If the value of radius $r_e=R_{t/e}$ of the surface of "loose nucleus" of the galaxy is the minimum possible in mirror symmetric configuration of intrinsic space of the galaxy (when in CFREU $(dr/dR)_e=0$ and $(db_c/dR)_e=0$, where: $b_{ce}>0$, $R_{inside}(t)=r\left(1-\sqrt{1-r_e/r}\right)^2/\psi-r_c\left(1-\sqrt{1-r_e/r_c}\right)^2/\psi$, $\frac{1}{R_{outside}(t)}=\left[\left(1+\sqrt{1-r_e/r}\right)^{-2}/r-\left(1+\sqrt{1-r_e/r_c}\right)^{-2}/r_c\right]\frac{1}{\psi}=r_e^{-2}\left[r\left(1-\sqrt{1-r_e/r}\right)^2-r_c\left(1-\sqrt{1-r_e/r_c}\right)^2\right]\frac{1}{\psi}=R_{inside}(t)r_e^{-2}$ and $\psi=1-\left(1-\sqrt{1-r_e/r_c}\right)^2 r_c/r_e$ [41]), then its "loose nucleus" will de facto be the antiquasar. And, consequently, all stars of "loose nucleus" of galaxy will consist of only antimatter. The solution of equations of gravitational field of GR in background Euclidean space [35, 41, 43, 62] confirms the principal possibility of existence of such "loose" structure of galaxies.

Due to the low strength of gravitational field outside the loose nuclei of galaxies they can indeed be considered as "island Universes" [80 – 82] (non-isolated island systems [38]) that have individual intrinsic values of gravitational constant. Taking into account the larger values in the past of the gravitational masses not only of the attracted bodies, but also of the bodies that attract them, the complete galactic value of the gravitational "constant" will be as follows [Danylchenko, 2024a]:

$$^gG_{00}\approx{}^gG_{00dop}=\frac{^EG_{00}}{b_{cdop}^2}=\left(\frac{1+z_{dop}}{f(z_{dop})}\right)^2{}^EG_{00}=\frac{D_M^2}{D_A^2}\frac{^EG_{00}}{[f(z_{dop})]^2}\equiv\left(\frac{1+z_{dop}}{1+2z_{dop}}\right)^2\frac{R^2}{r^2}{}^EG_{00}=\frac{(1+z_{dop})^4}{(1+2z_{dop})^2}{}^EG_{00}.$$

Let us examine the movements of objects of such galaxy using metrically homogeneous scale of cosmological time, by which the frequency of radiation of its stars does not change in time and the redshift of its wavelengths appears because of the evolutionary decreasing of velocity of light in comoving with expanding Universe FR[42]. By the synchronous to it scale s of intrinsic times in FR_{obs}

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[41] When $R_e(\tau)=R_{t/e}=r_e$: $r=r_e(1+\tilde{R}/R_e)(1+R_e/\tilde{R})/4=[r_e+\tilde{R}_t(\tau)][1+r_e/\tilde{R}_t(\tau)]/4$, where: $\tilde{R}=\tilde{R}_t(\tau)R_e/r_e$ and $\tilde{R}_t(\tau)$ are the values of the radial coordinate R in CFREU; τ is the cosmological time measured in CFREU; $\tilde{R}_{t/inside}(\tau)=\psi R(t)+r_c(1-\sqrt{1-r_e/r_c})^2=r\left(1-\sqrt{1-r_e/r}\right)^2$, $r_e^2/\tilde{R}_{t/outside}(\tau)=\psi r_e^2/R(t)+r_c(1-\sqrt{1-r_e/r_c})^2=r\left(1-\sqrt{1-r_e/r}\right)^2=\tilde{R}_{t/inside}(\tau)$, $r_c=c/H_E=(3/\Lambda)^{1/2}$.

[42] Here when $f(z_{dop})=1$, in fact, the evolutionary decrease of the gravitational constant according to Dirac's hypothesis is considered [77]. However, the most likely is an indirect decrease in the effective value of the gravitational constant when $f(z_{dop})=(1+2z_{dop})/(1+z_{dop})$ due to a decrease in the coordinate velocity of light: ${}^EG_{eff}={}^EG_{00}(c^4/v_{cr}^4)={}^EG_{00}b_{cj}^{-2}\approx{}^EG_{00}(1+z)^4(1+2z)^{-2}$ [83]. Exactly this reflects the presence of $1/b_{cj}$ times larger

of distant observer ($z_{dop}>0$, $b_{cdop}=f(z_{dop})/(1+z_{dop})$, $m_{in0}(z)=m_{gr0}(z)f(z_{dop})/(1+z_{dop})$, r, ${}^{E}G_{00}$) and in comoving FR_{0g} of the galaxy ($z_0=0$, $b_{ce}=1$, $m_{in0}(z_0)=m_{gr0}(z_0)$, $R=r(1+z_{dop})$, ${}^{E}G_{0gdop}={}^{E}G_{00}[(1+z_{dop})/f(z_{dop})]^2$) we will have the following ratios of pseudo-forces of gravity and inertia in these FRs:

$$\mathbf{F}_{gr}(z_0)=m_{gr0}M_{gr0}\frac{{}^{E}G_{0gdop}}{\rho_0^2}=m_{gr0}M_{gr0}\frac{{}^{E}G_{0gdop}}{R^2\operatorname{Sin}^2\mathrm{A}}=m_{gr0}M_{gr0}\frac{{}^{E}G_{00}}{r^2\operatorname{Sin}^2\mathrm{A}}=\frac{\operatorname{Sin}^2\alpha}{\operatorname{Sin}^2\mathrm{A}}\mathbf{F}_{gr}(z)=\frac{\rho^2(1+z_{dop})^2}{\rho_0^2[f(z_{dop})]^2}\mathbf{F}_{gr}(z),$$

$$\mathbf{F}_{in}(z_0)=m_{in0}(z_0)\Omega_0^2\rho_0=m_{gr0}(z_0)\Omega_0^2 R\operatorname{Sin}\mathrm{A}=m_{in0}(z)\Omega_0^2\rho\operatorname{Sin}\mathrm{A}\frac{(1+z_{dop})^3}{[f(z_{dop})]^2}=\frac{\Omega_0^2\operatorname{Sin}\mathrm{A}(1+z_{dop})^3}{\Omega^2\operatorname{Sin}\alpha[f[z_{dop})]^2}\mathbf{F}_{in}(z)=\frac{\Omega_0^2\rho_0(1+z_{dop})^2}{\Omega^2\rho[f(z_{dop})]^2}\mathbf{F}_{in}(z),$$

where: ${}^{E}G_{0g}R^{-2}[f(z_{dop})]^2={}^{E}G_{00}r^{-2}$; $\rho_0=R\operatorname{Sin}\mathrm{A}$ and $\rho=r\operatorname{Sin}\alpha$ are the radiuses of orbits of objects of galaxy in FR_{0g} and in FR_{obs} correspondingly; A and α are the aperture angles of radiuses of orbits of galaxy in CFREU and in FR_{obs} correspondingly; Ω_0 and Ω are the angular velocities of rotation of galactic objects in FR_{0g} and in FR_{obs} correspondingly.

In order for centrifugal pseudo-forces of inertia to compensate the pseudo-forces of gravity the following conditions should be fulfilled according to this:

$$\rho_0^3\Omega_0^2=\rho_0 v_0^2=\rho v^2=\rho^3\Omega^2=M_{gr0}{}^{E}G_{00}/b_{rdop}=M_{gr0}{}^{E}G_{0gdop}=M_{gr0}{}^{E}G_{00}(1+z_{dop})^2[f(z_{dop})]^{-2}=M'_{gr0}{}^{E}G_{00},$$

$$\rho'_0=\rho=M_{gr0}{}^{E}G_{00}/b_c=M_{gr0}{}^{E}G_{00}/b_{cdop}b_{cgr}=M_{gr0}{}^{E}G_{0g}=M_{gr0}{}^{E}G_{00}(1+z)^2 f^{-2}(z)=M_{gr0}{}^{E}G_{00}(1+z_{dop})^2(1+z_{gr})^2 f^{-2}(z)=M''_{gr0}{}^{E}G_{00},$$

where: $b_c=b_{cdop}b_{cgr}$; $b_{cdop}=f(z_{dop})/(1+z_{dop})$; $b_{cgr}\equiv b_{\cos}=v_{cvos}^2c^{-2}=f(z_{gr})/(1+z_{gr})$; $(1+z)=(1+z_{dop})(1+z_{gr})$; v_{cvos} is the value of coordinate velocity of light in the outer space; z_{dop} and z_{gr} are the Dopplerian and gravitational redshifts of the spectrum of radiation of distant galaxies correspondingly; v_0 and v are the linear velocities of rotation of galactic objects in FR_{0g} and in FR_{obs} correspondingly.

So, mostly namely due to the ignoring of essentially bigger value of gravitational constant in distant cosmological past the imaginary necessity in the bigger mass $M''_{gr0}=M_{gr0}{}^{E}G_{0g}/{}^{E}G_{00}=M_{gr0}(1+z)^2 f^{-2}(z)=M_{gr0}(1+z)^4(1+2z)^{-2}>>M_{gr0}$ and, therefore the imaginary necessity in fictive dark matter, appears.

Observed radiuses of orbits of galactic objects do not differ from their eigenvalues ρ_0 only in case of the absence of gravitational dilation of intrinsic time of galactic objects by the outer space that surrounds them: $\rho=\rho_0 v_0^2 v^{-2}=\rho_0 c^2 v_{cvos}^{-2}=\rho_0/b_{\cos}=\rho_0(1+z_{gr})^2/(1+2z_{gr})$ or in case when the gravitational dilation of the time is taken into account in the eigenvalue of gravitational constant ($\rho=\rho'_0$). All this is in a good agreement with the theory of dimensions.

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gravitational mass for the source of gravity and for the object that is moving by inertia in gravitational field (compared to its inertial mass). Based on the redshift of the relict radiation z=1089, the relict value of the gravitational "constant" could not exceed Newton's gravitational constant by more than 297300 times. Whereas, according to Dirac's hypothesis, this excess could be much larger, equal to 1188000.

The most significant fact id the absence of relativistic dilation of intrinsic time of galaxies according to received transformations. And this confirms the correspondence of the orbital motion of galactic astronomical objects to GT-Lagrangians and GT-Hamiltonians or to Lorentz-conformal transformation of increments of metrical intervals and metrical time for the galaxies [62]. Since the galaxies in FR of people's world are inertially falling onto the pseudo-horizon of the past, then according to these conformal relativistic transformations there fundamentally should be no relativistic dilation of their time. The dilation of their intrinsic time rate could be only gravitational in cosmological past because the gas-dust matter, in which they were immersed, had big density at that time. For the nearest galaxies, which (as our galaxy) are located now in the vacuum outer space, we can accept that angular velocity of observed orbital motion of their objects was not essentially smaller at that time than it is now ($\Omega \approx \Omega_0$). And, consequently, radiuses of orbits of their objects in CFREU are practically not decreased since that distant time ($\rho \approx \rho_0$).

And, consequently, in contrast to FR of superficially cooled down astronomical objects, the galaxies itself (similarly to their evolutionary cooling down stars) have non-rigid FR. Radial distances to their stars $R_s = R_{s0} \exp[-H_E(\tau - \tau_0)]$ in FRs of their superficially cooled down planets are evolutionary decreasing by the reverse Hubble law due to evolutionary decreasing of gravitational constant ${}^E G_R = {}^E G_{R0} \exp[-2H_E(\tau - \tau_0)]$ in these FRs. So due the stars of the galaxy indeed move not in closed orbits but in spiral orbits. And, consequently, this fits well with the spiral-wave nature of matter and of the Universe as a whole [44, 45, 47]. Of course, by using the gauge transformation of scales of intrinsic time of galaxies [74] we can guarantee the invariance of gravitational constant in their non-rigid FRs [50]. However, the galactic objects will anyway move in CFREU in spiral orbits.

13. The condition of invariance of thermodynamic potentials and parameters with regard to the relativistic transformations

Thermodynamic potentials and parameters of matter as well as the temperatures of its phase transitions are purely internal properties of matter [4, 5] and, therefore, fundamentally should not be changed during relativistic transformations of increments of spatial coordinates and time. One more thing that denotes it is the presence of two absolutely opposite relativistic generalizations of thermodynamics [84], according to one of which [85 – 88] moving body is colder than resting body, while according to another one [1], moving body is hotter than motionless body. Moreover, in spite of the declared in SR relativistic shrinkage of the size of body along the direction of its motion the molar volume of moving matter also should not be changed during the relativistic transformations of increments of spatial coordinates and time [64]. In order to fulfill the general covariance of equations of not only thermodynamics but also mechanics in SR and in GR there should be a principle of unobservability of deformation and metrical inhomogeneity of matter on the level of its microobjects. Indeed, instead of metrically inhomogeneous background Euclidean space [25] the intrinsic spaces of matter that have gravitational curvature are used in GR. And, therefore, of course, the local kinematic "curvature" of intrinsic space of the observer of moving body should be introduced in SR instead of relativistic length shrinkage.

In commonly accepted but erroneous interpretation of SR besides the Ehrenfest paradox the correspondent to it paralogism of enclosed trajectory (circle, ellipse) takes place. Due to expected relativistic shrinkage of the size of standard of length (meter) of the body that moves by enclosed trajectory its length (according to its intrinsic standard of length) according to external observer should be $\Gamma=(1-v^2c^{-2})^{-1/2}$ times greater than by the standard of length of this observer. And time, which is required for body to perform the full turn, by its intrinsic clock should be the same number of times smaller than by the clock of this observer. And, consequently, according to external observer the velocity of orbital motion of the body in intrinsic FR of the body should be Γ^2 times greater than its value that is registered by this direct external observer. Lorentz transformations do not guarantee this, since according to them the velocity of motion of the body in its intrinsic FR is the same as in FR_{out} of external observer.

Increments of coordinate time and spatial coordinates can be expressed not only in four-dimensional pseudo-Euclidean Minkowsky space, but also in similar to it four-dimensional hyperbolic space[43] [38]. Let us examine at first the movement along the one direction. According to Lorentz transformations we will have:

$$cdt'=\text{ch}(\psi_t-\psi_{t0})ds=\frac{1-vv_0c^{-2}}{\sqrt{(1-v^2c^{-2})(1-v_0^2c^{-2})}}ds=\frac{\text{ch}(\psi_t-\psi_{t0})}{\text{ch}\psi_t}cdt=\sqrt{\frac{1-v^2c^{-2}}{1-v'^2c^{-2}}}cdt\,,$$

$$dl'=\text{sh}(\psi_t-\psi_{t0})ds=\frac{(v-v_0)/c}{\sqrt{(1-v^2c^{-2})(1-v_0^2c^{-2})}}ds=\frac{\text{sh}(\psi_t-\psi_{t0})}{\text{sh}\psi_t}dl=\frac{v'}{v}\sqrt{\frac{1-v^2c^{-2}}{1-v'^2c^{-2}}}dl\,,$$

$$v'=\frac{dl'}{dt'}=c\ \text{th}(\psi_t-\psi_{t0})=\frac{v-v_0}{1-vv_0c^{-2}}=\frac{\text{th}(\psi_t-\psi_{t0})}{\text{th}\psi_t}v\,,$$

where: $ds=cd\hat{t}=\sqrt{1-v'^2c^{-2}}dt'=\sqrt{1-v^2c^{-2}}dt=\mathbf{invar}$, $\text{th}\psi_t=v/c$, $\text{sh}\psi_t=(v/c)(1-v^2c^{-2})^{-1/2}$, $\text{ch}\psi_t=(1-v^2c^{-2})^{-1/2}$.

When $\psi_{t0}=0$ ($v_0=0$):

[43] The usage of hyperbolic four-dimensional space instead of pseudo-Euclidean is more preferable since exactly this space corresponds to exponential expansion of the Universe (evolutionary conformally-gaugely self-contraction of matter in CFREU) and reflects the self-consistency (mutual dependence) of the rate of time and the velocity of propagation of electromagnetic interaction that sets this rate [79, 98, 99]. Moreover, the necessity to use the hyperbolic addition of velocities of motion of matter is possibly caused by the discreteness of changes of its collective spatial-temporal microstates, which are perceived as continuous motion only due to the high frequency of changes of these Gibbs microstates.

$$cdt'{=}cdt{=}\mathrm{ch}\psi_t ds{=}\frac{c}{\sqrt{1{-}v^2c^{-2}}}d\hat{t}\,,\ \frac{dt}{d\hat{t}}{=}\mathrm{ch}\psi_t{=}\frac{1}{\sqrt{1{-}v^2c^{-2}}}\,,\ dl'{=}dl{=}\mathrm{sh}\psi_t ds{=}\frac{vd\hat{t}}{\sqrt{1{-}v^2c^{-2}}}\,,\ \frac{dl}{d\hat{t}}{=}c\ \mathrm{sh}\psi_t{=}\frac{v}{\sqrt{1{-}v^2c^{-2}}}\,.$$

And, consequently, in the intrinsic time $\hat{t}$ of moving body the velocity of its motion is greater than by the observations from external FRs, which is, of course, related to the dilation of intrinsic time of moving body in SR. Due to invariance of the time of such interval (that is equal to the intrinsic time of moving matter) to the relativistic transformations this time could be used as a unified universal (cosmological) time if at least inertially moving matter would not have the dilation of its intrinsic time. In order to guarantee the invariance of thermodynamic parameters and potentials to relativistic transformations it is required that exactly the time of inertially moving matter should be invariant to relativistic transformations. And this obviously can be guaranteed only by Lorentz-conformal transformations. Conformal transformation of increments of time and coordinates do not have an influence on the form of transformations of projections of velocities and, therefore, it is quite acceptable.

In general case the Lorentz transformations of increments of time and coordinates as well as of the projections of velocities of motion during the transition from $\mathrm{FR_{out}}$ to $\mathrm{FR_0}$ ($\psi_{t0}(v_0){=}\mathrm{arth}(v_0/c)$) will be as follows:

$$dt'{=}\frac{dt{-}v_0c^{-2}dx}{\sqrt{1{-}v_0^2c^{-2}}}{=}\sqrt{\frac{1{-}v^2c^{-2}}{1{-}v'^2c^{-2}}}dt{=}\frac{\mathrm{ch}(\psi_t{-}\psi_{t0})}{\mathrm{ch}\psi_t}dt{=}\frac{\mathrm{ch}(\psi_t{-}\psi_{t0})}{c}ds_{tx}\,,$$

$$dx'{=}\frac{dx{-}v_0dt}{\sqrt{1{-}v_0^2c^{-2}}}{=}\frac{v_x'}{v_x}\sqrt{\frac{1{-}v^2c^{-2}}{1{-}v'^2c^{-2}}}dx{=}\frac{\mathrm{sh}(\psi_t{-}\psi_{t0})}{\mathrm{sh}\psi_t}dx{=}\mathrm{sh}(\psi_t{-}\psi_{t0})ds_{tx}\,,\qquad dy'{=}dy\,,\qquad dz'{=}dz\,,$$

$$v_x'{=}\frac{v_x{-}v_0}{1{-}v_xv_0c^{-2}}{=}v_x\frac{\mathrm{th}(\psi_t{-}\psi_{t0})}{\mathrm{th}\psi_t}{=}c\ \mathrm{th}(\psi_t{-}\psi_{t0})\,,\ \ v_y'{=}\frac{v_y\sqrt{1{-}v_0^2c^{-2}}}{1{-}v_xv_0c^{-2}}{=}v_y\sqrt{\frac{1{-}v'^2c^{-2}}{1{-}v^2c^{-2}}}{=}\frac{v_y\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t{-}\psi_{t0})}\,,$$

$$v_z'{=}\frac{v_y\sqrt{1{-}v_0^2c^{-2}}}{1{-}v_xv_0c^{-2}}{=}v_z\sqrt{\frac{1{-}v'^2c^{-2}}{1{-}v^2c^{-2}}}{=}\frac{v_z\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t{-}\psi_{t0})}\,,$$

where: $ds_{tx}=\sqrt{c^2(dt')^2-(dx')^2}=\sqrt{c^2(dt)^2-(dx)^2}=\mathbf{invar}$, $\frac{dt}{dt'}{=}\frac{v_y'}{v_y}{=}\frac{v_z'}{v_z}{=}\sqrt{\frac{1{-}v_x'^2c^{-2}}{1{-}v_x^2c^{-2}}}{=}\sqrt{\frac{1{-}v'^2c^{-2}}{1{-}v^2c^{-2}}}{=}\frac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t{-}\psi_{t0})}$.

And, taking into account that $cdt'{=}c\cos\varphi_x'\mathrm{cth}(\psi_t{-}\psi_{t0})dl'$, we will receive $dl'{=}[\cos^2\varphi_x'\mathrm{cth}^2(\psi_t{-}\psi_{t0}){-}1]^{-1/2}ds$. And, according to this and according to transformations of trigonometric functions of angles [38, 89, 90] we will have:

$$cdt'{=}\cos\varphi_x'\mathrm{cth}(\psi_t{-}\psi_{t0})[\cos^2\varphi_x'\mathrm{cth}^2(\psi_t{-}\psi_{t0}){-}1]^{-1/2}ds{=}[1{-}\sec^2\varphi_x'\mathrm{th}^2(\psi_t{-}\psi_{t0})]^{-1/2}ds\,,$$

$$dx'{=}\cos\varphi_x'[\cos^2\varphi_x'\mathrm{cth}^2(\psi_t{-}\psi_{t0}){-}1]^{-1/2}ds\,,\quad dy'{=}\cos\varphi_y'[\cos^2\varphi_x'\mathrm{cth}^2(\psi_t{-}\psi_{t0}){-}1]^{-1/2}ds\,,$$

$$dz'=\cos\varphi'_z[\cos^2\varphi'_x\,\mathrm{cth}^2(\psi_t-\psi_{t0})-1]^{-1/2}ds\,,\qquad \frac{dl'}{dl}=\frac{\cos\varphi_x\,\mathrm{sh}(\psi_t-\psi_{t0})}{\cos\varphi'_x\,\mathrm{sh}\psi_t}=\sqrt{\frac{\cos^2\varphi_x\,\mathrm{cth}^2\psi_t-1}{\cos^2\varphi'_x\,\mathrm{cth}^2(\psi_t-\psi_{t0})-1}}=\varsigma_l\,,$$

$$\frac{dt'}{dt}=\frac{\mathrm{ch}(\psi_t-\psi_{t0})}{\mathrm{ch}\psi_t}=\frac{\cos\varphi'_x\,\mathrm{cth}(\psi_t-\psi_{t0})}{\cos\varphi_x\,\mathrm{cth}\psi_t}\varsigma_l\,,\qquad \frac{dx'}{dx}=\frac{\cos\varphi'_x}{\cos\varphi_x}\varsigma_l=\sqrt{\frac{\mathrm{cth}^2\psi_t-\sec^2\varphi_x}{\mathrm{cth}^2(\psi_t-\psi_{t0})-\sec^2\varphi'_x}}=\varsigma_x\,,$$

$$\frac{dy'}{dy}=\frac{\cos\varphi'_y\cos\varphi_x\,\mathrm{sh}(\psi_t-\psi_{t0})}{\cos\varphi_y\cos\varphi'_x\,\mathrm{sh}\psi_t}=\frac{\cos\varphi'_y}{\cos\varphi_y}\varsigma_l=1\,,\qquad \frac{dz'}{dz}=\frac{\cos\varphi'_z\cos\varphi_x\,\mathrm{sh}(\psi_t-\psi_{t0})}{\cos\varphi_z\cos\varphi'_x\,\mathrm{sh}\psi_t}=\frac{\cos\varphi'_z}{\cos\varphi_z}\varsigma_l=1\,,$$

where: $\sin\varphi'_x=\mathrm{sech}(\psi_t-\psi_{t0})=\sin\varphi_x\dfrac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t-\psi_{t0})}=\sin\varphi_x\sqrt{\dfrac{1-v'^2c^{-2}}{1-v^2c^{-2}}}=\dfrac{\sin\varphi_x\sqrt{1-v_0^2c^{-2}}}{1-(v_0/c)\cos\varphi_x}$, $\cos\varphi'_x=\mathrm{th}(\psi_t-\psi_{t0})=\dfrac{\cos\varphi_x-v_0/c}{1-(v_0/c)\cos\varphi_x}$,

$\mathrm{ctg}\varphi'_x=\dfrac{\mathrm{sh}(\psi_t-\psi_{t0})}{\mathrm{sh}\psi_t}\mathrm{ctg}\varphi_x=\mathrm{sh}(\psi_t-\psi_{t0})=\dfrac{\cos\varphi_x-v_0/c}{\sin\varphi_x\sqrt{1-v_0^2c^{-2}}}$, $\cos\varphi'_y=\cos\varphi_y/\varsigma_l$, $\cos\varphi'_z=\cos\varphi_z/\varsigma_l$ ($v=c\cos\varphi_x$,

$\psi_t=\mathrm{arth}(\cos\varphi_x)$, $\mathrm{sh}\psi_t=\mathrm{ctg}\varphi_x$, $\mathrm{ch}\psi_t=\mathrm{cosec}\varphi_x$, $\mathrm{th}\psi_t=\cos\varphi_x$).

Since hyperbolic cosine cannot be equal to zero the increment of time in FR_{out} can be equal to zero only if interval s is equal to zero. But this corresponds only to world lines of radiation in hypothetical absolute vacuum. Moreover, when $dt=0$ and $ds=0$ then also $dx=0$. That is why it is out of the question that there can be any synchronous measurement of the length of moving body in FR_{out}. And, consequently, synchronous fixating of coordinates of two distant one from another objects of moving body is fundamentally impossible. Asynchronous fixating [91] of their coordinates in FR_{out} obviously should correspond to the same collective gravithermodynamic (spatial-temporal) Gibbs microstate of the whole matter of moving body. Since correspondent to it front of intrinsic time of moving body propagates in FR_{out} at $v_{t0}=c^2/v_0$ velocity [46, 92], then when $dt_{ij}=v_0c^{-2}dx_{ij}$ we'll receive:

$$dx'_{ij}=\frac{dx_{ij}-v_0dt_{ij}}{\sqrt{1-v_0^2c^{-2}}}=\sqrt{1-v_0^2c^{-2}}\,dx_{ij}=\mathrm{sech}\psi_{t0}dx_{ij}=\mathrm{th}\psi_{t0}ds_{ij}\,.$$

And, therefore, according to Lorentz transformations not the contraction but vice versa enlargement of longitudinal coordinate "size" of moving body takes place. And only in case of such increasing of coordinate length of moving body the Lorentz transformations do not lead to paralogism of enclosed trajectory, since how many times the time needed to pass this trajectory is decreased – the same number of times the coordinate length of distance passed by the observer (that rests in FR_0) is decreased[44]. However regarding the motion of FR_{out} in his/her FR_0 the paradoxal opinion is formed, based on the identification (in SR) of increments of coordinates and increments

[44] This is, of course, not enough weighty getting rid of paralogism of enclosed trajectory in SR, since the conclusions are made being based on analysis of increments of coordinate time and spatial coordinates and not being based on increments of metrical segments of time and space.

of metrical segments. After all, each of two observers considers that dilation of intrinsic time and the elongation of moving body belong to opposite FR.

The considerations that instead of relativistic shrinkage of longitudinal size of moving body the increasing of it can take place were expressed by various authors [93 – 96]. However, it can take place only for forcibly accelerated bodies. Anyway the shrinkage of the size in background Euclidean space of the observer should take place for inertially moving bodies. Due to the necessity to fulfill the general covariance of the physical equations the change of metrical size of moving body in intrinsic space (that has curvature) of the observer should, of course, be absent [31, 33, 97].

And this means that Lorentz transformations are the transformations of only spatial coordinates and coordinate time and not of metrical spatial segments or metrical time intervals. And, therefore, it is still required to multiply the matrix of transformations of increments of coordinates [38] by the matrix of transition to the increments of metrical segments. This matrix should be similar to the matrix of metrical tensor of GR and, of course, it should include not only the indexes of local curvature of time (values of local coordinate velocities of light $v_{cv}=c(dt/d\widehat{t})=v_{cvr}(1-v^2 v_{cv}^{-2})^{1/2}$), but also direct or reverse indexes of local curvature of the space[45]:

$$\xi=d\widehat{x}/dx=1/\zeta=c/v_{cv}=\xi_r(1-v^2 v_{cv}^{-2})^{-1/2}, \qquad \zeta=dx/d\widehat{x}=v_{cv}/c=\zeta_r(1-v^2 v_{cv}^{-2})^{1/2},$$

where: dt and $d\widehat{t}$ are the increments of the spatially inhomogeneous coordinate (gravity-quantum) time in background pseudo-Euclidean STC and of the united intrinsic (gravithermodynamic) time of all gravithermodynamically bonded matter correspondingly; dx and $d\widehat{x}$ are the increments of spatial segments in background Euclidean space and in intrinsic space (that has local curvature) of matter correspondingly; $v_{cvr}=c\zeta_r=c/\xi_r$ and ξ_r, ζ_r are correspondingly the coordinate velocity of light and also the direct and reverse values of indexes of curvature of the space in the hypothetic point FR_{out}, in which moving body could be in the state of rest. At the same time, in the same way as in conventionally empty space in GR, $v_{cv}\xi=v_{cvr}/\zeta_r=c$, while for quickly distancing from observer galaxies the local deviations of coordinate velocity of light and curvature of the space are negligibly small ($v_{cvr}\approx c$, $\xi_r\approx 1$, $\zeta_r\approx 1$).

However, these indexes that take different values in different FRs can be as well directly included in the modernized Lorentz transformations themselves.

So, according to increment of metrical segment $d\widehat{x}=\xi dx=\xi_r(1-v^2 v_{cv}^{-2})^{-1/2}dx$ the real metrical velocity of inertial motion of the body in the uniform gravithermodynamic time (world time of GR [38]) of FR_{out} will be de facto equal to its intrinsic value in the FR of moving body [62 – 64]:

$$\hat{v}=d\hat{x}/d\hat{t}=(\xi v_{cv}/c)dx/dt=dx/dt=vc/v_{cv}=(vc/v_{cvr})(1-v^2v_{cv}^{-2})^{-1/2}=(vc/v_{cvr})\left[\left(1+\sqrt{1-4v^2v_{cvr}^{-2}}\right)/2\right]^{-1/2}=c\sqrt{1-v_{cv}^2v_{cvr}^{-2}}$$

where: $\xi v_{cv}=c$; $v=dx/d\hat{t}=\zeta\hat{v}=\hat{v}/\xi=\hat{v}v_{cv}/c=\hat{v}(v_{cvr}/c)(1-\hat{v}^2c^{-2})^{1/2}$ is the velocity of motion of object in background regular space of FR_{out}, which does not take into account the curvature contributed by nearby astronomical objects and by the moving body itself.

And this means that not only the decreasing of coordinate velocity of light, but also the increasing of curvature of intrinsic space of FR_{out} is locally compensated by the inertial motion. It is obvious that gravitational curvature of regular space (gravitational decreasing of longitudinal size of the body that falls free in background Euclidean space) is completely compensated by the local curvature of this space, which appears due to the increasing of the velocity of inertial motion of body in gravitational field. And, consequently, the local coordinate velocity of light as well as indexes of local curvature of the space in the point of instantaneous dislocation of inertially moving body correspond in its intrinsic FR to their values ξ_r, ζ_r in hypothetical point of the start of independent motion of the body and not to their regular values in the points of instantaneous dislocation of the body in FR_{out}. Being based on the change of exactly this real metrical velocity of the body Möller received the acceleration of body motion $G=d\hat{v}/d\hat{t}=(1-v^2v_{cv}^{-2})^{-3/2}dv/d\hat{t}$ [38, 46, 92].

According to this the Hamiltonian of inert free energy and Lagrangian of ordinary rest energy as well as Hamilton and Lagrange momenta of the inertially moving body are correspondingly equal to [78]:

$$\mathrm{H}=E_0\Gamma=m_0cv_{cv}(1-v^2v_{cv}^{-2})^{-1/2}=m_0cv_{cvr}=\mathbf{const}(t),$$

$$\mathrm{L}=W_0/\Gamma=m_0c^3(1-v^2v_{cv}^{-2})^{1/2}/v_{cv}=m_0c^3/v_{cvr}=\mathbf{const}(t),$$

$$\mathrm{P_H}=m_0\hat{v}\Gamma=m_0v\Gamma c/v_{cv}=m_0vc/v_{cvr}(1-v^2v_{cv}^{-2})=2m_0vc/v_{cvr}(1+\sqrt{1-4v^2v_{cvr}^{-2}}),$$

$$\mathrm{P_L}=m_0\hat{v}=m_0vc/v_{cv}=(m_0vc/v_{cvr})(1-v^2v_{cv}^{-2})^{-1/2}=(m_0vc/v_{cvr})\left[\left(1+\sqrt{1-4v^2v_{cvr}^{-2}}\right)/2\right]^{-1/2},$$

while:
$$v_{cv}^{-2}\mathrm{H}^2-\mathrm{P_H^2}=v_{cv}^2c^{-4}\mathrm{L}^2+\mathrm{P_L^2}=m_0^2c^2.$$

Lorentz invariance of the velocity of light fundamentally takes place only in the point of disposition of the clock [98, 99]. In distant from the clock points (as it takes place in GR for coordinate velocity of light) it can be non-equal to the constant of velocity of light. That is why it is quite possible that more complex (than purely Lorentz) transformations of increments of coordinates and coordinate time can be required in SR. All of this is the consequence of the presence of local gravitational fields and correspondent to them local distortions (deformations) of intrinsic space of the observer in regular (conforming to the laws) STC of the observer. These local

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[45] According to condition of GR for the conventionally empty space $ab=1$ (for radial direction) the following takes

deformations of real STC do not correspond to the equations of gravitational field of regular STC. Exactly the fact that inertial motion of matter does not correspond to equations of regular gravitational field should allow mathematical describing of these local deformations of regular STC of the observer.

And, as it follows from the solution of equations of gravitational field of GR with non-zero value of cosmological constant $\Lambda = 3H_E^2 c^{-2}$, the free fall of distant galaxies onto the events pseudo-horizon of the Universe is accompanied by the correspondent to velocity of their motion gravitational field, which is set by the distribution of coordinate velocity of light: $v_{cv} = c(1 - v^2 v_{cv}^{-2})^{1/2} = c\sqrt{(1 + \sqrt{1 - 4v^2 c^{-2}})/2}$. Similar local gravitational influence on the metrics of space-time, obviously, can be indicated by any inertial motion of matter.

In GR instead of transformations of velocities of motion, which are determined in the point *i* by gravity-quantum clock of the observer, their gravithermodynamic values $\hat{v} = d\hat{x}/d\hat{t} = {}^i vc/{}^i v_{cv}$, which are normalized by the coordinate velocity of light and therefore are independent from the readings of any certain gravity-quantum clock, are indeed transformed by the Lorentz rules. They, despite taking into account the curvature of observer's space, yet ignore the possibility that this curvature can be changed by the moving body which leads to the imaginary observability of relativistic deformation of this moving body. Thus, the transition from the usage of local gravity-quantum clock of any observer to the usage of independent from their readings uniform gravithermodynamic (planetary) time $\hat{t} = (c/v_{cv})t$ of all RGTD-bonded matter de facto takes place. And this is quite logical. In contrast to gravity-quantum times[46] the discrete change of the collective gravithermodynamic state of matter happens with the same frequency in the whole space that is filled with RGTD-bonded matter. The uniform gravithermodynamic time (that has gravitational curvature) corresponds to exactly this discrete change.

Moreover, during the transition from CFREU to FR of the observer in GR the conformal Lorentz transformations, which in contrast to pure Loretz transformations give the possibility to reflect physical reality in more adequate way, are also used. That is why even in case of the conventional absence of gravitational field conformal gravitationally-Lorentz transformations [70] of increments of coordinates and time and of the velocities of matter motion should be used instead of the ordinary Lorentz transformations also in SR. If body moves at velocity v_0 and taking this into

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place here: $\xi v_l/c = v_l/c\zeta = 1$ and $\xi_r v_{lr}/c = v_{lr}/c\zeta_r = 1$.

[46] The fact that there is a gravitational dilation of intrinsic time in the bowels of the planet does not mean that physical processes will flow there slower that on its surface. Quite the contrary, these fast flowing processes will flow even faster by the intrinsic time of the bowels of the planet than by the observations from the surface of the planet.

account its limit velocity in background regular[47] space of the $\mathrm{FR_{out}}$ of external observer is $v_{l0}=v_{lr0}\Gamma_0^{1-p}=v_{lr0}(1-v_0^2v_{l0}^{-2})^{(p-1)/2}$, then in comoving with it $\mathrm{FR_0}$ and in $\mathrm{FR_{out}}$ the increments of coordinates (and, thus, of metrical segments) of its moving objects and time will be as follows [78]:

$$N'_C cdt'=\frac{v'_l d\hat{t}'}{\sqrt{(1-\hat{v}'^2c^{-2})^p}}=\frac{v'_{lG}d\hat{t}'}{\sqrt{1-\hat{v}'^2c^{-2}}}=\mathrm{ch}(\psi_t-\psi_{t0})v'_{lG}d\hat{t}'=N_C\frac{cdt-(v_0/v_{l0})dx_m}{\sqrt{1-v_0^2v_{l0}^{-2}}}=\frac{v_l d\hat{t}-(\hat{v}_0/c)\zeta d\hat{x}_m}{\sqrt{(1-\hat{v}_0^2c^{-2})(1-\hat{v}^2c^{-2})^p}}=$$

$$=\frac{v_{lG}d\hat{t}-(\hat{v}_0/c)\zeta_G d\hat{x}_m}{\sqrt{(1-\hat{v}_0^2c^{-2})(1-\hat{v}^2c^{-2})}}=\frac{v_{lG}d\hat{t}}{\sqrt{1-\hat{v}'^2c^{-2}}},\qquad v'_{lG}d\hat{t}'=v_{lG}d\hat{t}=ds,\qquad \zeta'_G d\hat{x}'_m=\mathrm{th}\psi'_t ds=\mathrm{th}(\psi_t-\psi_{t0})v'_{lG}d\hat{t}'=(\hat{v}'/c)v'_{lG}d\hat{t}',$$

$$N'_C dx'_m=\frac{\zeta' d\hat{x}'_m}{\sqrt{(1-\hat{v}'^2c^{-2})^p}}=\frac{\zeta'_G d\hat{x}'_m}{\sqrt{1-\hat{v}'^2c^{-2}}}=\mathrm{ch}(\psi_t-\psi_{t0})\zeta'_G d\hat{x}'_m=N_C\frac{dx_m-(v_0/v_{l0})cdt}{\sqrt{1-v_0^2v_{l0}^{-2}}}=\frac{\zeta d\hat{x}_m-(\hat{v}_0/c)v_l d\hat{t}}{\sqrt{(1-\hat{v}_0^2c^{-2})(1-\hat{v}^2c^{-2})^p}}=$$

$$=\frac{\zeta_G d\hat{x}_m-(\hat{v}_0/c)v_{lG}d\hat{t}}{\sqrt{(1-\hat{v}_0^2c^{-2})(1-\hat{v}^2c^{-2})}}=\mathrm{sh}(\psi_t-\psi_{t0})v_{lG}d\hat{t},\qquad \frac{\zeta_G}{v_{lG}}\frac{d\hat{x}'_m}{d\hat{t}}=\frac{\zeta'_G}{v'_{lG}}\frac{d\hat{x}'_m}{d\hat{t}'}=\mathrm{th}\psi'_t=\frac{\hat{v}'}{c},$$

$$N'_C dy'_m=\frac{\zeta' d\hat{y}'_m}{\sqrt{(1-\hat{v}'^2c^{-2})^p}}=\frac{\zeta'_G d\hat{y}'_m}{\sqrt{1-\hat{v}'^2c^{-2}}}=\mathrm{ch}(\psi_t-\psi_{t0})\zeta'_G d\hat{y}'_m=N_C dy_m=\frac{\zeta d\hat{y}_m}{\sqrt{(1-\hat{v}^2c^{-2})^p}}=\frac{\zeta_G d\hat{y}_m}{\sqrt{1-\hat{v}^2c^{-2}}}=\mathrm{ch}\psi_t\zeta_G d\hat{y}_m,$$

$$\zeta'_G d\hat{y}'_m=\frac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t-\psi_{t0})}\zeta_G d\hat{y}_m=\sqrt{\frac{1-\hat{v}'^2c^{-2}}{1-\hat{v}^2c^{-2}}}\zeta_G d\hat{y}_m=\frac{\sqrt{1-\hat{v}_0^2c^{-2}}}{1-\hat{v}_0\hat{v}_x c^{-2}}\zeta_G d\hat{y}_m,$$

$$N'_C dz'_m=\frac{\zeta' d\hat{z}'_m}{\sqrt{(1-\hat{v}'^2c^{-2})^p}}=\frac{\zeta'_G d\hat{z}'_m}{\sqrt{1-\hat{v}'^2c^{-2}}}=\mathrm{ch}(\psi_t-\psi_{t0})\zeta'_G d\hat{z}'_m=N_C dz_m=\frac{\zeta d\hat{z}_m}{\sqrt{(1-\hat{v}^2c^{-2})^p}}=\frac{\zeta_G d\hat{z}_m}{\sqrt{1-\hat{v}^2c^{-2}}}=\mathrm{ch}\psi_t d\hat{z}_m,$$

$$\zeta'_G d\hat{z}'_m=\frac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t-\psi_{t0})}\zeta_G d\hat{z}_m=\sqrt{\frac{1-\hat{v}'^2c^{-2}}{1-\hat{v}^2c^{-2}}}\zeta_G d\hat{z}_m=\frac{\sqrt{1-\hat{v}_0^2c^{-2}}}{1-\hat{v}_0\hat{v}_x c^{-2}}\zeta_G d\hat{z}_m;$$

$$N_C cdt=\frac{v_l d\hat{t}}{\sqrt{(1-\hat{v}^2c^{-2})^p}}=\frac{v_{lG}d\hat{t}}{\sqrt{1-\hat{v}^2c^{-2}}}=\mathrm{ch}(\psi'_t-\psi'_{t0})v_{lG}d\hat{t}=N'_C\frac{cdt'-(v'_0/v'_{l0})dx'_m}{\sqrt{1-v_0'^2v_{l0}'^{-2}}}=\frac{v'_l d\hat{t}'-(\hat{v}'_0/c)\zeta' d\hat{x}'_m}{\sqrt{(1-\hat{v}_0'^2c^{-2})(1-\hat{v}'^2c^{-2})^p}}=$$

$$=\frac{v'_{lG}d\hat{t}'-(\hat{v}'_0/c)\zeta'_G d\hat{x}'_m}{\sqrt{(1-\hat{v}_0'^2c^{-2})(1-\hat{v}'^2c^{-2})}}=\frac{v'_{lG}d\hat{t}'}{\sqrt{1-\hat{v}^2c^{-2}}},\qquad v_{lG}d\hat{t}=v'_{lG}d\hat{t}'=ds,\qquad d\hat{x}=\mathrm{th}\psi_t ds=\mathrm{th}(\psi'_t-\psi'_{t0})v_{lG}d\hat{t},$$

$$N_C dx_m=\frac{\zeta d\hat{x}_m}{\sqrt{(1-\hat{v}^2c^{-2})^p}}=\frac{\zeta_G d\hat{x}_m}{\sqrt{1-\hat{v}^2c^{-2}}}=\mathrm{ch}\psi_t\zeta_G d\hat{x}_m=N'_C\frac{dx'_m-(v'_0/v'_{l0})cdt'}{\sqrt{1-v_0'^2v_{l0}'^{-2}}}=\frac{\zeta' d\hat{x}'_m-(\hat{v}'_0/c)v'_l d\hat{t}'}{\sqrt{(1-\hat{v}_0'^2c^{-2})(1-\hat{v}'^2c^{-2})^p}}=$$

$$=\frac{\zeta'_G d\hat{x}'_m-(\hat{v}'_0/c)v'_{lG}d\hat{t}'}{\sqrt{(1-\hat{v}_0'^2c^{-2})(1-\hat{v}'^2c^{-2})}}=\mathrm{sh}(\psi'_t-\psi'_{t0})v'_{lG}d\hat{t}',\qquad \frac{\zeta_G}{v'_{lG}}\frac{d\hat{x}}{d\hat{t}'}=\frac{\zeta_G}{v_{lG}}\frac{d\hat{x}}{d\hat{t}}=\mathrm{th}\psi_t=\mathrm{th}(\psi'_t-\psi'_{t0}),$$

where: $v'_0=-v_0$ ($\hat{v}'_0=-\hat{v}_0=-v_0c/v_{l0}$); $v'_{l0}=v_{l0}$; $\psi_t=\mathrm{arth}(\hat{v}/c)$, $\psi'_t=\mathrm{arth}(\hat{v}'/c)=-\mathrm{arth}(\hat{v}/c)$ ($\psi_{t0}=\mathrm{arth}(\hat{v}_0/c)$, $\psi'_{t0}=\mathrm{arth}(\hat{v}'_0/c)=-\mathrm{arth}(\hat{v}_0/c)$); $v_l=v_{lr}\Gamma_m^{1-p}$ and $\Gamma_m=(1-v_m^2v_l^{-2})^{-1/2}$ are values of the limit velocity of motion in the background regular space and Lorentz shrinkage of dimensions of mobile object m

[47] Background regular space can have regular curvature. Therefore, additional kinematic curvature of this space will be locally imposed on its regular curvature.

(matter) in regular space of the FR_{out}; $v'_{lG}=\eta'(p,G)v'_{lr}$, $v_{lG}=\eta(p,G)v_{lr}$, $v'_{lr}\equiv v_{lr}=c\zeta_r=c/\xi_r$; $v'_{lr0}\equiv v_{lr0}$, $v'_{l0}=v'_{lG0}/\Gamma_0'^{1-p}$, $v'_l=v_{lG}/\Gamma_m'^{1-p}$, $\Gamma'_0=(1-v_0'^2v_{l0}'^{-2})^{-1/2}$ and $\Gamma'_m=(1-v_m'^2v_l'^{-2})^{-1/2}$ are values of the limit velocity of motion[48] and Lorentz shrinkage of dimensions of stationary and mobile objects in regular space of the FR_0 correspondingly; dx'_m, dy'_m, dz'_m are the increments of metrical segment projections of mobile object in FR_0, and: $dx_m=v_{mx}dt$, $dy_m=v_{my}dt$, $dz_m=v_{mz}dt$ are the increments of coordinates of mobile object in FR_{out} of observer of the motion of the whole body and its objects; v_m and v_l, v_{lr} are the real and limit velocities of motion of object m in FR_{out} correspondingly; $\zeta=\sqrt{(x^2+y^2+z^2)/(\widehat{x}^2+\widehat{y}^2+\widehat{z}^2)}=\zeta_G(1-v^2v_l^{-2})^{(p-1)/2}=\zeta_G(1-\widehat{v}^2c^{-2})^{(p-1)/2}$ and $\zeta'=\sqrt{(x'^2+y'^2+z'^2)/(\widehat{x}'^2+\widehat{y}'^2+\widehat{z}'^2)}=\zeta'_G(1-v'^2v_l'^{-2})^{(p-1)/2}=\zeta'_G(1-\widehat{v}'^2c^{-2})^{(p-1)/2}$ are the all-side shrinkages of the size of moving body in background regular space in FR_{out} and in FR_0 correspondingly; $\zeta_G=\eta(p,G)\zeta_r$ and $\zeta'_G=\eta'(p,G)\zeta_r$ are the functions of index p and the acceleration G of forced motion; ζ_r is a parameter that characterizes the curvature of intrinsic space of observer in the rest initial state of moving body; $N_C=(1-v^2v_l^{-2})^{-p/2}=(1-\widehat{v}^2c^{-2})^{-p/2}$ and $N'_C=(1-v'^2v_l'^{-2})^{-p/2}=(1-\widehat{v}'^2c^{-2})^{-p/2}$ are the kinematic scale factors in the FR_{out} and in the FR_0 correspondingly; $(p-1)$ is a degree of shrinkage of the size of moving body in background regular space.

According to this, the transformations of the velocities projections of motion will have the following form [78]:

$$\frac{\widehat{v}'_{mx}}{c}=\frac{1}{c}\frac{dx'_m}{dt'}=\frac{\zeta' d\widehat{x}'_m}{v'_l d\widehat{t}'}=\frac{v'_{mx}}{v'_l}=\frac{v_{mx}/v_l-v_0/v_{l0}}{1-v_0v_{mx}/v_{l0}v_l}=\frac{\widehat{v}_{mx}-\widehat{v}_0}{c-\widehat{v}_0\widehat{v}_{mx}/c},\quad \frac{\widehat{v}'_{my}}{c}=\frac{1}{c}\frac{dy'_m}{dt'}=\frac{\zeta' d\widehat{y}'_m}{v'_l d\widehat{t}'}=\frac{v'_{my}}{v'_l}=\frac{v_{my}}{v_l}\frac{\sqrt{1-v_0^2v_{l0}^{-2}}}{1-v_0v_{mx}/v_{l0}v_l}=\widehat{v}_{my}\frac{\sqrt{1-\widehat{v}_0^2c^{-2}}}{c-\widehat{v}_0\widehat{v}_{mx}/c},$$

$$\frac{\widehat{v}'_{mz}}{c}=\frac{1}{c}\frac{dz'_m}{dt'}=\frac{\zeta' d\widehat{z}'_m}{v'_l d\widehat{t}'}=\frac{v'_{mz}}{v'_l}=\frac{v_{mz}}{v_l}\frac{\sqrt{1-v_0^2v_{l0}^{-2}}}{1-v_0v_{mx}/v_{l0}v_l}=\widehat{v}_{mz}\frac{\sqrt{1-\widehat{v}_0^2c^{-2}}}{c-\widehat{v}_0\widehat{v}_{mx}/c},\qquad \sqrt{1-\widehat{v}'^2c^{-2}}=\frac{\sqrt{(1-\widehat{v}_0^2c^{-2})(1-\widehat{v}^2c^{-2})}}{1-\widehat{v}_0\widehat{v}_{mx}c^{-2}},$$

$$\frac{\widehat{v}_{mx}}{c}=\frac{1}{c}\frac{dx_m}{dt}=\frac{\zeta d\widehat{x}_m}{v_l d\widehat{t}}=\frac{v_{mx}}{v_l}=\frac{v'_{mx}/v'_l-v'_0/v'_{l0}}{1-v'_0v'_{mx}/v'_{l0}v'_l}=\frac{\widehat{v}'_{mx}-\widehat{v}'_0}{c-\widehat{v}'_0\widehat{v}'_{mx}/c},\quad \frac{\widehat{v}_{my}}{c}=\frac{1}{c}\frac{dy_m}{dt}=\frac{\zeta d\widehat{y}_m}{v_l d\widehat{t}}=\frac{v_{my}}{v_l}=\frac{v'_{my}}{v'_l}\frac{\sqrt{1-v_0'^2v_{l0}'^{-2}}}{1-v'_0v'_{mx}/v'_{l0}v'_l}=\widehat{v}'_{my}\frac{\sqrt{1-\widehat{v}_0'^2c^{-2}}}{c-\widehat{v}'_0\widehat{v}'_{mx}/c},$$

$$\frac{\widehat{v}_{mz}}{c}=\frac{1}{c}\frac{dz_m}{dt}=\frac{\zeta d\widehat{z}_m}{v_l d\widehat{t}}=\frac{v_{mz}}{v_l}=\frac{v'_{mz}}{v'_l}\frac{\sqrt{1-v_0'^2v_{l0}'^{-2}}}{1-v'_0v'_{mx}/v'_{l0}v'_l}=\widehat{v}'_{mz}\frac{\sqrt{1-\widehat{v}_0'^2c^{-2}}}{c-\widehat{v}'_0\widehat{v}'_{mx}/c},\qquad \sqrt{1-\widehat{v}^2c^{-2}}=\frac{\sqrt{(1-\widehat{v}_0'^2c^{-2})(1-\widehat{v}'^2c^{-2})}}{1-\widehat{v}'_0\widehat{v}'_{mx}c^{-2}},$$

where the real velocities of motion of observed object and of FR_0 are equal to $\widehat{v}_{mx}=v_{mx}c/v_l$, $\widehat{v}'_{mx}=v'_{mx}c/v'_l$, $\widehat{v}_{my}=v_{my}c/v_l$, $\widehat{v}'_{my}=v'_{my}c/v'_l$, $\widehat{v}_{mz}=v_{mz}c/v_l$, $\widehat{v}'_{mz}=v'_{mz}c/v'_l$ and $\widehat{v}_0=v_0c/v_{l0}$ correspondingly.

[48] It is quite possible that this means that not only real velocities of propagation of radiation in moving matter but also the alternative to hypothetical pseudo-vacuum velocity of light limit velocity of matter individual motion is anisotropic in moving body in FR_{out} [51]. However let us consider it isotropic for a while.

When $v'_{mx}=0$, $v'_{my}=0$, $v'_{mz}=0$ ($d\hat{x}=d\hat{x}_0$, $v_{mx}=v_0$, $v_l=v_{l0}$, $\zeta=\zeta_0$) and $d\hat{t}=(\hat{v}_0\zeta_0/cv_{l0})d\hat{x}_0$ (that corresponds to the identical collective spatial-temporal Gibbs microstate of the whole matter that moves at v_0 velocity) there is a relativistic invariance of longitudinal metrical sizes of moving body ($d\hat{x}' \equiv d\hat{x}'_0 = d\hat{x}_0 = \mathbf{invar}$), independently from the values of index *p*. Due to the isotropy of kinematic self-contraction of the sizes of moving body in background regular space the transversal metrical segments will also be relativistically invariant. And this, of course, corresponds to the accepted in GR principle of unobservability of deformation of matter on the level of its microobjects (de facto to the principle of metrical homogeneity of the space of observer of matter motion)[49]. Inequality of increments of transversal metrical segments in different FRs, when relativistically invariant increments of metrical time are the same, is caused by the difference of transversal components of velocities of motion in those FRs.

According to the increment of times $d\hat{t}$ and $d\hat{t}'$ ($dx_m=v_0dt$ and $v_l=v_{l0}$, and: $dx'_m=0$, $dy'_m=0$, $dz'_m=0$, $v'_l=v_{lr0}$), as well as of conformal interval when body moves inertially ($v'_{lG}=v_{lG}=v_{kr}$) [78]:

$$(ds)^2=N_C^2[c^2(dt)^2-(dx_m)^2-(dy_m)^2-(dz_m)^2]=N_C^2\{v_l^2(d\hat{t})^2-\zeta^2(d\hat{x}_m)^2-\zeta^2[(d\hat{y}_m)^2+(d\hat{z}_m)^2]\}=v_{lG}^2(d\hat{t})^2=$$

$$=N_C'^2[c^2(dt')^2-(dx'_m)^2-(dy'_m)^2-(dz'_m)^2]=N_C'^2\{v_l'^2(d\hat{t}')^2-\zeta'^2(d\hat{x}'_m)^2-\zeta'^2[(d\hat{y}'_m)^2+(d\hat{z}'_m)^2]\}=v_{lG}'^2(d\hat{t}')^2$$

takes place not only the invariance of the rate of the count of inertially moving clock, but also the invariance in relation to relativistic transformations of counted by them unified gravithermodynamic time of the Universe ($d\hat{t}'=d\hat{t}=\mathbf{invar}$) which, of course, can correspond only to the unprompted motion (inertial motion or chaotic motion) of any objects. From the condition of conservation in FR_0 of the Hamiltonian of inert free energy of bodies that are free falling it follows that $p_0=2$. In case of forced motion (when $p\neq 2$ and $v'_{lG}\neq v_{lG}\neq v_{kr}$, $\eta'(p, G)\neq\eta(p, G)\neq 1$) the dilation of intrinsic time of moving objects can indeed take place, which is confirmed by the increasing of lifespan of unstable microobjects that are formed in experiments on accelerators. The rate of coordinate (gravity-quantum) time $dt=v_ld\hat{t}$, which is spatially inhomogeneous in gravitational field, is of course changed along the trajectory of inertial motion of objects. However, the influence of gravitational field on the count of gravity-quantum clock is completely compensated by the inertial motion similarly to the complete compensation of gravity forces caused by it.

The limit velocities of the matter individual motion itself (which is decreased by the gravitational field) in FR_0 can be expressed via its real velocities of motion $\hat{v}'$ and via the velocity of motion in background regular space $v'=\hat{v}'v'_l/c$ in the following way:

[49] Instead of metrically inhomogeneous background Euclidean spaces [25] the metrically homogeneous spaces that have curvature are used in GR in order to fulfill the general covariance of formulations of physical laws.

$$v'_l = v_{lr}\sqrt{1-\bar{v}'^2 c^{-2}} = v_{lr}\sqrt{\left(1+\sqrt{1-4v'^2 v'^{-2}_{lr}}\right)/2} \qquad (v' = v'_l\sqrt{1-v'^2_l v'^{-2}_{lr}}).$$

Them values when gravitational field is hypothetically absent[50] ($v_{lr}=c$) will be determined by the dependence that guarantees the Lorentz-invariance of thermodynamic potentials and parameters in this case as well: $v'_{l0} = c\sqrt{\left(1+\sqrt{1-4v'^2_0 c^{-2}}\right)/2}$.

And, consequently, it is quite possible that in the case of any spontaneous (not forced) motion there indeed should not be any time dilation of moving clock. The motion, quite the contrary, even compensates the gravitational dilation of the time. Moreover, during such motion there is an absence of declared in SR non-fulfillment of simultaneity of the events that take part in different places in FR of moving body, which are simultaneous in observer's FR. However, of course, this can be related only to inertial motion ob body in the Universal gravitational field that surrounds it, while purely Lorentz dilation of time in comoving to moving body FR_0, as well as dilation that is induced by gravitational field, are completely compensated by all-round isotropic self-contraction of this body in FR_{out} (self-contraction of its size in background regular space). At least, the deceleration of orbital motion of astronomical objects of far galaxies that are distancing from us at high velocities is not confirmed by astronomical observations[51].

It is obvious that not only the fundamentally unobservable in FR of people's world gravitational self-contraction of matter (on the level of its microobjects) in the background Euclidean space [25], but also its motion can cause the advance of evolutionary self-contraction of matter of moving bodies in CFREU comparing to the conventionally motionless bodies in it. However, it should be taken into account that the ordinary Lorentz transformations as well as used now in GR trivial conformal gravitationally-Lorentz transformations are the transformations of increments of only spatial coordinates and not of metrical segments[52]. Relativistic shrinkages of length and volume of

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[50] Namely the applicability of the concept of limit velocity of substance individual (separate) motion for the description of not only the gravitational field, but also the motion, urged the author to reject the usage of such a term as coordinate velocity of light.

[51] Astronomers, quite the contrary, are looking for non-baryonic dark matter, which would allow to explain the quite big velocities of orbital motion of astronomical objects on the edge of far galaxies that are distancing from us at high velocities. Moreover, in order to explain the imaginary accelerated expansion of the Universe (that follows from the false notion about the dilation of intrinsic time of distant galaxies) astronomers are forced to "fill" the Universe also with dark energy.

[52] Mutually observed shrinkage of longitudinal and transversal size (increments of coordinate time and spatial coordinates) of moving objects is indeed not paradoxical since vectors of world points of these objects are located in different three-dimensional sections (hyperplanes) of four-dimensional pseudo-Euclidean space and are inclined one to another at hyperbolic angle that corresponds to the velocities of their relative motion. Orthogonal spatial projections of vectors of world points on the opposite hyperplane always should be smaller than the spatial components of four-dimensional vector. At the same time, orthogonal projection of coordinate time, quite the contrary, should be greater than the temporal component of orthogonally projected four-dimensional vector. Precisely this is guaranteed by Lorentz-conformal transformations. However, we should remember that these are transformations only of increments of coordinates and not of metrical segments. Moreover it should be taken into account that these transformations of four-dimensional segments should correspond to the same spatial-temporal Gibbs microstate of the whole gravithermodynamically bonded matter of moving body. And this means that projected four-dimensional segment

moving bodies should be fundamentally unobservable in the people's world similarly to the gravitational shrinkage of molar volume of matter in background Euclidean space. General covariance of formulation of physical laws will be fulfilled if the kinematic "curvature" (densening) of intrinsic space of observer of moving matter is used instead of them. That is why the molar volume of matter as well as all other its thermodynamic parameters are invariant relatively to spatial-temporal transformations.

Thus, the inertial motion of the matter in gravitational field not only prevents the gravitational increasing of its refractive index of radiation $n_j \neq n_{ir}\left(1+\sqrt{(1-4v'_{0j}v_{lir}^{-2})/2}\right)^{-1/2}$ (n=**const**(t)), but also causes in the regular space of the CO_{out} the relativistic (kinematic) self-contraction of it in both longitudinal and transversal directions [51]. According to this the rate of metrical time of inertially moving bodies is unchangeable and relativistically invariant ($\zeta'_G=\zeta_G=\zeta_r=v_{lG}/c=v_{lr}/c$, $d\widehat{t}'=d\widehat{t}$). According to this we will have the following expressions for the transformation of increments of metrical segments ($d\widehat{x}_m$, $d\widehat{y}_m$, $d\widehat{z}_m$) and coordinates (dt, dx_m, dy_m, dz_m):

$$d\widehat{x}'_m=\frac{\zeta_G d\widehat{x}_m-(\widehat{v}_0/c)v_{lG}d\widehat{t}}{\zeta'_G(1-\widehat{v}_x\widehat{v}_0c^{-2})}=\frac{\widehat{v}_x-\widehat{v}_0}{1-\widehat{v}_x\widehat{v}_0c^{-2}}d\widehat{t}=\mathrm{th}(\psi_t-\psi_{t0})cd\widehat{t}=\widehat{v}'_x d\widehat{t}',$$

$$d\widehat{x}_m=\frac{\zeta'_G d\widehat{x}'_m-(\widehat{v}'_0/c)v'_{lG}d\widehat{t}'}{\zeta_G(1-\widehat{v}'_x\widehat{v}'_0c^{-2})}=\frac{\widehat{v}'_x-\widehat{v}'_0}{1-\widehat{v}'_x\widehat{v}'_0c^{-2}}d\widehat{t}'=\mathrm{th}(\psi'_t-\psi'_{t0})cd\widehat{t}'=\widehat{v}_x d\widehat{t},$$

$$d\widehat{y}'_m=\frac{d\widehat{y}_m\sqrt{1-\widehat{v}_0^2c^{-2}}}{1-\widehat{v}_x\widehat{v}_0c^{-2}}=\frac{\widehat{v}_y\sqrt{1-\widehat{v}_0^2c^{-2}}}{1-\widehat{v}_x\widehat{v}_0c^{-2}}d\widehat{t}=\frac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t-\psi_{t0})}\widehat{v}_y d\widehat{t}=\widehat{v}'_y d\widehat{t}',$$

$$d\widehat{y}_m=\frac{\mathrm{ch}(\psi_t-\psi_{t0})}{\mathrm{ch}\psi_t}d\widehat{y}'_m=\frac{d\widehat{y}'_m\sqrt{1-\widehat{v}_0'^2c^{-2}}}{1-\widehat{v}'_x\widehat{v}'_0c^{-2}}=\frac{\widehat{v}'_y\sqrt{1-\widehat{v}_0'^2c^{-2}}}{1-\widehat{v}'_x\widehat{v}'_0c^{-2}}d\widehat{t}'=\widehat{v}_y d\widehat{t},$$

$$d\widehat{z}'_m=\frac{\mathrm{ch}\psi_t d\widehat{z}_m}{\mathrm{ch}(\psi_t-\psi_{t0})}=\frac{d\widehat{z}_m\sqrt{1-\widehat{v}_0^2c^{-2}}}{1-\widehat{v}_x\widehat{v}_0c^{-2}}=\frac{\widehat{v}_z\sqrt{1-\widehat{v}_0^2c^{-2}}}{1-\widehat{v}_x\widehat{v}_0c^{-2}}d\widehat{t}=\widehat{v}'_z d\widehat{t}',$$

$$d\widehat{z}_m=\frac{d\widehat{z}'_m\sqrt{1-\widehat{v}_0'^2c^{-2}}}{1-\widehat{v}'_x\widehat{v}'_0c^{-2}}=\frac{\widehat{v}'_z\sqrt{1-\widehat{v}_0'^2c^{-2}}}{1-\widehat{v}'_x\widehat{v}'_0c^{-2}}d\widehat{t}'=\frac{\mathrm{ch}\psi'_t}{\mathrm{ch}\psi_t}\widehat{v}'_z d\widehat{t}'=\widehat{v}_z d\widehat{t};$$

$$dt'=\frac{\sqrt{1-\widehat{v}_0^2c^{-2}}(dt-\widehat{v}_0c^{-2}dx_m)}{(1-\widehat{v}_x\widehat{v}_0c^{-2})^2}=\frac{\sqrt{1-\widehat{v}_0^2c^{-2}}}{1-\widehat{v}_x\widehat{v}_0c^{-2}}dt=\sqrt{\frac{1-\widehat{v}'^2c^{-2}}{1-\widehat{v}^2c^{-2}}}dt=\frac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t-\psi_{t0})}dt \qquad (dx_m=\widehat{v}_x dt),$$

$$dt=\frac{\sqrt{1-\widehat{v}_0'^2c^{-2}}(dt'-\widehat{v}'_0c^{-2}dx'_m)}{(1-\widehat{v}'_x\widehat{v}'_0c^{-2})^2}=\frac{\sqrt{1-\widehat{v}_{0c}'^2c^{-2}}}{1-\widehat{v}'\widehat{v}'_0c^{-2}}dt'=\sqrt{\frac{1-\widehat{v}^2c^{-2}}{1-\widehat{v}'^2c^{-2}}}dt'=\frac{\mathrm{ch}\psi'_t}{\mathrm{ch}\psi_t}dt' \qquad (dx'_m=\widehat{v}'_x dt),$$

should be perpendicular to the axis of coordinate time of hyperplane, in which this body rests and on which the projection of segment takes place, and not to the axis of coordinate time of hyperplane, in which the projected four-dimensional segment lies. And, consequently, hyperbolic projection of segment on this axis of coordinate time should be equal to zero.

$$dx'_m = \frac{\sqrt{1-\hat{v}_0^2c^{-2}}(dx_m - \hat{v}_0 dt)}{(1-\hat{v}_x\hat{v}_0c^{-2})^2} = \frac{\sqrt{1-\hat{v}_0^2c^{-2}}}{1-\hat{v}_x\hat{v}_0c^{-2}}dx_{ij} = \sqrt{\frac{1-\hat{v}'^2c^{-2}}{1-\hat{v}^2c^{-2}}}dx_{ij} = \frac{\mathrm{ch}\psi_t}{\mathrm{ch}(\psi_t - \psi_{t0})}dx_{ij} \qquad (dx_m = dx_{ij},\ dt = \hat{v}_x c^{-2} dx_{ij}),$$

$$dx_m = \frac{\sqrt{1-\hat{v}_0'^2c^{-2}}(dx'_m - \hat{v}'_0 dt')}{(1-\hat{v}'_x\hat{v}'_0c^{-2})^2} = \frac{\sqrt{1-\hat{v}_0'^2c^{-2}}}{1-\hat{v}'_x\hat{v}'_0c^{-2}}dx'_{ij} = \sqrt{\frac{1-\hat{v}^2c^{-2}}{1-\hat{v}'^2c^{-2}}}dx'_{ij} = \frac{\mathrm{ch}(\psi_t - \psi_{t0})}{\mathrm{ch}\psi_t}dx'_{ij} \qquad (dx'_m = dx'_{ij},\ dt' = \hat{v}'_x c^{-2} dx'_{ij}),$$

$$dy'_m = \frac{\mathrm{ch}^2\psi_t}{\mathrm{ch}^2(\psi_t - \psi_{t0})}dy_m = \frac{(1-\hat{v}_0^2c^{-2})}{(1-\hat{v}_x\hat{v}_0c^{-2})^2}dy_m, \qquad dy_m = \frac{1-\hat{v}^2c^{-2}}{1-\hat{v}'^2c^{-2}}dy'_m = \frac{(1-\hat{v}_0'^2c^{-2})}{(1-\hat{v}'_x\hat{v}'_0c^{-2})^2}dy'_m,$$

$$dz'_m = \frac{1-\hat{v}'^2c^{-2}}{1-\hat{v}^2c^{-2}}dz_m = \frac{(1-\hat{v}_0^2c^{-2})}{(1-\hat{v}_x\hat{v}_0c^{-2})^2}dz_m, \qquad dz_m = \frac{\mathrm{ch}^2(\psi_t - \psi_{t0})}{\mathrm{ch}^2\psi_t}dz'_m = \frac{(1-\hat{v}_0'^2c^{-2})}{(1-\hat{v}'_x\hat{v}'_0c^{-2})^2}dz'_m,$$

where: dx_{ij} and dx'_{ij} are the increments of coordinates that correspond to spatial transition to another object *j*, which is located in the same collective spatial-temporal microstate that the initial object *i* (while the increments dx_m and dx'_m correspond to the change in time of the spatial location of the same object *m*).

While the tensor of energy-momentum is formed in GR being based on purely Lorentz transformations of increments of coordinates and time, the metric tensor is de facto formed being based on their conformal gravitationally-Lorentz transformations. And namely the conformal self-contraction in background Euclidean space of CFREU of galaxies that are quickly distancing from the observer (and of their astronomical objects) is responsible for the curvature of intrinsic space of observer as well as for the coverage of the whole infinite space by the fictive sphere of the events pseudo-horizon when the cosmological constant is $\Lambda = 3H_E^2c^{-2}$. On the sphere of pseudo-horizon, of course, the conformity of infinity of not only cosmological past, but also of the space (division of one infinity by another infinity helps to get rid of both) takes place [100]. Due to isotropy of coordinate velocity of light in GR the thermodynamic potentials and parameters of only astronomical objects that conditionally motionless in CFREU can be Lorentz-invariant in GR. Only they are inertially falling onto pseudo-horizon of events of the Universe with the conservation of the value of Hamiltonian of inert free energy of rest and the value of Lagrangian of ordinary rest energy.

Moreover in any observer's FR the coordinate sizes of these objects (in the moment when they emit the radiation) are conformally reduced in their cross-section more than it is required for the absence of dilation of their intrinsic time. According to GR their transverse coordinate scale factor N_Λ formally exceeds its limit value, beyond which there should be not a deceleration but acceleration of the rate of intrinsic time of moving body [74]:

$$N_{\Lambda 0} = \frac{R_G}{r_{G0}} = \frac{D_M}{D_A} = 1 + z = \frac{1}{1 - v_{G0}/v_{cv0}} > N_{C0} = \left(\frac{v_{lr0}}{v_{l0}}\right)\frac{1}{\sqrt{1 - v_0^2 v_{l0}^{-2}}} = \frac{1}{1 - v_0^2 v_{l0}^{-2}} \qquad (p_0 = 2),$$

where: $v_{cv0}=c\sqrt{1-v_{G0}^2 v_{cv0}^{-2}}=v_{l0}$; $v_{G0}=v_0$ is the velocity of radial motion of distant galaxy at the moment of emission of radiation by it; $D_M\equiv R_G\equiv r'_G$ is the transverse comoving distance to the galaxy in CFREU; $D_A\equiv r_{G0}$ is the angular diameter distance in the observer FR at the moment of emission of radiation by the galaxy; z is the redshift of the wavelength of radiation from the stars of the galaxy.

According to the increment of the interval [101]:

$$(ds)^2=c^2(dt')^2-(dx'_m)^2-(dy'_m)^2-(dz'_m)^2=N_\Lambda^2[c^2(dt)^2-(dx_m)^2-(dy_m)^2-(dz_m)^2]$$

when: $dx'_m=0$, $dy'_m=0$ and $dz'_m=0$ the $dx_m=v_G d\hat{t}=(v_G/v_{cv})c d\iota$, $dy_m=0$, $dz_m=0$, will take place, and:

$$c^2(dt')^2=N_{\Lambda0}^2(1-v_G^2 v_{cv}^{-2})(dt)^2=N_{\Lambda0}^2(1-v_G^2 v_{cv}^{-2})v_{cv}^2(d\hat{t})^2=c^2(1+v_G/v_{cv})^2(d\hat{t})^2=c^2[(v_{cv}+v_G)/(v_{cv}-v_G)](dt)^2.$$

And, consequently, the dilation of intrinsic time of astronomical objects of far galaxies that are distancing from observer is absent in conformally transformed time t of the observer FR and all the more so by its real clock that counts universal astronomical time $\hat{t}$. So, according to GR formalism not the time dilation but vice versa the acceleration of the rate of intrinsic time of distant galaxies takes place by the observer's clock: $dt'=(1+v_G/v_{cv})d\hat{t}>d\hat{t}$. However, if just the gravitational dilation of time of distant galaxies is completely compensated by the free fall of distant galaxies on the events pseudo-horizon, then indeed there fundamentally cannot be any contraction or dilation of the unified gravithermodynamic (not coordinate) time of matter of these galaxies.

That is why the Etherington identity $D_L=D_A(1+z)^2$ [72], which takes into account the fictive $(1+z)^{1/2}$ times decreasing of the number of quanta of energy emitted by the moving astronomical object (being based on the false notion about the deceleration of the rate of its intrinsic time), is indeed the paralogism. And, of course, it should be replaced by the $D_L=D_M(1+z)^{1/2}=D_A(1+z)^{3/2}$ identity, according to which the Hubble linear dependency $z=\Delta\lambda_D/\lambda_0=H_E D_M/c$ is strictly fulfilled namely for the metrical distance D_M, and not for the luminosity distance D_L [62, 65, 101]. And it means that the fictive dark energy is not needed for the Universe [62, 65, 101, 102].

At the moment of registration of radiation (when astronomical object that emitted it can be already non-existent) the predicted by GR value of scale factor is reduced to the value $N_\Lambda(t_{rG})=R_G/r_G=c/v_{cv}=(1-v_G^2 v_{cv}^{-2})^{-1/2}<(1-v_0^2 v_{l0}^{-2})^{-1}$. That is why the imaginary dilation (in $(1-v_G^2 v_{cv}^{-2})^{-1/2}$ times) of intrinsic time of these astronomical objects is indeed predicted. However this imaginary dilation of time strictly corresponds to the value of coordinate velocity of light v_{cv} in the place of present expected dislocation of astronomical object. And, consequently, it can be not kinematic but purely "gravitational" effect that is caused by the tendency of coordinate velocity of light to zero when approaching the events pseudo-horizon.

And this can take place in the case of the conformal gravitationally-Lorentz transformations of increments of space coordinates and time, which guarantee the relativistic invariance of the Lagrangian of ordinary rest energy of inertially moving body as well as of all thermodynamic potentials and parameters of its matter when the values of kinematic (N_C) and coordinate (N_Λ) scale factors are:

$$N_C=\frac{1}{v_{l0}^2}=\frac{1}{1-\widehat{v}_{G0}^2c^{-2}}=\frac{1}{1-v_{G0}^2v_{l0}^{-2}}=\frac{1}{1-r_{G0}^2r_c^{-2}}, \quad N_\Lambda=\frac{R_G}{r_G}=\frac{1}{\sqrt{1-\widehat{v}_G^2c^{-2}}}=\frac{1}{\sqrt{1-v_G^2v_l^{-2}}}=\frac{1}{\sqrt{1-r_G^2r_c^{-2}}}.$$

According to this the evolutionary process of self-contraction of correspondent to matter spiral-wave formations de facto forms the global gravitational-evolutionary gradient lens (GGEGL) in the Universe with the following gravity-optical power:

$$\Phi(r_G)=\frac{r_G}{r_c\left(r_c+\sqrt{r_c^2-r_G^2}\right)}=\frac{1}{r_{cG}(R_G)}=\frac{1}{r_G}-\frac{1}{R_G},$$

where: $r_{cG}=\left(r_c+\sqrt{r_c^2-r_G^2}\right)r_c/r_G\geq r_c$ is the local value of focal distance of GGEGL; $r_c\approx c/H_E=\sqrt{3/\Lambda}$ is the total focal distance of GGEGL (radius of the events pseudo-horizon of the Universe); R_G and r_G are radial distances to the galaxy correspondingly in CFREU and in FR of the observer at the moment of registration of the galaxy radiation by him.

However, the redshift z of the emission spectrum of the stars of distant galaxy is determined not by its Schwarzschild radius r_G and not by N_Λ, since in contrast to the transverse comoving distance to the galaxy in CFREU $D_M\equiv R_G$ (that corresponds to galaxy all the time during the propagation of its quantum of radiation) the distances with angular diameter $D_A\equiv r_{G0}$ and $N_{\Lambda 0}=D_M/D_A=1+z$ should correspond to the moment of emission of radiation by the galaxy.

The Schwarzschild solution of the equations of GR gravitational field makes the misleading impression that the space that surrounds galaxies is distancing from the observer together with them. And, consequently, far from the observer the FR of Schwarzschild solution can be considered as non-rigid continuation of the rigid FR of our galaxy. However the conservation of the energy of inertially distancing galaxies disproves this impression, since in nor-rigid FRs the law of conservation of energy of inertially moving bodies fundamentally cannot be fulfilled [50]. Therefore FR of Schwarzschild solution is rigid in all its length. And, consequently, the local kinematic curvature of the space, filled by moving matter, should be imposed on the curvature of its rigid regular space. Thus, the same as in the space that do not have regular curvature, we will have:

$$dx_G=\frac{dr}{\sqrt{1-r_g/r-\Lambda r^2/3}}\approx\frac{dr}{\sqrt{1-v_G^2v_l^{-2}}}=\frac{dr}{\sqrt{1-r^2r_c^{-2}}}, \quad d\widehat{x}_G=\frac{dx_G}{\sqrt{1-v_G^2v_l^{-2}}}\approx\frac{dr}{1-v_G^2v_l^{-2}}=\frac{dr}{1-r^2r_c^{-2}}=N_Cdr,$$

$$(ds)^2 = N_C^2[v_l^2(d\hat{t})^2 - (dx_G)^2] = N_C^2(1 - v_G^2 v_l^{-2}) v_l^2 (d\hat{t})^2 = v_l^2 (d\hat{t})^2 / (1 - v_G^2 v_l^{-2}) = c^2 (d\hat{t})^2 = \mathbf{invar}.$$

Taking into account that $v_l = c\sqrt{1 - r^2 r_c^{-2}}$, and $v_G = v_l r / r_c = (cr/r_c)\sqrt{1 - r^2 r_c^{-2}}$ we may find time $\Delta\hat{t}$ at which the radiation of galaxy will reach the observer and the galaxy itself will take the position that is simultaneous with this event:

$$\Delta\hat{t} = \int_{r_0}^{0} \frac{d\hat{r}}{v_c} = \int_{r_0}^{0} \frac{dr}{1 - r^2 r_c^{-2}} = \frac{r_c}{2c} \ln \frac{r_c + r_0}{r_c - r_0}, \qquad \Delta\hat{t} = \int_{r_0}^{r} \frac{d\hat{r}}{v_G} = \frac{1}{c} \int_{r_0}^{0} \frac{r_c dr}{r(1 - r^2 r_c^{-2})} = \frac{r_c}{2c} \ln \frac{r^2 (r_c^2 - r_0^2)}{r_0^2 (r_c^2 - r^2)}.$$

From here, taking into account that $r = r_c R (r_c^2 + R^2)^{-1/2}$, we will find:

$$r = \frac{r_c}{\sqrt{1 + (r_c/r_0 - 1)^2}}, \qquad r_0 = \frac{r_c r\left(\sqrt{r_c^2 - r^2} - r\right)}{r_c^2 - 2r^2} = \frac{r_c R}{r_c + R}, \qquad D_M \equiv R = \frac{r_c r_0}{r_c - r_0} = \frac{D_A}{1 - D_A H_E / c} = (1+z) D_A$$

The transversal comoving distance (that corresponds to the classical photometric dependency) to the distant astronomical object that is conventionally at rest, the same as for the observer, can be determined in CFREU also from the condition of invariance to coordinates transformations of the diameter:

$$D = 2r_0 \sin u_{r0} = 2\hat{r}_0 \sin u_{\hat{r}0} = 2R \sin u_R = \mathbf{inv}$$

of aperture of registration device [74]:

$$R = \frac{\left[\sqrt{1 - r_g/r_0} - (r_0 H_E / c)\cos\varphi_{\hat{r}}\right] r_0}{1 - r_g/r_0 - (r_0 H_E / c)^2} \approx \frac{r_0}{1 - r_0 H_E / c} = \frac{r_0 r_c}{r_c - r_0} = r_0 (z+1) = \frac{zc}{H_E},$$

where according to relativistic transformation of trigonometric functions of angles [38, 89, 90]: $\sin u_R = (\hat{r}_0 / R) \sin u_{\hat{r}0} = \sqrt{1 - v_0^2 / v_{l0}^2} [1 - (v_0 / v_{l0}) \cos\varphi_{\hat{r}}]^{-1} \sin u_{\hat{r}0}$ ($\varphi_{\hat{r}} = \pi$), a $\sin u_{\hat{r}0} = (r_0 / \hat{r}_0) \sin u_{r0} = \sin u_{r0} \sqrt{1 - r_g / r_0 - \Lambda r_0^2 / 3}$; $r_c \approx \sqrt{3/\Lambda} = c / H_E$ is the radius of the events pseudo-horizon on which the value of limit velocity of motion v_l is equal to zero [37, 42, 103].

As we see the global gravitational lens, formed along the world line of radiation, is already not the gradient lens since it has the constant gravity-optical power in the whole space:

$$\Phi = \frac{1}{r_c} = \frac{1}{r_0} - \frac{1}{R} \equiv \frac{1}{D_A} - \frac{1}{D_M} = \mathbf{const}(R).$$

According to this the proportionality of redshift of the wavelength of radiation $z = (H_E / c) D_M$ to the transversal comoving distance to the galaxy in CFREU $D_M \equiv R$, possibly should take place in all points of the only the space with isotropic coordinates [38, 69]. And such conformal-Euclidean metrics quite corresponds to the all-side isotropic shrinkage of the microobjects of moving bodies. And only the system of isotropic coordinates can guarantee the correspondence of the curvature of intrinsic spaces of matter to isotropic gravitational as well as evolutionary deformations of its microobjects in background Euclidean space of the expanding Universe.

And indeed the isotropic coordinates corresponds to the conventionally empty intrinsic space of the body that has the linear element (world interval) of external Schwarzschild solution in background Euclidean space and in cosmological time τ of CFREU [73]:

$$(ds)^2=N_C^2N_E^2\{v_{lb}^2(d\tau)^2-(dR)^2-R^2[(d\theta)^2+\sin^2\theta(d\varphi)^2]\}=$$

$$=N_C^2\left\{\frac{(R-R_{ge})^2}{(R+R_{ge})^2}c^2(d\tau)^2-\frac{r_{ge}^2(R+R_{ge})^4}{16R_{ge}^2R^4}\left[dR^2+R^2\{(d\theta)^2+\sin^2\theta(d\varphi)^2\}\right]\right\}=$$

$$=N_C^2\left\{c^2(1-r_{ge}/r)(d\tau)^2-\frac{16\exp[2H_E(\tau-\tau_k)]}{\left(1+\eta\sqrt{1-r_{ge}/r}\right)^4}\left[dR^2+R^2\{(d\theta)^2+\sin^2\theta(d\varphi)^2\}\right]\right\}=\frac{\tilde{v}_{lb}^2(d\tau)^2}{1-\tilde{v}_b^2\tilde{v}_{lb}^{-2}}=$$

$$=N_C^2\{[(1-r_{ge}/r)c^2-H_E^2r^2](d\hat{t})^2-[(1-r_{ge}/r)c^2-H_E^2r^2]^{-1}(dr)^2-r^2[(d\theta)^2+\sin^2\theta(d\varphi)^2]\}=(1-v^2v_l^{-2})^{-1}v_l^2(d\hat{t})^2.$$

Namely their conformal transformations when $R=R_k$ and gravitational radius $R_{gek}=r_{ge}/4$ in this space are equivalent to non-isotropic Schwarzschild coordinates [38, 69].

Here: $N_E=1/N_\Lambda=r/R=r_{ge}(R+R_{ge})^2/4R_{ge}R^2=4\left(1+\eta\sqrt{1-r_{ge}/r}\right)^{-2}\exp[H_E(\tau-\tau_k)]$; $R=R_{ge}r\left(1+\eta\sqrt{1-r_{ge}/r}\right)^2/r_{ge}$, $r=r_{ge}(R+R_{ge})^2/4RR_{ge}$[53]; $v_{lb}=4cR_{ge}R^2(R-R_{ge})/r_{ge}(R+R_{ge})^3=cR^2(R-R_{ge})(R+R_{ge})^{-3}\exp[-H_E(\tau-\tau_k)]$, $f_{Gb}=\tilde{v}_{lb}/c=(R-R_{ge})/(R+R_{ge})=(1-r_g/r)^{1/2}$; $R_{ge}=(r_{ge}/4)\exp[-H_E(\tau-\tau_k)]$ is the continuously decreasing value in conventionally empty background space of the gravitational radius r_{ge} of astronomical body; $\eta=1$ ($R>R_{ge}$) for the external part of the space that contains matter and $\eta=-1$ ($R<R_{ge}$) for the internal part of the space (that contains antimatter) of extremely massive hollow astronomical body.

According to this the dependence of redshift of wavelength radiation on the transversal comoving distance $D_M\equiv R$ will be the following:

$$\frac{H_E}{c}\int_R^{4R_{ge}}\frac{(R+R_{ge})^3dR}{R^2(R-R_{ge})}=\frac{H_E}{c}\int_{\tau_0}^{\tau_k}\frac{(R+R_{ge})^3v_{lb}d\tau}{R^2(R-R_{ge})}=1-\exp(-H_E\tau_0)=1-\frac{\lambda_k}{\lambda_0}=-\frac{\Delta\lambda}{\lambda_0},$$

$$z=\frac{\Delta\lambda}{\lambda_0}=\frac{H_E}{c}\left\{\left[R+\frac{r_{ge}^2}{16R}+r_{ge}\ln\frac{(R-r_{ge}/4)^2}{R}\right]-r_{ge}(1{,}0625+2\ln 1{,}5)\right\},$$

where: $v_{lbk}=c$, $v_{lb}=cR^2(R-R_{ge})(R+R_{ge})^{-3}\exp[H_E(\tau-\tau_k)]/0{,}384$, $\tau_0\le\tau\le\tau_k=0$, $\lambda_k/\lambda_0=\exp(-H_E\tau_0)$.

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[53] This dependence of the radial coordinate r of a distant object in the intrinsic FR of matter on its radial coordinate R in the CFREU corresponds to one and the same moment of cosmological time. Therefore, according to it, outside the observer's STC, r can take arbitrarily large values, exceeding the value of the radius r_c of the events pseudo-horizon. For a similar dependence, which corresponds to one and the same moment of the proper time of matter, this is fundamentally impossible. After all, within this pseudo-horizon the entire infinite space of the CFREU is contained at the corresponding moments of cosmological time observed in the STC.

Since far from the source of gravitational field: $r_{ge}/r\approx 0$, and $R\approx r\exp[-H_E(\tau-\tau_k)]$,then for the same moment of cosmological time (τ=**const**) the following conditions will also be fulfilled: $dR/dr\approx R/r$ and $\exp[2H_E(\tau-\tau_k)]\{(dR)^2+R^2[(d\theta)^2+\sin^2\theta(d\varphi)^2]\}\approx(dr)^2+r^2[(\theta)^2+\sin^2\theta(d\varphi)^2]$. Therefore far away the spatial Schwarzschild coordinates also form (together with universal cosmological time) the system of isotropic coordinates. And since the planet Earth inertially goes around the Sun and around its axis there fundamentally should not be the dilation of its intrinsic time the same as for all inertially moving astronomical objects. That is why its gravithermodynamical (astronomical) time is de facto identical to universal (absolute) cosmological time. And then it becomes quite understandable why far galaxies almost strictly[54] correspond to the Hubble law as well as to the gravity-optical lens despite the coordinates of intrinsic FR of the Earth are non-isotropic.

It can, of course, be assumed that the solution of the equations of gravitational field should be in isotropic Cartesian coordinates and only after that should be transformed to be in spherical system of coordinates. However, such solution in isotropic Cartesian coordinates [104] does not differ from the solution in isotropic spherical coordinates that corresponds to background Euclidean space and cosmological time of CFREU. In CFREU the galaxies are quasi-motionless (perform only some small peculiar moves). And, therefore, in equations of gravitational field (3) correspondent to this solution the cosmological constant Λ is responsible not for the radial motion of the galaxies, but for the evolutionary decreasing of spatially inhomogeneous standards of length in Euclidean space of CFREU [73]. And, of course, this solution of equations in isotropic coordinates fundamentally cannot correspond to intrinsic FR of matter, in which galaxies are distancing from the observer. Therefore only the non-isotropic coordinates can correspond to intrinsic FRs of matter (in contrast to CFREU) that have the events (visibility) pseudo-horizon. And this after all confirms the fact that CFREU (only in which the coordinates are isotropic) is indeed the global preferred FR [22] and that cosmological time (counted in it) is similar to absolute time of classical physics.

When we forcefully accelerate some body it is as if we send it into cosmological future relatively to the conventionally resting bodies in the Universe. Not only inert free energy, but also real total energy of its matter is increasing during that. The ordinary rest energy (that formally should be decreasing) is only the potentially possible its energy in the future state of inertial motion and equilibrium of matter and environment. And after this body starts inertial motion under the influence of Universal gravitational field it will only gradually lose its accumulated energy only due to its deceleration by the matter of the outer space. And only when its kinetic energy will start to correspond to the certain trajectory of motion in Universal gravitational field its real total energy

[54] The erroneous conclusion about non-fulfillment of Hubble linear dependence is caused by the usage of uncorrected luminosity distance instead of transversal comoving distance in it and by the taking into account the imaginary relativistic time dilation in distant galaxies.

will become equal to potentially possible total internal energy and there will be no time dilation of its clock due to the motion.

If the change of the velocity of motion of the body is characterized by an ordinary acceleration, then the change of energy of its objects is characterized by the Möller hyperbolic acceleration $G = v_{li}'^{2} d\ln v_l' / dx'$. Spatial distribution of the limit velocity of light in hyperbolic Möller FR (FRM) is determined by the following invariant dependency, which guarantees the independence of coordinate values of limit velocity of matter motion v_l' on the velocities of motion of external observers only when $p_0 = 2$, while correspondent to it value $N_{Ci} = v_{li}'^{2} v_{li}^{-2} = (1 - v_0^2 v_{li}^{-2})^{-1} \neq \mathbf{const}(x')$:

$$v_{lj}' = v_{li}'(1 + G_i v_{li}^{-2} x_{ij}' / N_{Ci}) = v_{li}'(1 + G_i v_{li}'^{-2} x_{ij}') = \mathbf{invar},$$

where x_{ij} is the distance in FRM of accelerating body from its random object i to its random object j.

Spatial distribution of Möller accelerations can be determined by the following invariant dependency, which takes into account the simultaneity in FRM of events that correspond to the same velocity of motion in any external FR of all its points ($v \equiv v_0 = \mathbf{const}(x')$, $v_{li} = v_{li}' \sqrt{\left(1 + \sqrt{1 - 4 v_0^2 v_{li}'^{-2}}\right)/2} \neq \mathbf{const}(x')$ when $t' = \mathbf{const}(x')$):

$$\frac{1}{G_j} = \frac{v_{li}'^{2}}{c^2 G_i^2} \frac{d\breve{v}_j}{d\breve{t}_j'} = \frac{v_{li}^2}{v_{lj}' G_i^2} \frac{d(v'/v_{lj}')}{dt'} = \frac{1}{G_i} + \frac{x_{ij}'}{v_{li}^2 N_{Ci}} = \frac{1}{G_i} + x_{ij}' v_{li}^{-2}(1 - v^2 v_{li}^{-2}) = \frac{1}{G_i} + x_{ij}' v_{li}'^{-2} = \frac{v_{lj}'}{G_i v_{li}'} = \mathbf{invar},$$

where v' is the velocity of free fall of bodies in gravity-inertial field of FRM.

And only if $N_{Ci} = (v_{li}'/v_{li})^2 = (1 - v_0^2 v_{li}^{-2})^{-1}$ the invariance of Möller accelerations relatively to spatial-temporal transformations can take place. So the values of Möller accelerations will be equal for the observers independently on the velocities of motion of those observers relatively to accelerating body.

The body that falls free in gravity-inertial field of FRM conserves its energy in the same way as when it falls in gravitational field. All resting or inertially moving bodies (which are even not under the influence of gravity-inertial field of FRM) also conserve their energy in FRM. That is why the following Lorentz-conformal transformations can guarantee the relativistic invariance of gravithermodynamic time and the Lagrangian of ordinary rest energy not only for inertially moving bodies, but also for the bodies that have stable FRM.

Velocities of motion normalized by their maximal possible (limit) values are defined in those transformations not in proper gravity-quantum time of some observer but in unified gravithermodynamic time (that has curvature) of the whole RGTD-bonded matter. So the metrical inhomogeneity (formed by matter) of not only space but also time takes place in STC of CFREU. In order to guarantee the general covariance of equations of physics the STCs that have curvature of both space and time are de facto used in GR as well as in RGTD instead of Euclidean STCs. This helps to hide (behind the curvature of intrinsic STC of observer) the metrical inhomogeneity of background Euclidean space as well as of background Euclidean cosmological time of the Universe. The motion of matter creates additional local curvatures of intrinsic space-time of observer. That is why in order to guarantee the general covariance of equations of physics we should consider the principle of unobservability of not only relativistic shrinkage of longitudinal and transversal size of moving matter, but also of relativistic dilation of its intrinsic time. Instead of this relativistic dilation of time we should consider the local curvature of time of STC of observer, which is caused due to the motion of matter in a form of correspondent local distribution of gravitational potentials (limit velocities of individual motion of matter).

Gravitational dilation of gravity-quantum time of mobile and resting matter should be considered as the manifestation of curvature of unified gravithermodynamic time of the whole RGTD-bonded matter of the Universe. That is why only the normalized velocities of motion of matter (that reflect the presence of local curvature of unified gravithermodynamic time in the place of instantaneous dislocation of moving matter) should be used in equations of motion.

These conformal gravitationally-Lorentz transformations of increments of spatial coordinates and time also guarantee the absence of dilation of intrinsic time of inertially moving matter. However, they can be conformally-gaugely transformed without the influence on the values of real and limit velocities of individual motion of homogeneous matter and, thus, on the values of its thermodynamic potentials and parameters. The transformations of velocities of motion that are normalized by the limit velocities of motion of matter form the Lorentz group.

Exactly these conformal gravitationally-Lorentz transformations correspond to metrically homogeneous scale of cosmological time. According to purely Lorentz transformations the time on far astronomical objects flows slower the more those objects are distanced in the past. And this takes place despite the fact that in cosmology, quite the contrary, physical processes would flow faster in cosmological past than nowadays. And this means that both used now in cosmology and defined by ordinary Lorentz transformations scales of cosmological time are exponential. The former one speeds up physical processes in infinitely far cosmological past and, as a result, makes it finite. The latter one slows down physical processes in infinitely far past and de facto stops their flow on the pseudo-horizon of the past[55], which covers in observer FR the whole infinite space of the Universe.

[55] The physical processes flow quite fast (as it is suggested in cosmology) by the intrinsic clock of astronomical objects that are located near the pseudo horizon of events in the deep cosmological past. However the singular sphere of pseudo-horizon of events (that belongs only to infinitely far cosmological past) has the certain specific square and is not an imaginary singular point, in which "Big Bang of the Universe" happened. Schwarzschild singular sphere (that belongs only to infinitely far cosmological future) also has the certain specific square according to the solutions of equations of gravitational field of GR despite the fact that in background Euclidean space it is indeed a point. In

14. Generalized equations of thermodynamics

If during the inertial motion of matter the main role is played by conserving Lagrangian of its ordinary rest energy and Hamiltonian of its inert free energy, then during the quasi-equilibrium (quasi-uniform) motion of matter that gradually cools the main role is played by gradually decreasing Lagrangians of its ordinary rest energy W_0 (identical to the multiplicative component of Gibbs free energy G_0) and of multiplicative component of its thermodynamic internal energy. And therefore, according to the Lagrangian construction[56] of the energy-momentum tensor of a quasi-equilibrially cooling matter, not only the parameter $b = v_l^2 c^{-2}$ of the gravitational field equations, but also the relativistic shrinkage $\Gamma_m = (1 - v_m^2 v_l^{-2})^{-1/2}$ of the radial dimensions of the matter are hidden thermodynamic parameters. Namely, for the non-rigid FR which is comoving with the cooling gas, we will have the following gravitational field equations (which correspond not to the metric STC, but to the inseparable from matter its own physical STC, in which there is no radial motion of the molecules of matter, and time is counted by the clocks comoving with it):

$$b_c' / a_c b_c r - r^{-2}(1 - 1/a_c) + \Lambda = \kappa(p - ST/V) = (\kappa T_{00} / \sqrt{b}\Gamma_m V)(R_T - S) = \kappa T_{00} R_{TS} / \sqrt{b_c} V \,,$$

$$a_c' / a_c^2 r + r^{-2}(1 - 1/a_c) - \Lambda = \kappa(\mu_{gr} c^2 - p) = \kappa(\mu_{00} c^2 - p_{00}) / \sqrt{b}\Gamma_m = \kappa U_{00} / \sqrt{b_c} V \,,$$

$$(\ln a_c b_c)' / a_c r = \kappa G_0 / V = (U_{00} / V + p - ST/V) = (\kappa / \sqrt{b}\Gamma_m V)(U_{00} + T_{00} R_{TS}) = \kappa G_{00} / \sqrt{b_c} V \,,$$

where: $b_c = b\Gamma_m^2 = v_l^2 c^{-2} \Gamma_m^2 = v_{lc}^2 c^{-2}$, $U_{00} = (m_{00} c^2 - p_{00} V) = U_0 \sqrt{b_c} = (U - U_{ad}) v_l \Gamma_m / c = \mathbf{const}(r)$,

$G_{00} = G_0 \sqrt{b_c} = (G_T - U_{ad}) v_l \Gamma_m / c = \mathbf{const}(r)$, $\quad S = \mathbf{const}(r)$[57], $\quad R_T = pV/T = \mathbf{const}(r)$,

$R_{TS} = R_T - S = \mathbf{const}(r)$, $T_{00} = T\Gamma_m v_l / c = \mathbf{const}(r,t)$, $A_\rho = TS / R_T = T^2 S / pV = \mathbf{const}(t)$.

Moreover, the thermodynamic processes in matter confront the intranuclear evolutionary and gravitational processes in it. While in mechanics the main role is played by the inert free energy $\mathrm{H} \equiv E = m_{in0} c^2 \Gamma_m = m_{00} c v_l \Gamma_m$ (equivalent to inertial mass $m_{in} = m_{00} v_l \Gamma_m / c$), in thermodynamics the main role is given not only to the internal energy U, but also enthalpy and Gibbs free energy $G = G_0 + U_{ad} = G_{00} / v_l \Gamma_m + U_{ad} = \mathrm{L}_m + U_{ad}$, the main part of which is an ordinary rest energy $W_0 \equiv G_0 = U + pV - pS - U_{ad} \equiv \mathrm{L}_m = m_{gr0} c^2 / \Gamma_m = m_{00} c^3 / v_l \Gamma_m = W_{00} / \sqrt{b_c}$ (equivalent to gravitational mass $m_{gr} = m_{00} c / v_l \Gamma_m$) of matter that gradually cools. Here:

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infinitely far cosmological future all astronomical objects should become points due to their evolutionary self-contraction in CFREU.

[56] Obviously, instead of the Hamiltonian construction, the hidden Lagrangian construction of the energy-momentum tensor of matter should be used in CFREU. After all, the evolutionary self-contraction of matter in it can be caused by the evolutionary decrease of the coordinate velocity of light in it, which is a hidden thermodynamic parameter of matter.

[57] Therefore, entropy is spatially homogeneous not only in matter that is cooled to the limit (maximally cooled), but also in gradually cooling matter that has a non-rigid FR.

$U_{ad} = U - U_0 = \mathbf{const}(r) > 0$ is spatially homogeneous additive compensation of multiplicative representation U_0 of internal energy at rest U of matter and, consequently, does not depend on the strength of gravitational field.

Therefore, frequency of intranuclear interaction:

$$f_G = q_N N_{RE} = q_N N_E / \Gamma_E = \eta_m v_l \Gamma_m / c = v_{lc} / v_{lc/cr} \le \eta_m$$

corresponds to inversely proportional to it frequency of electromagnetic interaction of matter molecules $f_I = \chi_m / f_G = q_M N_I = (v_{cm} / c) N_I = \psi_m c / v_l = \psi_{m0} c / v_{lc} = \chi_m v_{lc/cr} / v_{lc} \ge \psi_m$ ($f_{Gcr} = 1$, $f_{Icr} = 1$ when conditionally $\chi_m = \chi_{m0} = 1$).

This frequency is changing together with the change of velocity of light $v_{cm}=cq_M \le v_l$ in matter (that corresponds to radiation refractive index n_m at the wavelength of maximum of energy of thermal radiation) and with the change of internal scale factor[58] $N_I=\delta l_{cr}/\delta l \le 1$ of matter [29, 30, 32, 35, 105]. Here: $\psi_{m0} = \chi_m / \eta_m = \chi_m v_{lc/cr} / c = \chi_m v_{lcr} \Gamma_{mcr} / c$, $\psi_m = \psi_{m0} / \Gamma_m = \chi_m / \eta_m \Gamma_m = \chi_m v_{lcr} \Gamma_{mcr} / c\Gamma_m$, $\chi_m = \chi_{m0}$ $\eta_m = c / v_{lc/cr} = c / \Gamma_{mcr} v_{lcr}$ are the constants of matter that cools to the limit (χ_{m0}, ψ_{m0}) and of matter that gradually cools (χ_m, ψ_m)[59], which is not identical for different matters and for their various phase or aggregate states and not dependent both on strength of gravitational field and on matter thermodynamic parameters; v_l and v_{lcr} are maximum possible (limit) velocities of matter individual motion (which are identical to the vacuum coordinate velocities of light of GR) in any point and on the phase boundary of the same matter (or on the boundary of different matters) correspondingly; $v_{lc} = v_l \Gamma_m > v_l$ and $v_{lc/cr} = v_{lcr} \Gamma_{mcr}$ are the limit velocity of individual motion of quasi-equilibrium cooling down matter in the comoving with it the non-rigid FR; Γ_{mcr} is the Lorentz shrinkage of dimensions of matter (that moves in the process of quasi-equilibrium cooling down) on the phase boundary of the same matter or with another matter; δl_{cr} is minimal possible distance of electromagnetic interaction between molecules of certain matter or its critical value; *c* is constant of the velocity of light.

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[58] It is obvious, the every matter forms in gravitational field its own thermodynamic STC, the curvature of which partially compensates the curvature of STC of the whole RGTD-bonded matter.

[59] These constants unambiguously correspond only to the homogeneous matter of not layered astronomical body that does not possesses any matter outside its borders. In any other case it is only gaugely changed since due to logarithmicity of gravitational potential (that is formed based on correspondent thermodynamic potential) it does not directly influence the strength of gravitational field. Changes of the strength of gravitational field in it take place under the influence of other matters on the formation of its spatially inhomogeneous thermodynamic state [29, 30, 32, 35]. When there is a violation of thermodynamic equilibrium with environment they can substantially influence on the magnitude of limit velocity of substance individual (separate) motion and, thus, on the magnitude of ordinary rest energy of matter and equivalent to it gravitational mass. So, for example, in spite of the increasing of thermal energy of matter during its heating its ordinary rest energy and, therefore, gravitational mass are ostensibly decreasing [52 – 54].

In contrast to used in cosmology spatially inhomogeneous external scaling factor N_E, which is the cause of the curvature of matter intrinsic space, internal scaling factor N_I takes nonsimilar values for different matters and depends on thermodynamic state of matter. This factor characterizes the distinction between average statistic value of interaction distance δl in the atoms of concrete matter and the value of this distance δl_{cr} that corresponds to critical equilibrium values of internal energy multiplicative component U_{cr}, Gibbs free energy G_{cr}, temperature T_{cr}, pressure p_{cr}. And if parameter $q_M = v_{cm}/c = 1/n_m < 1$ characterizes the difference of real velocity of electromagnetic interaction propagation in matter from the constant of velocity of light *c*, then N_I is responsible for compensation of the influence of increase of propagation velocity of electromagnetic wave on the frequency of electromagnetic interaction f_I of matter microobjects. If for gases and simplest liquids the dependencies of instantaneous values of their thermodynamic parameters and potentials on q_M and $N_I = \sigma_m / N_{RE} = \sigma_m / \Gamma_{mE} N_E$ ($\sigma_m = \mathbf{const}(r)$) allow to separate these variables, then instantaneous value of their Gibbs free energy (that corresponds to their instantaneous thermodynamic microstates) can be expressed via these two parameters and via their function R_T in the following way:

$$\breve{G}(q_M,N_I,\breve{R}_T)=\breve{U}(q_M,N_I,\breve{R}_T)-\breve{S}(q_M,N_I,\breve{R}_T)\breve{T}(q_M,N_I,\breve{R}_T)+\breve{V}(q_M,N_I)\breve{p}(q_M,N_I).$$

Methods of thermodynamics allow us to analyze equilibrium states of matter even when there is no analytic dependence of internal energy of matter on its thermodynamic parameters. In order to identify some features, let us consider the simplest analytical dependencies for gases and simple liquids. According to them the instantaneous values of main thermodynamic parameters and potentials can be represented in the following way:

$$\breve{S}=-\left(\frac{\partial\breve{G}}{\partial\breve{T}}\right)_{\breve{p}}=-\left(\frac{\partial\breve{F}_T}{\partial\breve{T}}\right)_{\breve{V}}=\frac{\beta_{ST}\breve{R}_T}{\beta_{pV}}(\hat{S}),\quad \breve{T}=\left(\frac{\partial\breve{H}_T}{\partial\breve{S}}\right)_{\breve{p}}=\left(\frac{\partial\breve{U}}{\partial\breve{S}}\right)_{\breve{V}}=\frac{\beta_{pV}U_{cr}}{\breve{R}_T}(\hat{T})=\frac{c\psi_{m0}\beta_{pV}U_{cr}}{\Gamma_m v_l\breve{R}_T}=\frac{\beta_{pV}\breve{U}_0}{\breve{R}_T},$$

$$\breve{V}=\left(\frac{\partial\breve{H}_T}{\partial\breve{p}}\right)_{\breve{S}}=\left(\frac{\partial\breve{G}}{\partial\breve{p}}\right)_{\breve{T}}=\frac{U_{cr}}{p_l}(\hat{V}),\qquad \breve{p}=-\left(\frac{\partial\breve{U}}{\partial\breve{V}}\right)_{\breve{S}}=-\left(\frac{\partial\breve{F}_T}{\partial\breve{V}}\right)_{\breve{T}}=\beta_{pV}p_l(\hat{p}),$$

$$\breve{U}=\breve{U}_0+\breve{U}_{ad}=\frac{R_{UT}\breve{Z}\breve{T}}{\beta_{pV}}+\breve{U}_{ad}=\frac{\breve{R}_T\breve{T}}{\beta_{pV}}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\frac{\breve{T}\breve{S}}{\breve{R}_T}d\breve{R}_T=\frac{\breve{p}\breve{V}}{\beta_{pV}}+\beta_{ST}\int_{\breve{R}_{T0}}^{\breve{R}_T}(\hat{T})(\hat{S})\frac{d\breve{R}_T}{\breve{R}_T}=$$

$$=U_{cr}\left[q_M N_I+\beta_{ST}\int_{\breve{R}_{T0}}^{\breve{R}_T}(q_M N_I/\breve{R}_T)\ln(q_M^{1}N_I)d\breve{R}_T\right]=\breve{a}_\rho\breve{T}/\beta_{pV}+\int_{\breve{a}_{\rho0}}^{\breve{a}_\rho}\breve{A}_\rho d\breve{a}_\rho=$$

And this decrease in the gravitational mass of heated bodies is due to its equivalence not to thermodynamic internal (free thermal) energy at all, but actually to multiplicative component of Gibbs free energy.

$$=U_{cr}\left[\left(\frac{p_l\breve{V}}{U_{cr}}\right)^{-\beta_{pV}}\exp\left(\frac{\beta_{pV}\breve{S}}{\breve{R}_T}\right)+\beta_{pV}\int_{\breve{R}_{T0}}^{\breve{R}_T}\left(\frac{p_l\breve{V}}{U_{cr}}\right)^{-\beta_{pV}}\exp\left(\frac{\beta_{pV}\breve{S}}{\breve{R}_T}\right)\frac{\breve{S}}{\breve{R}_T^2}d\breve{R}_T\right]=$$

$$=U_{cr}\left[\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)^{\frac{\beta_{pV}}{\beta_H}}\exp\left(\frac{\beta_{pV}\breve{S}}{\beta_H\breve{R}_T}\right)+\beta_{pV}\int_{\breve{R}_{T0}}^{\breve{R}_T}\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)^{\frac{\beta_{pV}}{\beta_H}}\exp\left(\frac{\beta_{pV}\breve{S}}{\beta_H\breve{R}_T}\right)\frac{\breve{S}}{\breve{R}_T^2}d\breve{R}_T\right]=$$

$$=\left\{\breve{R}_T\breve{T}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\left[\beta_H\ln\left(\frac{\breve{R}_T\breve{T}}{U_{cr}\beta_{pV}}\right)-\beta_{pV}\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right)\right]\breve{T}d\breve{R}_T\right\}\frac{1}{\beta_{pV}}=$$

$$=U_{cr}\left[(\hat{T})+\beta_{ST}\int_{\breve{R}_{T0}}^{\breve{R}_T}(\hat{T})(\hat{S})\frac{d\breve{R}_T}{\breve{R}_T}\right]=\frac{1}{\beta_{pV}}\left\{\breve{R}_T\breve{T}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pV}U_{cr}}\right)+\beta_{pV}\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]\breve{T}d\breve{R}_T\right\},$$

$$\breve{F}_T=\breve{U}-\breve{S}\breve{T}=U_{cr}\left[(\hat{T})-\beta_{ST}\int_{[(\hat{S})(\hat{T})/\breve{R}_T]_0}^{(\hat{T})(\hat{S})/\breve{R}_T}\breve{R}_T d\left(\frac{(\hat{T})(\hat{S})}{\breve{R}_T}\right)\right]=\breve{F}_{T0}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\frac{\breve{S}\breve{T}}{\breve{R}_T}d\breve{R}_T=$$

$$=U_{cr}\left\{[1-\ln(\hat{T})-\beta_{pV}\ln(\hat{V})](\hat{T})+\int_{\breve{R}_{T0}}^{\breve{R}_T}[\ln(\hat{T})+\beta_{pV}\ln(\hat{V})](\hat{T})/\breve{R}_T]d\breve{R}_T\right\}=$$

$$=\breve{U}_0(1-\beta_{pV}\breve{S}/\breve{R}_T+\breve{U}_{ad}=\breve{T}(R_{UT}\breve{Z}/\beta_{pV}-\breve{S})+\breve{U}_{ad}=$$

$$=\frac{1}{\beta_{pV}}\left\{\breve{R}_T\breve{T}\left[1-\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pV}U_{cr}}\right)-\beta_{pV}\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]+\int_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pV}}\right)+\beta_{pV}\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]\breve{T}d\breve{R}_T\right\},$$

$$\breve{H}_T=\breve{U}+\breve{p}\breve{V}=\breve{U}+\breve{R}_T\breve{T}=\breve{U}_0(1+\beta_{pV})+\breve{U}_{ad}=R_{UT}\breve{Z}\breve{T}(1/\beta_{pV}+1)+\breve{U}_{ad}=$$

$$=\breve{H}_{T0}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\frac{\breve{T}\breve{S}}{\breve{R}_T}d\breve{R}_T=\frac{\beta_H\breve{R}_T\breve{T}}{\beta_{pV}}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\frac{\breve{T}\breve{S}}{\breve{R}_T}d\breve{R}_T=U_{cr}\left[\beta_H(\hat{T})+\beta_{ST}\int_{\breve{R}_{T0}}^{\breve{R}_T}\frac{(\hat{T})(\hat{S})}{\breve{R}_T}d\breve{R}_T\right]=$$

$$=U_{cr}\left[\beta_H\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)^{\frac{\beta_{pV}}{\beta_H}}\exp\left(\frac{\beta_{pV}\breve{S}}{\beta_H\breve{R}_T}\right)+\beta_{pV}\int_{\breve{R}_{T0}}^{\breve{R}_T}\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)^{\frac{\beta_{pV}}{\beta_H}}\exp\left(\frac{\beta_{pV}\breve{S}}{\beta_H\breve{R}_T}\right)\frac{\breve{S}}{\breve{R}_T^2}d\breve{R}_T\right]=$$

$$=\frac{\beta_H}{\beta_{pV}}\left\{\breve{R}_T\breve{T}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pV}U_{cr}}\right)-\frac{\beta_{pV}}{\beta_H}\ln\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)\right]\breve{T}d\breve{R}_T\right\}=$$

$$=\frac{1}{\beta_{pV}}\left\{\beta_H\breve{R}_T\breve{T}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pV}U_{cr}}\right)+\beta_{pV}\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]\breve{T}d\breve{R}_T\right\}=$$

$$= c\psi_{m0}U_{cr}\left\{\frac{\beta_H}{\Gamma_m v_l}+\beta_{ST}\int\limits_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right)-(\text{l}-1)\ln n_m\right]\frac{d\breve{R}_T}{\breve{R}_T\Gamma_m v_l}\right\},$$

$$\breve{G}=U_{cr}\left[\beta_H(\hat{T})-\beta_{ST}\int\limits_{[(\hat{S})(\hat{T})/\breve{R}_T]_0}^{(\hat{S})(\hat{T})/\breve{R}_T}\breve{R}_T d\left(\frac{(\hat{S})(\hat{T})}{\breve{R}_T}\right)\right]=\breve{U}_0\left[1+\beta_{pV}\left(1-\frac{\breve{S}}{\breve{R}_T}\right)\right]+\breve{U}_{ad}=\breve{T}\left[R_{UT}\breve{Z}\left(\frac{1}{\beta_{pV}}+1\right)-\breve{S}\right]+\breve{U}_{ad}=$$

$$=\breve{H}_T-\breve{S}\breve{T}=\breve{G}_0+\int\limits_{\breve{R}_{T0}}^{\breve{R}_T}\frac{\breve{S}\breve{T}}{\breve{R}_T}d\breve{R}_T=\beta_H U_{cr}\left\{\left[1-\ln(\hat{T})+\frac{\beta_{pV}}{\beta_H}\ln(\hat{p})\right](\hat{T})+\int\limits_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln(\hat{T})-\frac{\beta_{pV}}{\beta_H}\ln(\hat{p})\right]\frac{(\hat{T})}{\breve{R}_T}d\breve{R}_T\right\}=$$

$$=\breve{H}_{T0}-\int\limits_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\frac{\beta_H\breve{a}_\rho\breve{T}}{\beta_{pV}}-\int\limits_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{a}_\rho d\breve{A}_\rho=\frac{\beta_H\breve{R}_T\breve{T}}{\beta_{pV}}\left[1-\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pv}U_{cr}}\right)+\frac{\beta_{pV}}{\beta_H}\ln\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)\right]+$$

$$+\int\limits_{\breve{R}_{T0}}^{\breve{R}_T}\left[\frac{\beta_H}{\beta_{pV}}\ln\left(\frac{\breve{R}_T\breve{T}}{\beta_{pV}U_{cr}}\right)-\ln\left(\frac{\breve{p}}{\beta_{pV}p_l}\right)\right]\breve{T}d\breve{R}_T=\frac{\beta_G R_{UT}\breve{Z}\breve{T}}{\beta_{pV}}+\breve{U}_{ad}=U_{cr}f_I[1+\beta_{pV}-\beta_{ST}\ln(f_I^{\text{l}}N_I^{1-\text{l}})]+\breve{U}_{ad}=$$

$$= c\psi_{m0}U_{cr}\left\{\frac{\beta_H}{\Gamma_m v_l}-\int\limits_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\left(\frac{\beta_{ST}}{\breve{R}_T\Gamma_m v_l}\left[\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right)-(\text{l}-1)\ln n_m\right]\right)\right\}=$$

$$=\frac{c\psi_{m0}U_{cr}\beta_{ST}}{\Gamma_m v_l}\left\{\left[\frac{\beta_H}{\beta_{ST}}-\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right)+(\text{l}-1)\ln n_m\right]+\Gamma_m v_l\int\limits_{\breve{R}_{T0}}^{\breve{R}_T}\left[\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right)-(\text{l}-1)\ln n_m\right]\frac{d\breve{R}_T}{\breve{R}_T\Gamma_m v_l}\right\},$$

where: $\breve{U}_0=(\hat{T})U_{cr}$, $\breve{H}_{T0}=\beta_H\breve{U}_0$, $\breve{G}_0=\beta_G\breve{U}_0$, $\breve{F}_{T0}$ are multiplicatively dependent on $q_M=1/n_m$ and N_I components of instantaneous values of internal energy, enthalpy, Gibbs free energy and Helmholtz free energy of instantaneous Gibbs microstate of matter correspondingly;

$\breve{U}_{ad}=\sum\limits_{i=2}^{n}\int\limits_{\breve{a}_{i0}}^{\breve{a}_i}\breve{A}_i d\breve{a}_i=\int\limits_{\breve{a}_{\rho 0}}^{\breve{a}_\rho}\breve{A}_\rho d\breve{a}_\rho=\int\limits_{\breve{R}_{T0}}^{\breve{R}_T}(\breve{T}\breve{S}/\breve{R}_T)d\breve{R}_T>0$ is instantaneous value of realized via negative feedback partial additive compensation of multiplicative representation of thermodynamic potentials of microstate of matter (a multiplicative decrease in its free energies over time);

$\breve{a}_\rho\equiv\breve{R}_T=\breve{p}\breve{V}/\breve{T}$ and $\breve{A}_\rho=\breve{T}\breve{S}/\breve{R}_T=\breve{T}^2\breve{S}/\breve{p}\breve{V}$ are respectively, extensive and intensive resulting thermodynamic parameters of the real gas;

$(\hat{S})=\ln(q_M^{\text{l}}N_I)=\ln(f_I^{\text{l}}N^{1-\text{l}})$, $(\hat{V})=q_M^{-1/\text{k}}N_I^{-\text{m}}=q_M^{\text{m}-1/\text{k}}f_I^{-\text{m}}=f_I^{-1/\text{k}}N_I^{1/\text{k}-\text{m}}=(\Gamma_m v_l/c\psi_{m0})^{1/\beta_{pV}}\exp(\breve{S}/\breve{R}_T)$,

$(\hat{p})=q_M^{1+1/\text{k}}N_I^{1+\text{m}}=q_M^{1/\text{k}-\text{m}}f_I^{1+\text{m}}=f_I^{1+1/\text{k}}N_I^{\text{m}-1/\text{k}}=(\Gamma_m v_l/c\psi_{m0})^{-\beta_H/\beta_{pV}}\exp(-\breve{S}/\breve{R}_T)$,

$(\hat{T})=(\hat{p})(\hat{V})=q_M N_I=f_I=\chi_m/f_G=\psi_m c/v_{cv}\equiv\psi_{m0}c/\Gamma_m v_l=\psi_{m0}b^{-1/2}/\Gamma_m$ are normalized values of thermodynamic parameters (entropy, molar volume, pressure and temperature) of Gibbs microstates of matter;

$$\beta_{pV}=\frac{\breve{p}\breve{V}}{\breve{U}_0}=\frac{\mathrm{k(l-1)}}{\mathrm{klm-1}}>0,\quad \beta_H=\frac{\breve{H}_{T0}}{\breve{U}_0}=1+\beta_{pV}=\frac{\mathrm{k(lm+l-1)-1}}{\mathrm{klm-1}},\quad \beta_{ST}=\frac{\breve{S}\breve{T}}{\breve{U}_0\ln(q_M^{\mathrm{l}}N_I)}=\frac{\mathrm{km-1}}{\mathrm{klm-1}}>0,$$

$$\beta_{pT}=\beta_{pV}\left(1-\frac{\breve{S}}{\breve{R}_T}\right),\quad \beta_G=\frac{\breve{G}_0}{\breve{U}_0}=1+\beta_{pT}=1+\beta_{pV}-\beta_{ST}\ln(q_M^{\mathrm{l}}N_I)=\beta_H-\frac{\mathrm{l(km-1)}}{\mathrm{klm-1}}\ln q_M-\frac{\mathrm{km-1}}{\mathrm{klm-1}}\ln N_I=$$

$$=\frac{\mathrm{k(lm+l-1)-1}}{\mathrm{klm-1}}-\frac{\mathrm{l(km-1)}}{\mathrm{klm-1}}\ln f_I+\frac{\mathrm{(km-1)(l-1)}}{\mathrm{klm-1}}\ln N_I,$$

$$\beta_{GR}=\frac{\breve{G}}{\breve{U}_0}=1+\beta_{pV}-\frac{\beta_{ST}}{(\hat{T})}\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\frac{\mathrm{k(lm+l-1)-1}}{\mathrm{klm-1}}-\frac{\mathrm{km-1}}{(\mathrm{klm-1})q_M N_I}\int_{[(\hat{S})(\hat{T})/\breve{R}_T]_0}^{(\hat{S})(\hat{T})/\breve{R}_T}\breve{R}_T d\left[\frac{q_M N_I\ln(q_M^{\mathrm{l}}N_I)}{\breve{R}_T}\right];$$

$p_I(p_{IE},a)=\mathrm{n}\,p_{cr}=\mathbf{const}(r)$, $p_{IE}=\mathrm{n}_E\,p_{cr}\neq\mathbf{const}(r)$, while: $\mathrm{n}=\mathbf{const}(r)$ and $\mathrm{n}_E\neq\mathbf{const}(r)$ are the hidden variables that are the indicatorsi of the magnitudes of instantaneous microfluctuations of values of pressure and molar volume when $\breve{p}\breve{V}=\mathbf{const}$ and during not absolutely rigid retention of occupied by gas constant volume in the intrinsic space of matter and in Euclidean space correspondingly [25];

$\mathrm{k}=\mathbf{const}(r)$, $\mathrm{l}=\mathbf{const}(r)$, $\mathrm{m}=\mathbf{const}(r)$ are the spatially homogeneous hidden variables that are indicators of the influence of parameters $q_M=1/n_m$ and $N_I=\sigma_m/N_{RE}$ on the parameters of thermodynamic microstates of latently coherent matter[60].

Variables k, l , m and n characterize instantaneous collective microstates of the whole gravithermodynamically bonded matter and similarly to the wave functions of quantum mechanics can take with certain probability any arbitrary instantaneous values. The probability that Gibbs microstate of matter have instantaneous energy, the corresponding certain composition of values of these variables, obviously, is represented by canonic Gibbs distribution. The concrete mathematical expectations $\tilde{k}(R_T)$, $\tilde{l}(R_T)$, $\tilde{m}(R_T)$, $\tilde{n}(R_T)$, $\tilde{n}_E(R_T,a)$ of those variables (that depend on the parameter R_T) correspond to parameters of a thermodynamic macrostate of matter. It is exactly the dependence of the mathematical expectation $\tilde{n}_E(R_T,a)$ [61] of the hidden parameter n_E also on the index of curvature *a* of the intrinsic space of matter that is responsible for its curvature.

Normalized values of thermodynamic parameters of instantaneous microstates of matter are mutually related via the following dependencies:

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60 It is possible that latent coherence of matter is brought on (together with the new moment of its proper time) by the next turn of spiral wave of space-time modulation of dielectric and magnetic permeabilities of physical vacuum [29, 47].

61 Differential equations of the gravitational field specify only the radial gradients of the parameters *a* and *b*, and not their absolute values. Therefore, at the same point in space, the values of not only the real velocity of radiation propagation v_{cm}, but also of the parameter $b=v_l^2c^{-2}$ may differ for different substances that border each other in the same space. But the value of the parameter *a* is taken to be the same for them both in GR and in RGTD. However, the possibility of its change together with the change in pressure in the gas cylinder is not excluded.

$$(\hat{S}) = \mathrm{l}\ln q_M + \ln N_I = \mathrm{l}\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right) - (\mathrm{l}-1)\ln\left(\frac{\sigma_m}{N_{RE}}\right) = \frac{\beta_H}{\beta_{ST}}\ln(\hat{T}) - \frac{\beta_{pV}}{\beta_{ST}}\ln(\hat{p}) = \frac{\ln(\hat{T})}{\beta_{ST}} + \frac{\beta_{pV}}{\beta_{ST}}\ln(\hat{V}) = \frac{\beta_H}{\beta_{ST}}\ln(\hat{V}) + \frac{\ln(\hat{p})}{\beta_{ST}},$$

$$\ln(\hat{T}) = \ln q_M + \ln N_I = \ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right) = \frac{\beta_{ST}}{\beta_H}(\hat{S}) + \frac{\beta_{pV}}{\beta_H}\ln(\hat{p}) = \beta_{ST}(\hat{S}) - \beta_{pV}\ln(\hat{V}) = \ln(\hat{p}) + \ln(\hat{V}),$$

$$\ln(\hat{V}) = -\frac{\ln q_M}{\mathrm{k}} - \mathrm{m}\ln N_I = -\mathrm{m}\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right) + \frac{1-\mathrm{km}}{\mathrm{k}}\ln n_m = \frac{\beta_{ST}}{\beta_H}(\hat{S}) - \frac{\ln(\hat{p})}{\beta_H} = \frac{\beta_{ST}}{\beta_{pV}}(\hat{S}) - \frac{\ln(\hat{T})}{\beta_{pV}} = \ln(\hat{T}) - \ln(\hat{p}),$$

$$\ln(\hat{p}) = \frac{\mathrm{k}+1}{\mathrm{k}}\ln q_M + (\mathrm{m}+1)\ln N_I = (\mathrm{m}+1)\ln\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right) + \frac{\mathrm{km}-1}{\mathrm{k}}\ln n_m =$$

$$= \beta_{ST}(\hat{S}) - \beta_H\ln(\hat{V}) = -\frac{\beta_{ST}}{\beta_{pV}}(\hat{S}) + \frac{\beta_H}{\beta_{pV}}\ln(\hat{T}) = \ln(\hat{T}) - \ln(\hat{V}).$$

As it was expected, all instantaneous thermodynamic potentials reach their minimum independently both on the values of variables k, l , m, n, and on the value of spatial gas-related (liquid-related) parameter $\breve{R}_T$:

$$\left(\frac{\partial\breve{U}}{\partial\breve{R}_T}\right)_{\breve{S},\breve{V}} = 0, \qquad \left(\frac{\partial\breve{H}_T}{\partial\breve{R}_T}\right)_{\breve{S},\breve{p}} = 0, \qquad \left(\frac{\partial\breve{F}_T}{\partial\breve{R}_T}\right)_{\breve{T},\breve{V}} = 0, \qquad \left(\frac{\partial\breve{G}}{\partial\breve{R}_T}\right)_{\breve{T},\breve{p}} = 0.$$

And, moreover, the change in space of available thermodynamic parameters of matter that gradually cools is inevitably accompanied by the change of its hidden thermodynamic parameters Γ_m and v_l:

$$\left(\frac{\partial U}{\partial\hat{r}}\right)_t = T\left(\frac{\partial S}{\partial\hat{r}}\right)_t - p\left(\frac{\partial V}{\partial\hat{r}}\right)_t = -U_0\left[\left(\frac{\partial\ln\Gamma_m}{\partial\hat{r}}\right)_t + \left(\frac{\partial\ln v_l}{\partial\hat{r}}\right)_t\right],$$

$$\left(\frac{\partial H_T}{\partial\hat{r}}\right)_t = T\left(\frac{\partial S}{\partial\hat{r}}\right)_t + V\left(\frac{\partial p}{\partial\hat{r}}\right)_t = -H_{T0}\left[\left(\frac{\partial\ln\Gamma_m}{\partial\hat{r}}\right)_t + \left(\frac{\partial\ln v_l}{\partial\hat{r}}\right)_t\right],$$

$$\mathbf{F}_{gr} = \left(\frac{\partial G}{\partial\hat{r}}\right)_t = -S\left(\frac{\partial T}{\partial\hat{r}}\right)_t + V\left(\frac{\partial p}{\partial\hat{r}}\right)_t = -G_0\left[\left(\frac{\partial\ln\Gamma_m}{\partial\hat{r}}\right)_t + \left(\frac{\partial\ln v_l}{\partial\hat{r}}\right)_t\right],$$

where: $\partial\hat{r}$ is the increment of metric radial distance.

And the bigger the distance from matter to the gravitational attraction center the smaller is its internal energy. That is why in contrast to inert free energy (which is the greater the greater the distance from the substance to the gravitational attraction center) the thermal energy behaves like a negative mass. And this is confirmed by numerous investigations of the influence of heating of matter on its weight [52 – 54].

Precisely the condition of spatial homogeneity of the compressibility coefficient of RGTD-bonded matter $Z(t) = R_T(t)/R_{UT} = \mathbf{const}(r)$ [62] determines the spatial distribution of the set of main thermodynamic parameters of this matter that gradually cools.

Of course, every matter has its values of gravitational potentials, since the common for the whole RGTD-bonded matter gravitational field forms only its gradients in the space. However, in order to make all thermodynamic parameters of all individual thermodynamic STC of these matters conformed with the parameters *a* and *b* of Schwarzschild solution of common for them gravitational field the appropriate conditions should be fulfilled.

According to received expressions for thermodynamic potentials limit velocity v_l of individual motion of definite substance (the equivalent to pseudo-vacuum velocity of light v_{cv} in GR) is the thermodynamic hidden parameter. At that the founded in GR by Tolman [3] condition for the mechanic equilibrium of cooled down to the limit matter[63]:

$$T_{00} = Tv_{cv}/c \equiv Tv_l/c = \psi_{m0}U_{cr}\widetilde{\beta}_{pV}/R_T = \mathbf{const}(r,t)\,, \qquad (4)$$

could be fulfilled for real gases and liquids only due to the possibility of self-realization by them of optimal values of mathematical expectations of their hidden variable β_{pV}:

$$\widetilde{\beta}_{pV}(T,p) = \widetilde{\beta}_{pVk}(T_k,p_k)R_T(T,p)/R_{Tk}(T_k,p_k)\,.$$

The same way, additional condition $S = \mathbf{const}(r)$ and derived from it conditions:

$$v_l n_m^{\tilde{l}-1} \equiv v_{cv} n_m^{\tilde{l}-1} = v_{cv}(c/v_{cm})^{\tilde{l}-1} = \mathbf{const}(r)\,, \quad v_l N_I^{1-1/\tilde{l}} = v_{cv}(\sigma_m/N_{RE})^{1-1/\tilde{l}} = \mathbf{const}(r)\,,$$

$$TSv_l/c = T_{00}S = \psi_{m0}\widetilde{\beta}_{ST}U_{cr}[\ln\psi_{m0} - \ln(v_l/c) - (\tilde{l}-1)\ln n_m] = \mathbf{const}(r)$$

for cooled down to the limit matter could be fulfilled for correspondent to them values of mathematical expectation of hidden variable β_{ST}:

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[62] This is nothing more than the expression of the tendency to align the magnitudes of extensive parameters of matters in the whole filled with them space. Only such main (field) intensive thermodynamic parameters as temperature and pressure in principle cannot be (or become) absolutely spatially homogenous in quasi-equilibriumly cooling down matter. Some other the fielded intensive thermodynamic parameters, which are related to the possibility of appearance of not only gravitational but also magnetic and electric fields in the RGTD-bonded matter, also cannot become absolutely spatially homogenous.

[63] At the first sight the increasing of thermal, and thus also total, energy of the gas while approaching the gravitational attraction center is paradoxical since its inert free energy, and thus its inertial mass, are, on the contrary, decreasing. However this is the undeniable fact. Even the temperature of the air is increasing with the decreasing of the height above the surface of the Earth. So the matter that fell inertially in gravitational field should (in the process of decelerating of its motion) at first cool down and only then heat up, using the thermal energy of objects of the environment. That will happen since the part of its kinetic energy will be spent for the deformation and destruction of the objects on which it has fallen. It is impossible to achieve the required increasing of total internal energy of fallen matter using only the transition of kinetic energy into thermal energy. It is identical to the compressed freon, which after its expansion cools down the environment. Unfortunately this effect cannot be checked with gases due to the absence of absolutely rigid balloon, which would not compress the gas that is inside of it after hitting the ground. However it will probably be possible to check it on rigid enough solid matter if we would place in its center the shockproof fast-acting temperature sensor with the device that would remotely transmit the results of the temperature measurement.

$$\tilde{\beta}_{ST}(T,p)\tilde{l}(T,p) = \tilde{\beta}_{STk}(T_k,p_k)\tilde{l}_k(T_k,p_k)S/S_k .$$

However, considering all of this normalized value of enthalpy H_T:

$\hat{H}_{T00} = (H_T - U_{ad})v_{cv}/c = U_{cr}\psi_{m0}(1+\tilde{\beta}_{pV}) = H_{00}U_{cr}\psi_{m0}v_{cv}^{-2}/\hat{\mu}_{00}V \neq \mathbf{const}(r)$, since in GR:

$\tilde{\beta}_{pV} = pV/\hat{E} = p/\hat{\mu}_{in0}c^2 = p/\hat{\mu}_{00}v_{cv}c = (H_{00}c/v_c V - \hat{\mu}_{00}v_{cv}c)/\hat{\mu}_{00}v_{cv}c = H_{00}v_{cv}^{-2}/\hat{\mu}_{00}V - 1 \neq \mathbf{const}(r)$.

And this already does not correspond to the equations of GR gravitational field [39, 30], according to which [3]:

$$U \equiv \hat{E} = H_T - pV = H_{00}c/v_{cv} - pV = \hat{\mu}_{00}Vv_{cv}c \neq \hat{\mu}_{00}V_{00}c^3/v_{cv},$$

where: $H_{00} = \mathbf{const}(r)$, $V \neq V_{00}c^2v_{cv}^{-2}$, $V_{00} = \mathbf{const}(r,t)$.

Moreover, spatial inhomogeneity of hidden parameters $\tilde{\beta}_{pV}(R_T)$ and $\tilde{\beta}_{ST}(R_T)$ does not correspond to the concept of self-creation (by matter) of a single collective Gibbs thermodynamic microstate with similar in the whole space hidden variables k, l , m and n.

And, therefore, the only substances that can be in mechanic equilibrium state in GR are cooled down to the limit hypothetic substances – matter of rigid body, ideal gas and ideal liquid that are only substances for which $R_T \equiv R_{UT} = \mathbf{const}(r,t)$ and, thus, $\tilde{\beta}_{pV} = \mathbf{const}(r)$ and $H_{T00} = \mathbf{const}(r)$.

However, such cooled down to the limit hypothetical substances in principle cannot form their spatially inhomogeneous thermodynamic state and, thus, cannot create gravitational field that corresponds to it. The reason for this is the absence of electromagnetic interactions of their molecules. And this, of course, is one of the main internal contradictions of used in equations of GR gravitational field simplified reflection of thermodynamic properties of matter.

Only matter which continuously (quasi-equilibrium) cools and have $W_{00} \equiv G_{00} = G_0\Gamma_m v_{cv}/c = U_{cr}\tilde{\beta}_G\psi_{m0} = \mathbf{const}(r)$ (when $A_\rho = TS/R_T = T^2S/pV = \mathbf{const}(t)$, $R_T = \mathbf{const}(r)$, $\tilde{\beta}_{pV} = \mathbf{const}(r)$ and $\tilde{\beta}_{ST} = \mathbf{const}(r)$) can be the real matter in GR. And it is quite possible in the case of the following dependence of entropy S on Lorentz shrinkage of dimensions of the matter Γ_m, the values of coordinate-like velocity of light $v_{cv} \equiv v_l$ and on the light refractive index n_m and on mathematical expectation of the value of hidden thermodynamic variable $\tilde{l} > 1$ of matter:

$$S(t) = S_k(t_k)\frac{\tilde{\beta}_{ST}[\ln\psi_{m0} - \ln(\Gamma_m v_l/c) - (\tilde{l}-1)\ln n_m]}{\tilde{\beta}_{STk}[\ln\psi_{m0} - \ln(\Gamma_{mk}v_{lk}/c) - (\tilde{l}_k-1)\ln n_{mk}]} = S_k(t_k)\frac{\tilde{\beta}_{ST}[\tilde{l}\ln(c\psi_{m0}) - \tilde{l}\ln v_{lc} - (\tilde{l}-1)\ln N_l]}{\tilde{\beta}_{STk}[\tilde{l}_k\ln(c\psi_{m0}) - \tilde{l}_k\ln v_{lck} - (\tilde{l}_k-1)\ln N_{lk}]},$$

where: $v_{lc}n_m^{\tilde{l}-1} \equiv \Gamma_m v_{cv}n_m^{\tilde{l}-1} = \Gamma_m v_{cv}(c/v_{cm})^{\tilde{l}-1} = \mathbf{const}(r)$, $v_{lc}N_l^{1-1/\tilde{l}} = \Gamma_m v_{cv}(\sigma_m/N_{RE})^{1-1/\tilde{l}} = \mathbf{const}(r)$,

$S_k(t_k)$, $\tilde{\beta}_{STk}$, $\tilde{l}_k$, N_{lk}, Γ_{mk}, v_{lk}, n_{mk} are values of parameters of matter in a moment of time t_k. However, it is possible only if use unstable entropy in equations of gravitational field of GR (as it is in RGTD). In this case not only the entropy but also the parameter (which characterizes the same compressibility coefficient $Z(t)$ of a homogeneous matter in the whole space) is spatially homogeneous.

The conditions of mechanic equilibrium are in the dependencies of thermodynamic potentials on thermodynamic parameters of matter that gradually cools. For the energy of extended system [5] (which is not only the enthalpy but also the Gibbs free energy), we will have:

$$\left(\frac{\partial G}{\partial \hat{r}}\right)_t = \frac{G_0}{T}\left(\frac{\partial T}{\partial \hat{r}}\right)_t = V\left(\frac{\partial p}{\partial \hat{r}}\right)_t - S\left(\frac{\partial T}{\partial \hat{r}}\right)_t = \frac{G_0 V}{H_{T0}}\left(\frac{\partial p}{\partial \hat{r}}\right)_t = -G_0\left(\frac{\partial \ln v_{lc}}{\partial \hat{r}}\right)_t \equiv -W_0\left[\left(\frac{\partial \ln v_l}{\partial \hat{r}}\right)_t + \left(\frac{\partial \ln \Gamma_m}{\partial \hat{r}}\right)_t\right],$$

where: $W_0 \equiv H_{T0} = U + pV - U_{ad} = Ec^2 v_{lc}^{-2} = m_{gr0}c^2/\Gamma_m = m_{00}c^3/\Gamma_m v_l$ is the ordinary rest energy of matter, identical to multiplicative component $G_0 = \tilde{\beta}_G(\hat{T})U_{cr} = \tilde{\beta}_G U_{cr}\psi_{m0}c/v_{lc} = G_{00}c/\Gamma_m v_l$ of Gibbs free energy $G = \tilde{\beta}_G U_{cr}\psi_{m0}c/v_{lc} + U_{ad}$ $(\tilde{\beta}_G U_{cr}\psi_{m0}c = \mathbf{const}(r))$; U_{ad}=**const**(r) is the mathematical expectation of partial additive compensation of multiplicative representation of thermodynamic potentials of matter; $\mu_{gr0}=m_{gr0}/V=m_{00}c^3/v_l V$ is gravitational mass density of cooled matter; $\mu_{gr0}c^2/\Gamma_m = \mathrm{L}_m/V$ is the density of Lagrangian of rest energy of matter that gradually cools;

$$V\left(\frac{\partial p}{\partial \hat{r}}\right)_t = \frac{H_{T0}}{T}\left(\frac{\partial T}{\partial \hat{r}}\right)_t \ (S = \mathbf{const}(r)),\ S\left(\frac{\partial T}{\partial \hat{r}}\right)_t = \frac{TSV}{H_{T0}}\left(\frac{\partial p}{\partial \hat{r}}\right)_t = \frac{\tilde{\beta}_{TS}V}{\tilde{\beta}_H}\left(\frac{\partial p}{\partial \hat{r}}\right)_t,$$

$$\left(\frac{\partial G}{\partial \hat{r}}\right)_t = \frac{\tilde{\beta}_G}{\dddot{\beta}_H}\left(\frac{\partial p}{\partial \hat{r}}\right)_t = \frac{[1+\tilde{\beta}_{pV}(1-S/R_T)]V}{1+\tilde{\beta}_{pV}}\left(\frac{\partial p}{\partial \hat{r}}\right)_t.$$

The absence of parameter Γ_m in (used in GR) condition of mechanical equilibrium (2) is related to its usage only for static states of matter. Moreover in GR there is a usage of the inert free energy[64] $\hat{E} = m_{00}cv_l\Gamma_m$ instead of the internal energy $U = U_0 + U_{ad} = Ec^2 v_l^{-2}\Gamma_m^{-2} + U_{ad} = U_{00}c/v_{lc} + U_{ad}$ in the expression for the enthalpy of matter and there is an ignoring of Lorentz-invariance of thermodynamic parameters and potentials [4, 5]. The equivalence of eigenvalue of mass $m_{00}\equiv{}^i m_{gr0i} = G_{0i}v_{li}c^{-3}={}^i G_{0i}c^{-2}$ of matter to the eigenvalue of its thermodynamic Gibbs free energy $G_{00}\equiv{}^i G_{0i}$, which is determined by proper gravity-quantum clock of matter in the point i of its disposition, is ignored in GR. And, thus, the invariance of all thermodynamic potentials and parameters, which are the eigenvalues of corresponding properties of matter, to gravity-temporal transformations is also ignored.

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[64] If total internal energy of matter would not be increasing during approaching the gravitational attraction center, but quite the contrary would be decreasing (as it takes place in GR that identify it with inert free energy of matter), then the hot magma would not be present in bowels of our planet due to the high pressure. Even gases at first liquefy with the increasing of pressure and only then solidify. That is why the usage of enthalpy in GR, which is formed not based on

So, in the state of strict mechanical equilibrium (Γ_m=1) the forces of gravity are proportional not to the inert free energy $E = W_0 v_l^2 c^{-2}$, but to multiplicative component of the Gibbs free energy $G_0 \equiv W_0 = Ec^2 v_l^{-2} = m_{00}c^3 / v_{lc}$ of matter that has not yet cooled. And this, of course, follows from the solutions of equations of gravitational field of GR for matter that has cooled down to the limit and, therefore, is in a state of mechanical equilibrium. As it was shown by Tolman [3] and as it follows from the Schwarzschild internal solution for incompressible ideal liquid [38], gravitational forces in this matter are proportional to enthalpy that does not decrease, unlike the inertial free energy E, but on the contrary, increases like the Gibbs free energy with approach to the gravitational attraction center. Ignoring of all this leads to imaginary necessity of dark non-baryonic matter in the Universe.

Obviously, the spatial homogeneity of the product of inert free energy and multiplicative component of the Gibbs free energy of matter $E_0 G_0 = \mathbf{const}(r)$ (that takes place not only for cooled down to the limit matter in GR, but also for matter that gradually cools) also corresponds to the spatial homogeneity of the compressibility coefficient $Z(t) = R_T(t) / R_{UT} = \mathbf{const}(r)$ of a homogeneous matter. In this case the inert free energy of one mole of matter that moves in the process of its cooling down is identical to the Hamiltonian $E_m = E_0 \Gamma_m = m_{00} c v_l \Gamma_m \equiv \mathrm{H}_{inm}$ inert free energy at rest E_0 of matter. While the multiplicative component of Gibbs free energy of matter that is defined by the eigenvalue of its molar mass m_{00}=$\mathbf{const}(r)$ is de facto identical to the Lagrangian $G_0 \equiv W_0 = W_{00} / \Gamma_m v_l = m_{00} c^3 / \Gamma_m v_l \equiv \mathrm{L}_{grm}$ of ordinary rest energy W_{00} of matter that gradually cools.

The downfallen matter potentially can accumulate the correspondent to W_0 the Gibbs free energy $G_0 = W_0 + U_{ad} < W_0 \Gamma + U_{ad}$ after the equilibrium state of rest is reached but only due to the heat exchange with the environment. And exactly due to the invariance of limit velocity of matter individual (separate) motion in comoving with it FR $v_{lc} = v_l \Gamma = \mathbf{invar}$ relatively to the transformation of spatial coordinates and time, not only the Hamiltonian of inert free energy at rest E_0 and Lagrangian of ordinary rest energy W_0, but also the multiplicative component G_0 of Gibbs free energy of matter (and, thus, all other thermodynamic potentials and thermodynamic parameters of any matter) are conformally-gravitationally Lorentz-invariant.

And since integration by parameter R_T takes place in the space, because of R_T=R_{T0}=$\mathbf{const}(r)$ the spatial additive compensation U_{ad} for matter that gradually cools is not only invariable but is

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the internal energy of matter that is increasing while approaching the gravitational attraction center, but based on its decreasing inert free energy, is the nonsense.

also can be very insignificant. And this, obviously, takes place not only far from the sources of radiation in molecular clouds of cold non-ionized gas, but also in highly rarefied cold plasma of the outer space even despite its mainly non-equilibrium thermodynamic state. In contrast to the condition of quasi-equilibrium of cooling down A_ρ=**const**(t), the condition of spatial homogeneity of the compressibility coefficient $Z(t) = R_T(t)/R_{UT} = \mathbf{const}(r)$ for this homogeneous plasma can also be fulfilled. And, consequently, not only in matter that gradually cools, but also in the outer space the U_{ad} can be negligibly small ($\varsigma_a \approx 1$). However, even if spatial additive compensation U_{ad} would take any arbitrary small value the Gibbs free energy of matter fundamentally cannot be smaller than its component – the inert free energy *E*, since: $G = G_0 + U_{ad} > G_0 = Ec^2 v_l^{-2}$.

Due to the smallness of U_{ad} not only the logarithm[65] of ordinary rest energy, but also logarithms thermodynamic internal energy and Gibbs free energy can be used as gravitational potential:

$$\mathbf{grad}\varphi = c^2 \mathbf{grad} \ln W_0 = c^2 \mathbf{grad} \ln U ,$$

$$\mathbf{grad}\varphi = c^2 \mathbf{grad} \ln G_0 = c^2 \mathbf{grad} \ln G = -\varsigma c^2 \mathbf{grad} \ln(v_{lc}/c) = -\varsigma c^2 \mathbf{grad}[\ln(v_l/c) + \ln\Gamma_m],$$

where: $\varsigma = 1/[1 + U_{ad}/U_{cr}\psi_{m0}c\widetilde{\beta}_G]$ is the coefficient of resistance of matter of the environment to the fall of bodies in gravitational field. And, so, self-creation by matter of the own spatially inhomogeneous thermodynamic state is responsible for the appearance of gravitational field in it.

Since parameter:

$$R_T = \frac{TS}{A_\rho} = \frac{U_{cr}\widetilde{\beta}_{ST} q_M N_I \ln(q_M^{\widetilde{l}} N_I)}{A_\rho} = \frac{U_{cr}\widetilde{\beta}_{ST} c\psi_{m0}[\ln\psi_{m0} - \ln\Gamma_m - \ln(v_l/c) - (1-\widetilde{l})\ln(v_{cm}/c)]}{A_\rho \Gamma_m v_l} \neq R_{T0}$$

expressed not only via constants (including also A_ρ=**const**(t) which characterizes the quasi-equilibrium of the process of cooling down of matter throughout the whole time), but also via velocity of the light in matter v_{cm}, limit velocity v_l of individual motion and Lorentz shrinkage of dimensions of the matter that moves in the process of quasi-equilibriumly cooling down $\Gamma_m \neq \mathbf{const}(r)$ ($\psi_m = \psi_{m0}/\Gamma_m \neq \mathbf{const}(r)$), then only via them we can in temporal form (via A_ρ) or

[65] Only such logarithmic gravitational potentials can correspond to the Einstein concept of inertia of free fall of bodies in gravitational field. Exactly when gravitational potential is equal to the logarithm of coordinate velocity of light in hypothetical absolute vacuum the Hamiltonian of body that falls free in this vacuum is conserved in GR (ς_v=1) [65]. Moreover, due to mutual dependence of gravitational potential (that is the logarithmic function of the limit velocity of substance individual (separate) motion) and thermodynamic parameters of matter there can be a misconception about the possibility to locally change the strength of gravitational field via the change of matter thermodynamic state. However it is not true, since the spatial distribution of the strength of gravitational field is the product of collective spatially inhomogeneous state of the whole gravithermodynamically bonded matter. Therefore, any matter that is located in this gravitational field should obey the collective influence. Namely the logarithmicity of gravitational potential allows to gaugely change it without changing the strength of gravitational field.

in spatial form (via $a_\rho \equiv R_T$) express instantaneous values of all main thermodynamic parameters and potentials of RGTD-bonded matter:

$$\breve{T} = \frac{\breve{A}_\rho \beta_{pV}}{\beta_{ST}(\daleth \ln q_M + \ln N_I)} = \frac{\breve{A}_\rho \beta_{pV}}{\beta_{ST}[\ln\psi_{m0} - \ln\Gamma_m - \ln(v_l/c) + (\daleth - 1)\ln(v_{cm}/c)]} =$$

$$= \frac{U_{cr}\beta_{pV} q_M N_I}{\breve{R}_T} = \frac{U_{cr}\beta_{pV} c\psi_{m0}}{\breve{R}_T \Gamma_m v_l} = \frac{\breve{p}\breve{V}}{\breve{R}_T} = \frac{U_{cr}\beta_{pV}}{\breve{R}_T}\left[\frac{U_{cr}}{p_l \breve{V}}\exp\left(\frac{\breve{S}}{\breve{R}_T}\right)\right]^{\beta_{pV}} =$$

$$= \beta_{pV}\breve{A}_\rho\left[\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right) + (1+\beta_{pV})\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]^{-1} = \frac{U_{cr}\beta_{pV}}{\breve{R}_T}\left[\frac{\breve{p}}{p_l\beta_{pV}}\exp\left(\frac{\breve{S}}{\breve{R}_T}\right)\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}},$$

$$\breve{S} = \frac{U_{cr}\beta_{ST}^2 q_M N_I(\daleth \ln q_M + \ln N_I)^2}{\beta_{pV}\breve{A}_\rho} = \frac{\beta_{ST}\breve{R}_T(\daleth \ln q_M + \ln N_I)}{\beta_{pV}} =$$

$$= \frac{U_{cr} c\psi_{m0}\beta_{ST}^2[\ln\psi_{m0} - \ln(v_{lc}/c) + (\daleth - 1)\ln(v_{cm}/c)]^2}{\beta_{pV}\breve{A}_\rho v_{lc}} =$$

$$= (\beta_{ST}\breve{R}_T/\beta_{pV})[\ln\psi_{m0} - \ln\Gamma_m - \ln(v_l/c) + (\daleth - 1)\ln(v_{cm}/c)] =$$

$$= \frac{U_{cr}\beta_{pV}\breve{A}_\rho}{\breve{T}^2}\left[\frac{\breve{p}}{p_l\beta_{pV}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{\beta_{pV}}{\beta_H}} = \frac{U_{cr}\beta_{pV}\breve{A}_\rho}{\breve{T}^2}\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}} =$$

$$= (\beta_{pV}^{-2}\breve{p}\breve{V}/\breve{A}_\rho)[\ln(\breve{p}/p_l\beta_{pV}) + \beta_H\ln(\breve{V}p_l/U_{cr})]^2,$$

$$\breve{p} = p_l\beta_{pV} q_M^{1+1/\mathrm{k}} N_I^{1+\mathrm{m}} = p_l\beta_{pV}\left(\frac{c\psi_{m0}}{\Gamma_m v_l}\right)^{1+\mathrm{m}}\left(\frac{c}{v_{cm}}\right)^{\mathrm{m}-1/\mathrm{k}} = \frac{\breve{R}_T\breve{T}}{\breve{V}} =$$

$$= p_l\beta_{pV}\left(\frac{U_{cr}}{p_l\breve{V}}\right)^{1+\beta_{pV}}\exp\left(\frac{\beta_{pV}\breve{A}_\rho}{\breve{T}}\right) = p_l\beta_{pV}\left(\frac{\breve{R}_T\breve{T}}{U_{cr}\beta_{pV}}\right)^{1+1/\beta_{pV}}\exp\left(-\frac{\breve{S}}{\breve{R}_T}\right) =$$

$$= p_l\beta_{pV}\left(\frac{\breve{S}\breve{T}^2}{U_{cr}\beta_{pV}\breve{A}_\rho}\right)^{1+\frac{1}{\beta_{pV}}}\exp\left(-\frac{\breve{A}_\rho}{\breve{T}}\right) = p_l\beta_{pV}\left(\frac{U_{cr}}{p_l\breve{V}}\right)^{1+\beta_{pV}}\exp\left(\frac{\beta_{pV}\breve{S}}{\breve{R}_T}\right),$$

$$\breve{V} = \frac{U_{cr}}{p_l q_M^{1/\mathrm{k}} N_I^{\mathrm{m}}} = \frac{U_{cr}}{p_l}\left(\frac{\Gamma_m v_l}{c\psi_{m0}}\right)^{\mathrm{m}}\left(\frac{v_{cm}}{c}\right)^{\mathrm{m}-\frac{1}{\mathrm{k}}} = \frac{\breve{R}_T\breve{T}}{\breve{p}} =$$

$$= \frac{U_{cr}}{p_l}\left[\left(\frac{p_l\beta_{pV}}{\breve{p}}\right)\exp\left(\frac{\beta_{pV}\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{1}{1+\beta_{pV}}} = \frac{U_{cr}}{p_l}\left(\frac{U_{cr}\beta_{pV}}{\breve{R}_T\breve{T}}\right)^{\frac{1}{\beta_{pV}}}\exp\left(\frac{\breve{S}}{\breve{R}_T}\right) =$$

$$= \frac{U_{cr}}{p_l}\left(\frac{U_{cr}\beta_{pV}\breve{A}_\rho}{\breve{S}\breve{T}^2}\right)^{\frac{1}{\beta_{pV}}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right) = \frac{U_{cr}}{p_l}\left[\left(\frac{p_l\beta_{pV}}{\breve{p}}\right)\exp\left(\frac{\beta_{pV}\breve{S}}{\breve{R}_T}\right)\right]^{\frac{1}{1+\beta_{pV}}},$$

$$\breve{U}=\breve{U}_0+\breve{U}_{ad}=U_{cr}q_M N_I+\int_{\breve{R}_{T0}}^{\breve{R}_T}\breve{S}\breve{T}\frac{d\breve{R}_T}{\breve{R}_T}=\breve{U}_0+\breve{A}_\rho\breve{R}_T-U^*_{ad}=\breve{U}_0+\breve{S}\breve{T}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=U_{cr}[1+\beta_{ST}\ln(q^1_M N_I)]q_M N_I-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\frac{U_{cr}\psi_{m0}c}{\Gamma_m v_l}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\breve{S}\breve{T}\frac{d\breve{R}_T}{\breve{R}_T}=\breve{S}\breve{T}\left(1+\frac{\breve{T}}{\beta_{pV}\breve{A}_\rho}\right)-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=U_{cr}\left(1+\frac{\beta_{pV}\breve{A}_\rho}{\breve{T}}\right)\left[\frac{\breve{p}}{p_l\beta_{pv}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=$$

$$=U_{cr}\left(1+\frac{\beta_{pV}\breve{A}_\rho}{\breve{T}}\right)\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T a\breve{A}_\rho=\frac{\breve{p}\breve{V}}{\beta_{pV}}\left[1+\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right)+(1+\beta_{pV})\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho,$$

$$\breve{F}_T=\breve{U}_0-\breve{U}^*_{ad}=U_{cr}q_M N_I-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\frac{U_{cr}c\psi_{m0}}{v_{lc}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\breve{U}_0-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=\frac{\breve{p}\breve{V}}{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\breve{p}\breve{V}}{\beta_{pV}}\left[\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right)+(1+\beta_{pV})\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]\frac{d\breve{A}_\rho}{\breve{A}_\rho}=\frac{\breve{S}\breve{T}^2}{\beta_{pV}\breve{A}_\rho}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=U_{cr}\left\{\left[\frac{\breve{p}}{p_l\beta_{pv}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\beta_{pV}}{\breve{T}}\left[\frac{\breve{p}}{p_l\beta_{pV}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}d\breve{A}_\rho\right\}=$$

$$=U_{cr}\left\{\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\beta_{pV}}{\breve{T}}\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}d\breve{A}_\rho\right\},$$

$$\breve{H}_T=\breve{H}_{T0}+\breve{a}_\rho\breve{A}_\rho-\breve{U}^*_{ad}=\breve{H}_{T0}+\breve{S}\breve{T}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=U_{cr}(1+\beta_{pV})q_M N_I+\int_{\breve{R}_{T0}}^{\breve{R}_T}\breve{A}_\rho d\breve{R}_T=$$

$$=\breve{H}_{T0}+\breve{U}_{ad}=U_{cr}[(1+\beta_{pV})+\beta_{ST}\ln(q^1_M N_I)]q_M N_I-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=$$

$$=\frac{U_{cr}(1+\beta_{pV})\psi_{m0}c}{\Gamma_m v_l}+\int_{\breve{R}_{T0}}^{\breve{R}_T}\breve{S}\breve{T}\frac{d\breve{R}_T}{\breve{R}_T}=\breve{S}\breve{T}\left(1+\frac{(1+\beta_{pV})\breve{T}}{\beta_{pV}\breve{A}_\rho}\right)-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=U_{cr}\left\{\left(1+\beta_{pV}+\frac{\beta_{pV}\breve{A}_\rho}{\breve{T}}\right)\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\beta_{pV}}{\breve{T}}\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}d\breve{A}_\rho\right\}=$$

$$=U_{cr}\left(1+\beta_{pV}+\frac{\beta_{pV}\breve{A}_\rho}{\breve{T}}\right)\left[\frac{\breve{p}}{p_l\beta_{pV}}\exp\frac{\breve{A}_\rho}{\breve{T}}\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}-U_{cr}\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\beta_{pV}}{\breve{T}}\left[\frac{\breve{p}}{p_l\beta_{pV}}\exp\frac{\breve{A}_\rho}{\breve{T}}\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}d\breve{A}_\rho=$$

$$=\frac{\breve{p}\breve{V}(1+\beta_{pV})}{\beta_{pV}}\left[1+\frac{1}{1+\beta_{pV}}\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right)+\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]-\frac{1}{\beta_{pV}}\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{p}\breve{V}\left[\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right)+(1+\beta_{pV})\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]\frac{d\breve{A}_\rho}{\breve{A}_\rho},$$

$$\breve{G}=\breve{H}_{T0}-\breve{U}^*_{ad}=\frac{U_{cr}(1+\beta_{pV})\psi_{m0}c}{v_{lc}}-\breve{U}^*_{ad}=\frac{(1+\beta_{pV})\breve{R}_T\breve{T}}{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\frac{(1+\beta_{pV})\breve{S}\breve{T}^2}{\beta_{pV}\breve{A}_\rho}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{S}\breve{T}\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=\frac{(1+\beta_{pV})\breve{p}\breve{V}}{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\breve{p}\breve{V}}{\beta_{pV}}\left[\ln\left(\frac{\breve{p}}{p_l\beta_{pV}}\right)+(1+\beta_{pV})\ln\left(\frac{p_l\breve{V}}{U_{cr}}\right)\right]\frac{d\breve{A}_\rho}{\breve{A}_\rho}=$$

$$=U_{cr}\left\{(1+\beta_{pV})\left[\frac{\breve{p}}{p_l\beta_{pv}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\beta_{pV}}{\breve{T}}\left[\frac{\breve{p}}{p_l\beta_{pV}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\frac{\beta_{pV}}{1+\beta_{pV}}}d\breve{A}_\rho\right\}=$$

$$=U_{cr}\left\{(1+\beta_{pV})\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}-\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\frac{\beta_{pV}}{\breve{T}}\left[\frac{U_{cr}}{p_l\breve{V}}\exp\left(\frac{\breve{A}_\rho}{\breve{T}}\right)\right]^{\beta_{pV}}d\breve{A}_\rho\right\},$$

where: $\left(\frac{\partial\breve{U}}{\partial\breve{A}_\rho}\right)_{\breve{S},\breve{V}}=0$, $\left(\frac{\partial\breve{H}_T}{\partial\breve{A}_\rho}\right)_{\breve{S},\breve{p}}=0$, $\left(\frac{\partial\breve{F}_T}{\partial\breve{A}_\rho}\right)_{\breve{T},\breve{V}}=0$, $\left(\frac{\partial\breve{G}}{\partial\breve{A}_\rho}\right)_{\breve{T},\breve{p}}=0$;

$v_{lc}=\Gamma_m v_l$ is the limit velocity of individual motion of matter that gradually cools in comoving with it FR (in its own space-time continuum (STC), in which the radial motion of molecules of matter that gradually cools is absent); $\breve{U}^*_{ad}=\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}\breve{R}_T d\breve{A}_\rho=\int_{\breve{A}_{\rho 0}}^{\breve{A}_\rho}(\breve{S}\breve{T}/\breve{A}_\rho)d\breve{A}_\rho\geq 0$ is instantaneous value of partial additive compensation of multiplicative representation of thermodynamic potentials of matter microstate (multiplicative increase of bound energy as we approach the gravitational attraction center); $\breve{G}$ is the instantaneous value of Gibbs energy G (that is similar to the Lagrangian, since it constantly tends to its minimum too).

As we can see, due to $A_\rho(r)=\mathbf{const}(t)$ when homogeneous matter is quasi-equilibrium cooling down the gravitational changes in time of its Gibbs free energy and Helmholtz free energy take place similarly to the changes in space of multiplicative component of internal energy U_0 and enthalpy H_{T0} correspondingly[66]. Precisely, if:

$$\left(\frac{\partial U}{\partial \hat{t}}\right)_r=-(U_0+U^*_{ad})\left\{1+\frac{\widetilde{\beta}_{ST}}{1+\widetilde{\beta}_{ST}\left[\ln(c\psi_{m0}/v_{lc})+(\widetilde{l}-1)\ln n_m\right]}\right\}\left[\left(\frac{\partial\ln v_l}{\partial\hat{t}}\right)_r+\left(\frac{\partial\ln\Gamma_m}{\partial\hat{t}}\right)_r\right]+$$

[66] The authors of GR, obviously, intuitively understood this fact. That is why GR is the genial creation, despite the fact that it ignores the principal invariance of thermodynamic parameters and potentials relatively to space-time transformations.

$$+\frac{(U_0+U_{ad}^*)\widetilde{\beta}_{ST}(\vec{l}-1)}{1+\widetilde{\beta}_{ST}[\ln(c\psi_{m0}/\Gamma_m v_l)+(\widetilde{l}-1)\ln n_m]}\left(\frac{\partial \ln n_m}{\partial \widehat{t}}\right)_r \text{, then:}$$

$$\left(\frac{\partial F_T}{\partial \widehat{t}}\right)_r=-S\left(\frac{\partial T}{\partial \widehat{t}}\right)_r-p\left(\frac{\partial V}{\partial \widehat{t}}\right)_r=-U_0\left(\frac{\partial \ln v_{lc}}{\partial \widehat{t}}\right)_r=-U_0\left[\left(\frac{\partial \ln \Gamma_m}{\partial \widehat{t}}\right)_r+\left(\frac{\partial \ln v_l}{\partial \widehat{t}}\right)_r\right],$$

$$\left(\frac{\partial G}{\partial \widehat{t}}\right)_r=-S\left(\frac{\partial T}{\partial \widehat{t}}\right)_r+V\left(\frac{\partial p}{\partial \widehat{t}}\right)_r=-H_{T0}\left(\frac{\partial \ln v_{lc}}{\partial \widehat{t}}\right)_r=-H_{T0}\left[\left(\frac{\partial \ln \Gamma_m}{\partial \widehat{t}}\right)_r+\left(\frac{\partial \ln v_l}{\partial \widehat{t}}\right)_r\right],$$

where: $\partial\widehat{t}$ is the increment of metric time of matter that gradually cools in a comoving with it FR.

Moreover, the multiplicative component of only the Gibbs free energy is proportional to the absolute temperature of matter not only in space but also in time. It is smaller the lower the temperature and, consequently, the higher the limit velocity v_{lc} of individual motion of matter (and the corresponding coordinate pseudovacuum velocity of light v_{cv} of GR).

The equations of thermodynamic state of gas for a predominantly hydrogen Universe would be as follows:

$$^{U}U=U_0+A_\rho R_T, \qquad ^{U}F=U_0, \qquad ^{U}H_T=H_{T0}+A_\rho R_T, \qquad A_\rho=T^2S/pV=\mathbf{const}(t),$$

$$^{U}G{=}^{U}H_{T0}=\frac{\widetilde{\beta}_H R_T T}{\widetilde{\beta}_{pV}}=\frac{\widetilde{\beta}_H pV}{\widetilde{\beta}_{pV}}=\frac{\widetilde{\beta}_H ST^2}{\widetilde{\beta}_{pV}A_\rho}=U_{cr}\widetilde{\beta}_H\left(\frac{p}{\widetilde{\beta}_{pV}p_l}\right)^{\frac{\widetilde{\beta}_{pV}}{\widetilde{\beta}_H}}\exp\left(\frac{\widetilde{\beta}_{pV}S}{\widetilde{\beta}_H R_T}\right),$$

$$d^{U}U=TdS-pdV+A_\rho dR_T, \quad d^{U}F=TdS-pdV, \quad d^{U}H_T=TdS+Vdp+A_\rho dR_T, \quad d^{U}G=TdS+Vdp.$$

In the process of free fall of matter in gravitational field the Helmholtz and Gibbs thermodynamic free energies, as well as the Hamiltonian of inert free energy of matter, are conserved not only due to the presence of weightlessness in its FR ($v_{lc}=v_l\Gamma_m=\mathbf{const}(t)$), but also due to the total compensation of the influence of gravitation on its thermodynamic state by the motion. However it is possible only in hypothetical absolutely empty space. But when there is a resistance to motion these energies will be gradually increasing due to the matter cannot reach the required for their conservation value Γ_m and thus also due to accommodation of the matter of falling body to the new thermodynamic state of matter of the environment.

Before the appearance of spatial inhomogeneity of limit velocity of matter v_l the only thing that could interfere its distancing from the future gravitational attraction center (due to tending of its Gibbs thermodynamic energy to its minimum) was the electromagnetic interaction of its molecules. That is why the hypothetic ideal gas and ideal liquid in principle cannot create their gravitational field.

As we see, here we have a dependency of spatial distribution of intrinsic values of these thermodynamic parameters and potentials (not the dependency of spatial distribution of other their values observed by other clocks and by other length standards) on v_{lc} (and, so, also on Γ_m and v_l). It would be non-logical if Γ_m and v_l would not influence on spatial distribution of the set of intrinsic values of main thermodynamic parameters of matter. So this does not contradict to invariance of thermodynamic parameters and potentials of matter relatively to the space-time transformations [29]. On the contrary, it only confirms the fact that limit velocity v_l of matter individual (separate) motion, as well as Γ_m, is the internal hidden RGTD-parameter of matter and not the non-dependent on certain RGTD-state of matter external gravitational parameter.

15. Physical and other thermodynamic characteristics of matter

At Tolman condition (4) and when β_{pV}=**const**(r) the parameter R_T should be invariable not only in space, but also in time. And this can correspond to the substance that abnormally cooling down ($S\neq$**const**(r)) and due to $TS=R_TA_\rho$=**const**(r) has exactly the following thermodynamic parameters: $T=T_{00}c/v_{lc}$, $S=S_{00}v_{lc}/c$ [67],

$$p=p_{cr}\left(\frac{v_{lc}}{v_{lc/cr}}\right)^{-\frac{\tilde{\beta}_H}{\tilde{\beta}_{pV}}}\exp\left[\frac{\tilde{\beta}_H(R_TA_\rho-U^*_{ad})(v_{lc/cr}-v_{lc})}{\tilde{\beta}_{pV}H^*_{T00}}\right],$$

$$V=\frac{c\tilde{\beta}_{pV}H^*_{T00}}{v_{lc/cr}\tilde{\beta}_H p_{cr}}\left(\frac{v_{lc}}{v_{lc/cr}}\right)^{\frac{1}{\tilde{\beta}_{pV}}}\exp\left[\frac{\tilde{\beta}_H(R_TA_\rho-U^*_{ad})(v_{lc}-v_{lc/cr})}{\tilde{\beta}_{pV}H^*_{T00}}\right],$$

where: T_{00}=**const**(r), S_{00}=**const**(r), $H^*_{T00}=H_{T0}v_{lc}/c$=**const**(r), $pV=c\tilde{\beta}_{pV}H^*_{T00}/v_{lc}\tilde{\beta}_H$; p_{cr} and $v_{lc/cr}$ are the critical values of parameters on the phase boundary of the substance or between substances.

The refractive index of such matter:

$$n_m=\left[\frac{c\psi_{m0}}{v_{lc}}\exp\left(-\frac{v_{lc}R_TA_\rho}{c\psi_{m0}U_{cr}\tilde{\beta}_{ST}}\right)\right]^{1/(\tilde{l}-1)}$$

depends not only on values of its characteristic parameters ψ_{m0} and U_{cr} and on the limit velocity v_{lc} of its individual motion, but also on the parameters $\tilde{l}$, $\tilde{\beta}_{ST}$ and R_T, that change in time together with the cooling down of matter.

Obviously, the stability of magnitude of extensive parameter $A_\rho=T^2S/pV$ takes place in the process of quasi-equilibrium cooling down of matter. If we experimentally find its averaged value for researched matter at the beginning of the research or if we measure the increments of thermodynamic parameters:

$$\left(\frac{\partial \ln S}{\partial \hat{t}}\right)_r=\left(\frac{\partial \ln p}{\partial \hat{t}}\right)_r+\left(\frac{\partial \ln V}{\partial \hat{t}}\right)_r-2\left(\frac{\partial \ln T}{\partial \hat{t}}\right)_r,$$

[67] Such spatial distribution of entropy does not correspond to the condition (5) and, therefore, is abnormal. Possibly it can be peculiar for astronomical formations that have extraordinary topology.

we can determine its entropy:

$$S=\frac{U_{cr}\widetilde{\beta}_{pV}A_\rho}{T^2}\left[\frac{p}{p_l\widetilde{\beta}_{pv}}\exp\left(\frac{A_\rho}{T}\right)\right]^{\frac{\widetilde{\beta}_{pV}}{\widetilde{\beta}_H}}=\frac{U_{cr}\widetilde{\beta}_{pV}A_\rho}{T^2}\left[\frac{U_{cr}}{p_lV}\exp\left(\frac{A_\rho}{T}\right)\right]^{\widetilde{\beta}_{pV}}=\frac{pV}{\widetilde{\beta}_{pV}^2A_\rho}\left[\ln\left(\frac{p}{\widetilde{\beta}_{pV}p_l}\right)+\widetilde{\beta}_H\ln\left(\frac{p_lV}{U_{cr}}\right)\right]^2=$$

$$=\frac{A_\rho R_T}{T}=R_T\left[\frac{1}{\widetilde{\beta}_{pV}}\ln\left(\frac{R_TT}{\widetilde{\beta}_{pV}U_{cr}}\right)+\ln\left(\frac{p_{cr}V}{U_{cr}}\right)\right]=R_T\left[\widetilde{\varepsilon}+\frac{1}{\widetilde{\beta}_{pV}}(\ln R_T+\ln T)+\ln V\right]=$$

$$=R_T\left[\left(1+\frac{1}{\widetilde{\beta}_{pV}}\right)\ln\left(\frac{R_TT}{\widetilde{\beta}_{pV}U_{cr}}\right)-\ln\left(\frac{p}{\widetilde{\beta}_{pV}\widetilde{p}_l}\right)\right]=R_T\left[\widetilde{\varepsilon}+\left(1+\frac{1}{\widetilde{\beta}_{pV}}\right)(\ln R_T+\ln T)-\ln p\right]=$$

$$=R_T\left[\left(1+\frac{1}{\widetilde{\beta}_{pV}}\right)\ln\left(\frac{\widetilde{p}_lV}{U_{cr}}\right)+\frac{1}{\widetilde{\beta}_{pV}}\ln\left(\frac{p}{\widetilde{\beta}_{pV}\widetilde{p}_l}\right)\right]=R_T\left[\widetilde{\varepsilon}+\left(1+\frac{1}{\widetilde{\beta}_{pV}}\right)\ln V+\frac{\ln p}{\widetilde{\beta}_{pV}}\right],$$

where: $\widetilde{\varepsilon}=\ln\widetilde{p}_l-(1+1/\widetilde{\beta}_{pV})\ln(m_{00}c^3/v_{lcr})-(\ln\widetilde{\beta}_{pV})/\widetilde{\beta}_{pV}=\mathbf{const}(\Delta t)$ and $\widetilde{\beta}_{pV}=\mathbf{const}(\Delta t)$ are mathematical expectations of the values of functions of arbitrary changing hidden variables k, l , m, n, which are the strictly constant magnitudes during the whole not very long time of the existence of any Gibbs thermodynamic microstate.

However, if we know $\widetilde{\varepsilon}$ and $\widetilde{\beta}_{pV}$ and if we determine only the molar volume of gas that gradually cools and the pressure in it, then we can determine only its bond energy:

$$W_{bnd}=ST=Vp\left[\widetilde{\varepsilon}+\left(1+\frac{1}{\widetilde{\beta}_{pV}}\right)\ln V+\frac{\ln p}{\widetilde{\beta}_{pV}}\right]. \tag{6}$$

In order to determine the entropy and, thus, the value of parameter A_ρ we should additionally measure the temperature of the gas. It is obvious that parameters $\widetilde{\varepsilon}$ and $\widetilde{\beta}_{pV}$ of the equation of the state of gas (6) can be determined also experimentally in the process of controlled change of its bond energy as well as of all its thermodynamic parameters.

The research of thermodynamic properties of matter should be performed only in its equilibrium states or using the dependencies of its thermodynamic potentials on thermodynamic parameters that take into account the variability of parameter R_T in the process of this research ($R_T\neq\mathbf{const}(t)$). In order to determine both the thermal expansion coefficient α and pressure γ and the elastic modulus K_T of gas or liquid it is enough to know only the thermal equation of the state (i.e. the gas compressibility coefficient $Z = R_T / R_{UT}$, which is determined by the parameter $R_T = pV / R_T$):

$$\alpha=\frac{1}{V_0}\left(\frac{\partial V}{\partial T}\right)_p=\frac{1}{V_0p}\left[R_T+T\left(\frac{\partial R_T}{\partial T}\right)_p\right], \qquad \gamma=\frac{1}{p_0}\left(\frac{\partial p}{\partial T}\right)_V=\frac{1}{p_0V}\left[R_T-T\left(\frac{\partial R_T}{\partial T}\right)_V\right],$$

$$K_T=-V_0\left(\frac{\partial p}{\partial V}\right)_T=\frac{R_T T}{V_0}-T\left(\frac{\partial R_T}{\partial V}\right)_T .$$

In order to determine their thermal capacity when volume and pressure are invariant[68] and, thus, all their thermodynamic potentials we should know not only R_T and critical phasic values of pressure p_{cr} and of internal energy multiplicative component $U_{cr}=m_{00}c^3/v_{lcr}$, but also the mathematical expectation $\tilde{\beta}_{pV}$ of the value of hidden variable $\beta_{pV}=\breve{p}\breve{V}/\breve{U}_0$:

$$C_V=\left(\frac{\partial U}{\partial T}\right)_V=\frac{1}{\tilde{\beta}_{pV}}\left[R_T+T\left(1+\frac{\tilde{\beta}_{pV}S}{R_T}\right)\left(\frac{\partial R_T}{\partial T}\right)_V\right]=$$

$$=\frac{1}{\tilde{\beta}_{pv}}\left\{R_T+T\left[1+(1+\tilde{\beta}_{pV})\ln\left(\frac{R_T T}{\tilde{\beta}_{pV}U_{cr}}\right)-\tilde{\beta}_{pV}\ln\left(\frac{p}{\tilde{\beta}_{pV}p_l}\right)\right]\left(\frac{\partial R_T}{\partial T}\right)_V\right\}=$$

$$=T\left(\frac{\partial S}{\partial T}\right)_V=\frac{1}{\tilde{\beta}_{pv}}\left\{R_T+T\left[1+\ln\left(\frac{R_T T}{\tilde{\beta}_{pV}U_{cr}}\right)+\tilde{\beta}_{pV}\ln\left(\frac{p_l V}{U_{cr}}\right)\right]\left(\frac{\partial R_T}{\partial T}\right)_V\right\},$$

$$C_p=T\left(\frac{\partial S}{\partial T}\right)_p=\left(\frac{\partial U}{\partial T}\right)_p+R_T+T\left(\frac{\partial R_T}{\partial T}\right)_p=\frac{1+\tilde{\beta}_{pV}}{\tilde{\beta}_{pV}}\left[R_T+T\left(1+\frac{\tilde{\beta}_{pV}S}{(1+\tilde{\beta}_{pV})R_T}\right)\left(\frac{\partial R_T}{\partial T}\right)_p\right],$$

$$C_p-C_V=R_T+T\left[\left(\frac{1+\tilde{\beta}_{pV}}{\tilde{\beta}_{pV}}+\frac{S}{R_T}\right)\left(\frac{\partial R_T}{\partial T}\right)_p-\left(\frac{1}{\tilde{\beta}_{pV}}+\frac{S}{R_T}\right)\left(\frac{\partial R_T}{\partial T}\right)_V\right], \qquad U=\frac{R_T T}{\tilde{\beta}_{pV}}+\int_{R_{T0}}^{R_T}\frac{TS}{R_T}dR_T .$$

Based on thermodynamic dependencies of thermal capacities when volume and pressure are invariant we can determine the mathematical expectation of dependencies of these functions on individual parameters R_T and θ, and, consequently, on any pair of main thermodynamic parameters:

$$\tilde{\beta}_{pV}=\frac{R_T T}{U_0}=\frac{R_T\left[\left(\frac{\partial R_T}{\partial T}\right)_p-\left(\frac{\partial R_T}{\partial T}\right)_V\right]}{C_V\left(\frac{\partial R_T}{\partial T}\right)_p-(C_p-R_T)\left(\frac{\partial R_T}{\partial T}\right)_V+T\left(\frac{\partial R_T}{\partial T}\right)_p\left(\frac{\partial R_T}{\partial T}\right)_V}.$$

The following correspond to the thermal Van der Waals equation of the state of real gases:

$$R_T=\frac{pV}{T}=\frac{R_{UT}}{(1+a_m/pV^2)(1-b_m/V)}=\frac{R_{UT}V}{V-b_m}-\frac{a_m}{TV}=R_{UT}\left[\frac{V}{V-b_m}-\theta\right], \qquad \theta=\frac{a_m}{R_{UT}TV},$$

$$dV=\frac{V^2[R_{UT}dT-(V-b_m)dp]}{pV^2-a_m(1-2b_m/V)}, \qquad \left(\frac{\partial R_T}{\partial T}\right)_V=\frac{a_m}{T^2V}=\frac{R_{UT}\theta}{T},$$

[68] Heat capacity when pressure is invariant is determined not by internal energy of the matter itself, but by equivalent to its enthalpy the energy of extended system that consists of this matter and the load that supports the needed pressure.

$$\left(\frac{dR_T}{\partial T}\right)_p=\frac{p}{T}\left[\left(\frac{\partial V}{\partial T}\right)_p-\frac{V}{T}\right]=\frac{a_m(1-2b_m/V)/(TV)+R_{UT}-R_T}{T\left[1-a_m(1-2b_m/V)/(pV^2)\right]}=\frac{R_T\{R_{UT}[1+\theta(1-2b_m/V]-R_T\}}{T[R_T-R_{UT}\theta(1-2b_m/V)]},$$

$$\widetilde{\beta}_{pV}=\frac{R_T\left\{R_T[R_{UT}(1-2\theta\, b_m/V)-R_T]+R_{UT}^2\theta^2(1-2b_m/V)\right\}}{R_T(C_V+R_{UT}\theta)\{R_{UT}[1+\theta(1-2b_m/V)]-R_T\}-R_{UT}\theta(C_p-R_T)[R_T-R_{UT}\theta(1-2b_m/V)]},$$

where: a_m and b_m are individual constants of certain matter.

According to this we receive the simple expression for the entropy of hypothetical ideal gas:

$$S=C_{V0}\ln\left(\frac{C_{V0}T}{U_{cr}}\right)+R_{UT}\ln\left(\frac{C_{V0}p_{cr}V}{R_{UT}U_{cr}}\right)=S_{cr}+C_{V0}\ln\left(\frac{T}{T_{cr}}\right)+R_{UT}\ln\left(\frac{V}{V_{cr}}\right)=S_k+C_{V0}\ln\left(\frac{T}{T_k}\right)+R_{UT}\ln\left(\frac{V}{V_k}\right),$$

where: $S_{cr}=(C_{V0}+R_{UT})\ln(C_{V0}T_{cr}/U_{cr})$, $C_{V0}=R_{UT}/\widetilde{\beta}_{pV}$; $V_{cr}=R_{UT}T_{cr}/p_{cr}$ and T_{cr} are critical phasic values of molar volume and temperature of ideal gas; V_k and T_k are their another arbitrary values.

The following expressions correspond to more precise Dieterici first thermal equation that uses an exponent with the same parameter $\theta=a_m/(R_{UT}TV)$:

$$R_T=\frac{R_{UT}}{1-b_m/V}\exp(-\theta), \qquad dV=\frac{R_{UT}(1+\theta)\exp(-\theta)dT-(V-b_m)dp}{p-a_mV^{-2}\exp(-\theta)},$$

$$\left(\frac{dR_T}{\partial T}\right)_p=\frac{R_{UT}(1+2\theta)\exp(-\theta)-R_T}{T\left[1-a_m\exp(-\theta)/(pV^2)\right]}=\frac{R_T[R_{UT}(1+2\theta)\exp(-\theta)-R_T]}{T[R_T-R_{UT}\theta\exp(-\theta)]}=\frac{R_T\Psi}{T},$$

$$\left(\frac{\partial R_T}{\partial T}\right)_V=\frac{R_T\theta}{T}, \qquad C_V=(1+\theta)\frac{R_T}{\widetilde{\beta}_{pV}}+\theta\, S, \qquad C_p=(1+\Psi)\frac{(1+\widetilde{\beta}_{pV})R_T}{\widetilde{\beta}_{pV}}+\Psi S,$$

$$C_p-C_V=[(1+\Psi)(1+1/\widetilde{\beta}_{pV})-(1+\theta)/\widetilde{\beta}_{pV}]+(\Psi-\theta)S,$$

$$\widetilde{\beta}_{pV}=\frac{(\Psi-\theta)R_T}{\Psi C_V-\theta C_p+\theta(1+\Psi)R_T}=\frac{R_T(1+\theta)[R_{UT}(1+\theta)\exp(-\theta)-R_T]}{R_{UT}\left[(1+2\theta)C_V+\theta^2C_p+\theta(1+\theta)R_T\right]\exp(-\theta)-R_T(C_V+\theta C_p)}.$$

Obviously, experimentally found heat capacities of gases can be represented as functions of only R_T and θ parameters.

Hidden variables β_{ST} and β_{pV} are invariant magnitudes in any moment of time that corresponds to the certain Gibbs collective microstate of the whole RGTD-bonded matter. And, thus, their derivatives by any thermodynamic parameter are equal to zero. The same can be told regarding mathematical expectations of those hidden variables $\widetilde{\beta}_{ST}$ and $\widetilde{\beta}_{pV}$, despite the dependence of their values on other thermodynamic parameters of matter.

16. The solutions of equations of gravitational field for cooled down to the limit and quantum quasi-equilibrium gases that gradually cools

Due to the fact that the whole gravithermodynamically bonded matter forms the collective spatial-temporal microstates (Gibbs microstates) the spatial integration of equations of gravitational field has the physical sense only for the specific moment of intrinsic time of matter and only in the (inseparable from it) intrinsic space. Exactly the cardinal absence of the velocity of motion of matter in integrated equations of matter state makes the problem of relativistic invariance of thermodynamic parameters and potentials of matter non-actual. Since in quasi-equilibrium clusters of homogenous gas that gradually cools the functions of time $t(R_T)$ and of rigidly related to cooling down gas radial coordinate $r(A_p)$ ($v_r = dr/dt = 0$) perform the time-like gas parameter $R_T \equiv \alpha_p(t) = pV/T = \mathbf{const}(r)$ and the space-like indicator of hierarchic complexity[69] of gas $A_p(r) = ST/R_T = ST^2/pV = \mathbf{const}(t)$ correspondingly, the spatial integration of equations of its gravithermodynamic state should be performed for the same value of parameter R_T while the temporal integration should be performed for the same value of indicator of hierarchic complexity A_p of any concrete microvolume of the gas [60, 106].

Given this, the gas cluster that gradually cools in the quasi-equilibrium state can be matched in GR to thermodynamic FR that corresponds to Schwarzschild parameters of equations of gravitational field. Since for gases that gradually cool the condition: $(T/V)dS/dr + dp/dr + (\hat{\mu}_{th0}c^2 + p)b'/2b = 0$ ($R_T = \mathbf{const}(r)$) is fulfilled, then not only in GR, but also and in RGTD we will have for these gases:

$$\frac{1}{R_T}\frac{dS}{dr} + \frac{1}{p}\frac{dp}{dr} = -\left(1 + \frac{1}{\tilde{\beta}_{pV}}\right)\frac{b'}{2b} = -\left[1 + \frac{\tilde{k}\tilde{l}\tilde{m} - 1}{\tilde{k}(\tilde{l} - 1)}\right]\frac{v'_{cv}}{v_{cv}} = \frac{\tilde{k}\tilde{l}(\tilde{m}+1) - (\tilde{k}+1)}{\tilde{k}(\tilde{l} - 1)T}\frac{dT}{dr}.$$

From here:

$$\frac{S - S_w(R_T)}{R_T} + \ln\left(\frac{p}{p_w(R_T)}\right) = -\left(\frac{1 + \tilde{\beta}_{pV}(R_T)}{2\tilde{\beta}_{pV}(R_T)}\right)\ln\frac{b}{b_w(R_T)} = \frac{\tilde{k}\tilde{l}(\tilde{m}+1) - (\tilde{k}+1)}{\tilde{k}(\tilde{l} - 1)}\ln\left(\frac{T}{T_w(R_T)}\right),$$

$$\frac{S}{R_T} = \frac{\tilde{\beta}_H}{\tilde{\beta}_{pV}}\ln\frac{R_T T}{U_{cr}} - \ln\frac{p}{p_l} - \frac{\ln\tilde{\beta}_{pV}}{\tilde{\beta}_{pV}}, \qquad p\exp\left(\frac{S}{R_T}\right) = -p_w\exp\left(\frac{S_w}{R_T}\right)\left(\frac{b}{b_w}\right)^{-\frac{\tilde{\beta}_H}{2\tilde{\beta}_{pV}}} = \tilde{\beta}_{pV}\tilde{\mu}_l c^2\left(\frac{b}{b_l}\right)^{\frac{\tilde{k}\tilde{l}(1+\tilde{m}) - (1+\tilde{k})}{2\tilde{k}(1-\tilde{l})}},$$

[69] While moving towards the center of the cluster in the same collective spatial-temporal microstate of matter its spatial structure becomes more complex and matter even can make transition into a new phase or even aggregate state. Gases under high pressure can turn into liquids, despite the high temperature. And substances that are solid at low pressure and low temperature, on the contrary, melt and become liquids under the influence of high temperature. But despite this, almost all multinucleon substances were formed under the influence of high pressure precisely in the depths of the stars.

where: $\widetilde{\beta}_{pV}(R_T)\widetilde{n}(R_T)=(p_{00}/p_{cr})\exp(S_{00}/R_T)$; $\widetilde{\beta}_{pV}=pV/U_0=p/c^2\hat{\mu}_{th0}=\widetilde{k}(\widetilde{l}-1)/(\widetilde{k}\widetilde{l}\widetilde{m}-1)=\mathbf{const}(r)$ (according to Boyle-Mariotte law [107]); $\widetilde{\beta}_H=H_0/U_0=1+\widetilde{\beta}_{pV}$; $\hat{\mu}_{th0}=\hat{\mu}_{00}c/v_{cv}$ is density of the thermal mass of hot gas that is not under pressure; $\widetilde{\beta}_{ST}=ST/(\hat{S})U_0=(\widetilde{k}\widetilde{m}-1)/(\widetilde{k}\widetilde{l}\widetilde{m}-1)=\mathbf{const}\,(r)$; $\widetilde{\mu}_l=p_{cr}c^{-2}\widetilde{n}/\widetilde{\beta}_{pV}$ is the limit value of density of the «thermal mass» of hot gas that is not under pressure.

Obviously, the cluster of gas that gradually cools have also the spatial homogeneity of gravithermodynamic intrinsic value (eigenvalue) of Gibbs free energy G^*_{00} (similarly to the spatial homogeneity of thermodynamic intrinsic value of enthalpy H^*_{00} of cooled down to the limit matter, as it was shown by Tolman [3]):

$$G^*_{00}=(v_{lc}/c)G=(v_{lc}/c)[U_0+U_{ad}+pV-TS]=U_{cr}\psi_{m0}[1+\widetilde{\beta}_{pV}-\widetilde{\beta}_{TS}\ln(f_I^{\widetilde{l}}N_I^{1-\widetilde{l}})]=U_{00}[1+\widetilde{\beta}_{pV}(1-S/R_T)]=\mathbf{const}(r,A_p),$$

where: $S=\mathbf{const}(r)$, $R_T=\mathbf{const}(r)$, $\widetilde{\beta}_{pV}=\mathbf{const}(r)$, $U_{ad}=0$, $N_I=f_I^{-\widetilde{l}/(1-\widetilde{l})}\exp[S\widetilde{\beta}_{pV}/\widetilde{\beta}_{ST}R_T(1-\widetilde{l})]$ and $v_{lc}=\sqrt{bc}=v_l\Gamma_m=c\psi_{m0}/f_I$ (when conditionally $\chi_m=1$).

Therefore:

$$V=(U_{cr}/\widetilde{p}_l)f_I^{-1/\widetilde{k}}N_I^{(1-\widetilde{k}\widetilde{m})/\widetilde{k}}=(U_{cr}/\widetilde{n}p_{cr})(b\psi_{m0}^{-2})^{1/2\widetilde{\beta}_{pV}}\exp(S/R_T)=(V_{00}/\widetilde{n})\exp(S/R_T)b^{1/2\widetilde{\beta}_{pV}},$$

$$p=\widetilde{p}_l\widetilde{\beta}_{pV}f_I^{(1+\widetilde{k})/\widetilde{k}}N_I^{(\widetilde{k}\widetilde{m}-1)/\widetilde{k}}=p_{cr}\widetilde{n}\widetilde{\beta}_{pV}(b\psi_{m0}^{-2})^{-\widetilde{\beta}_H/2\widetilde{\beta}_{pV}}\exp(-S/R_T)=p_{00}\widetilde{n}\widetilde{\beta}_{pV}\exp(-S/R_T)b^{-\widetilde{\beta}_H/2\widetilde{\beta}_{pV}},$$

$$T=\widetilde{\beta}_{pV}U_{cr}f_I/R_T=(\psi_{m0}U_{cr}\widetilde{\beta}_{pV}/R_T)b^{-1/2}=T_{00}b^{-1/2},\quad U_0=\psi_{m0}U_{cr}b^{-1/2}=(T_{00}R_T/\widetilde{\beta}_{pV})b^{-1/2}=U_{00}b^{-1/2},$$

$$H_0=\psi_{m0}U_{cr}\widetilde{\beta}_Hb^{-1/2}=(T_{00}R_T\widetilde{\beta}_H/\widetilde{\beta}_{pV})b^{-1/2},\ G_0=G_{00}b^{-1/2}=(H_{00}-T_{00}S)b^{-1/2}=(\widetilde{\beta}_H/\widetilde{\beta}_{pV}-S/R_T)R_TT_{00}b^{-1/2},$$

$$\hat{\mu}_{th0}c^2=(\widetilde{n}T_{00}R_T/V_{00}\widetilde{\beta}_{pV})\exp(-S/R_T)b^{-\widetilde{\beta}_H/2\widetilde{\beta}_{pV}}=\widetilde{\mu}_cc^2b^{-\widetilde{\beta}_H/2\widetilde{\beta}_{pV}}=r'_gr^{-2}/\kappa,$$

$$G_0/V=(\widetilde{n}T_{00}/V_{00})(R_T\widetilde{\beta}_H/\widetilde{\beta}_{pV}-S)\exp(-S/R_T)b^{-\widetilde{\beta}_H/2\widetilde{\beta}_{pV}}=(\widetilde{\mu}_cc^2+\widetilde{\sigma}_c)b^{-\widetilde{\beta}_H/2\widetilde{\beta}_{pV}}=(1+\widetilde{\beta}_{pT})r'_gr^{-2}/\kappa,$$

where: $b=v_{lc}^2c^{-2}$, $V_{00}=(U_{cr}/p_{cr})\psi_{m0}^{-1/\widetilde{\beta}_{pV}}$, $p_{00}=p_{cr}\psi_{m0}^{\widetilde{\beta}_H/\widetilde{\beta}_{pV}}$, $T_{00}=\psi_{m0}U_{cr}\widetilde{\beta}_{pV}/R_T=Tb^{1/2}$, $U_{00}=U_0b^{1/2}$, $G_{00}=G_0b^{1/2}=T_{00}(R_T\widetilde{\beta}_H/\widetilde{\beta}_{pV}-S)=U_{00}(1+\widetilde{\beta}_{pT})$; $\widetilde{\mu}_c=\widetilde{\mu}_lb_l^{\widetilde{\beta}_H/2\widetilde{\beta}_{pV}}=(\widetilde{n}T_{00}R_T/c^2V_{00}\widetilde{\beta}_{pV})\exp(-S/R_T)=\mathbf{const}(r)$ and $\widetilde{\sigma}_c=(\widetilde{n}T_{00}/V_{00})(R_T-S)\exp(-S/R_T)=\widetilde{\mu}_cc^2\widetilde{\beta}_{pV}(1-S/R_T)=\widetilde{\mu}_cc^2\widetilde{\beta}_{pT}=\mathbf{const}(r)$ are mathematical expectations (when $b=1$) of density of pseudo-mass (which is equivalent to the multiplicative component of the internal energy of a gas not under pressure) and the difference of densities of Gibbs free energy (whose multiplicative component is equivalent to the true mass of the gas) and internal energy of gas that is not under pressure, correspondingly; $\widetilde{\beta}_{pT}=(pV-TS)/U_0=\widetilde{\beta}_{pV}(1-S/R_T)$.

Due to the relativistic invariance of thermodynamic parameters and characteristics of matter the equations of gravitational field for spherically symmetric gas cluster that gradually cools can be expressed in comoving with it FR in the following way:

$$b'/abr-r^{-2}(1-1/a)+\Lambda(R_T)=\kappa(p-ST/V)=\kappa(\tilde{n}T_{00}/V_{00})(R_T-S)\exp(-S/R_T)b^{-\tilde{\beta}_H/2\tilde{\beta}_{pV}}=\kappa\tilde{\sigma}_c b^{-\tilde{\beta}_H/2\tilde{\beta}_{pV}},$$

$$a'/a^2r+r^{-2}(1-1/a)-\Lambda(R_T)=\kappa\mu_{gr0}c^2=\kappa(\tilde{n}T_{00}R_T/V_{00}\tilde{\beta}_{pV})\exp(-S/R_T)b^{-\tilde{\beta}_H/2\tilde{\beta}_{pV}}=\kappa\tilde{\mu}_c c^2 b^{-\tilde{\beta}_H/2\tilde{\beta}_{pV}}=r^{-2}r'_g, \quad (7)$$

$$\frac{1}{a(r)}=\left(\frac{\partial r}{\partial \tilde{r}}\right)^2=\chi(r)b(r)=-\kappa c^2\tilde{\mu}_c b(1+\tilde{\beta}_{pT})\int_{r_0}^{r} b^{-(1+3\tilde{\beta}_{pV})/2\tilde{\beta}_{pV}}rdr=\frac{1}{a_b}-\frac{\Lambda}{3}r^2=$$

$$=1-\left(1-\frac{\Lambda}{3}r_0^2\right)\frac{r_0}{r}-\frac{\kappa c^2\tilde{\mu}_c}{r}\int_{r_0}^{r} b^{-(1+\tilde{\beta}_{pV})/2\tilde{\beta}_{pV}}r^2dr-\frac{\Lambda}{3}r^2=1-\frac{r_g(r)}{r}-\frac{\Lambda}{3}r^2=\frac{1}{a_b(r)}-\frac{\Lambda}{3}r,$$

$$ab=\exp\left[(1+\tilde{\beta}_{pT})\int_{r_0}^{r}\frac{ar'_g dr}{r}\right], \qquad b(r)=\left(\frac{\tilde{\beta}_{pV}\psi_{m0}U_{cr}}{R_T T}\right)^2=\left(\frac{\tilde{k}(1-\tilde{l})}{1-\tilde{k}\tilde{l}\tilde{m}}\right)^2\left(\frac{U_{00}}{R_T T}\right)^2=\left(\frac{r'_g}{\kappa\tilde{\mu}_c c^2 r^2}\right)^{-\frac{2\tilde{\beta}_{pV}}{\tilde{\beta}_H}},$$

where: $r_g(r)=r(1-1/a_b)=(1-r_0^2\Lambda/3)r_0+\kappa\tilde{\mu}_l c^2 b_l^{(1+\tilde{\beta}_{pV})/2\tilde{\beta}_{pV}}\int_{r_0}^{r} b^{-(1+\tilde{\beta}_{pV})/2\tilde{\beta}_{pV}}r^2dr$ is the value of gravitational radius of matter that is covered by the sphere with radius $r\geq r_0$; r_0 is minimum possible value of Schwarzschild radial parameter ($1/a_0=0$).

According to this we will receive the differential equation of the second order for the gravitational radius of gas cluster that gradually cools in quasi-equilibrium state:

$$\frac{2\tilde{\beta}_{pV}}{\tilde{\beta}_H}\left(\frac{r''_g r}{r'_g}-2\right)\left(1-\frac{r_g}{r}-\frac{\Lambda r^2}{3}\right)-\frac{r_g}{r}+\frac{2\Lambda r^2}{3}=\tilde{\beta}_{pT}r'_g,$$

$$\frac{r''_g}{r(r-r_g-\Lambda r^3/3)}+\frac{\tilde{\beta}_H\tilde{\beta}_{pT}r'^2_g}{2\tilde{\beta}_{pV}r(r-r_g-\Lambda r^3/3)^2}-\frac{2r'_g}{r^2(r-r_g-\Lambda r^3/3)}+\frac{(1+\tilde{\beta}_{pV})(r_g-2\Lambda r^3/3)r'_g}{2\tilde{\beta}_{pV}r^2(r-r_g-\Lambda r^3/3)^2}=0.$$

When there are new parameters this equation is transformed into differential equation of the first order:

$$u'+\frac{ru^2}{n\varphi}=u'+\left(\frac{\tilde{\beta}_H\tilde{\beta}_{pT}}{2\tilde{\beta}_{pV}}-1\right)\frac{ru^2}{\varphi}=0, \qquad \psi\varphi'=\frac{r'_g\varphi(1+3\tilde{\beta}_{pV})(r_g-2\Lambda r^3/3)}{2\tilde{\beta}_{pV}r^2(1-r_g-\Lambda r^3/3)^2},$$

where: $u=\psi\varphi=r'_g\varphi/r(r-r_g-\Lambda r^3/3)$, $\psi=r'_g/r(r-r_g-\Lambda r^3/3)$,

$$n=\frac{2\tilde{\beta}_{pV}}{\tilde{\beta}_H\tilde{\beta}_{pT}-2\tilde{\beta}_{pV}}=\frac{2}{\tilde{\beta}_{pV}(1-S/R_T)-(1+S/R_T)}=\frac{2pVU_0}{(pV-ST)pV-(pV+ST)U_0}>0,$$

$$u'=\psi'\varphi+\psi\varphi'=\frac{r_g''\varphi}{r(r-r_g-\Lambda r^3/3)}-\frac{r_g'\varphi(1-r_g'-\Lambda r^2)}{r(r-r_g-\Lambda r^3/3)^2}-\frac{r_g'\varphi}{r^2(r-r_g-\Lambda r^3/3)}+\frac{r_g'\varphi'}{r(r-r_g-\Lambda r^3/3)}=\frac{r\psi^2\varphi}{n},$$

$$\psi'=\frac{r\psi^2}{n}-\psi\frac{\varphi'}{\varphi}=\frac{r\psi^2}{n}-\frac{(1+3\tilde{\beta}_{pV})(r_g-2\Lambda r^3/3)}{2\tilde{\beta}_{pV}r^2(r-r_g-\Lambda r^3/3)^2}r_g', \qquad \frac{\varphi'}{\varphi}=\frac{(1+3\tilde{\beta}_{pV})(r_g-2\Lambda r^3/3)}{2\tilde{\beta}_{pV}r(r-r_g-\Lambda r^3/3)}.$$

$$\varphi=\exp\left[\frac{(1+3\tilde{\beta}_{pV})}{2\tilde{\beta}_{pV}}\int_{r_0}^{r}\frac{(r_g-2\Lambda r^3/3)dr}{(r-r_g-\Lambda r^3/3)r}\right]\approx 1, \quad b(r)=\left(\frac{r_g'}{\kappa\tilde{\mu}_c c^2 r^2}\right)^{-\frac{2\tilde{\beta}_{pV}}{\tilde{\beta}_H}}=\left(\frac{\psi}{\kappa\tilde{\mu}_c c^2 a}\right)^{-\frac{2\tilde{\beta}_{pV}}{\tilde{\beta}_H}}.$$

And, therefore: $S=R_T[1+2(1/n-1)/\tilde{\beta}_H]$, $V=(V_{00}/\tilde{n})b^{1/2\tilde{\beta}_{pV}}\exp[1+2(1/n-1)/\tilde{\beta}_H]$,

$p=p_{00}\tilde{n}b^{-\tilde{\beta}_H/2\tilde{\beta}_{pV}}\exp[1+2(1/n-1)/\tilde{\beta}_H]$, $G_0=U_0[1+(3-2/n)\tilde{\beta}_{pV}]/\tilde{\beta}_H$.

Since in the central zone of gas cluster ($\varphi\approx 1, u\approx\psi$):

$$\frac{r\psi^2}{n}=\frac{(1-\tilde{\beta}_H\tilde{\beta}_{pT}/2\tilde{\beta}_{pV})r_g'^2}{r(r-r_g-\Lambda r^3/3)^2}>>\frac{(1+3\tilde{\beta}_{pV})(r_g-2\Lambda r^3/3)}{2\tilde{\beta}_{pV}r^2(r-r_g-\Lambda r^3/3)^2}r_g',$$

we will determine the approximate solution of differential equation $\tilde{\psi}'=r\tilde{\psi}^2/n$ exactly for this zone:

$$2n\left(\frac{1}{\tilde{\psi}}-\frac{1}{\tilde{\psi}_0}\right)=2n\left[\frac{r^2(1-r_g/r-\Lambda r^2/3)}{r_g'}-\frac{r_0^2(1-r_{g0}/r_0-\Lambda r_0^2/3)}{r_{g0}'}\right]=\frac{2n}{\kappa\tilde{\mu}_c c^2}\left(\frac{1}{ab^{\tilde{\beta}_H/2\tilde{\beta}_{pV}}}-\frac{1}{a_0 b_0^{\tilde{\beta}_H/2\tilde{\beta}_{pV}}}\right)=r^2-r_0^2.$$

From here:

$$r_g'=\frac{2nr^2}{a(r^2-\rho_0^2)}=2n\frac{r^2-rr_g-\Lambda r^4/3}{r^2-\rho_0^2}, \qquad r_g=(r^2-\rho_0^2)^n/z,$$

where: $\rho_0^2=r_0^2-2n(r_0/r_{g0}')(r_0-r_{g0}-\Lambda r_0^3/3)$, and the parameter z is determined from the equation:

$$-\frac{d(1/z)}{dr}=\frac{z'}{z^2}=\frac{2n(r^2-\Lambda r^4/3)}{(r^2-\rho_0^2)^{n+1}}.$$

The obtained differential equation is the quantum equation of gravitational (gravithermodynamic) field[70] since its solutions are the polynomial functions the degree indicators of which (n=3/2, 2, 5/2, 3 ... ∞) can take only integer or semi-integer values [108]:

$$r_g=-(r^2-\rho_0^2)^n\left[\frac{1}{z_0}-2n\int_{r_0}^{r}\frac{r^2-r^4\Lambda/3}{(r^2-\rho_0^2)^{n+1}}dr\right]=-(r^2-\rho_0^2)^n\left\{\frac{1}{z_0}-2n\int_{r_0}^{r}\left[-\frac{\Lambda/3}{(r^2-\rho_0^2)^{n-1}}+\frac{1}{(r^2-\rho_0^2)^n}-\rho_0^2\frac{1+\rho_0^2\Lambda/3}{(r^2-\rho_0^2)^{n+1}}\right]dr\right\}=$$

[70] Proposed by specialists in quantum theory the gravitation quantizations of gravitational field are artificial, while dynamic solutions of equations of gravitational field directly guarantee the quite natural quantization of the energy emitted by the gas cluster. It is probably due to the fact that in GR the static states of the cooled down to the limit matter are usually examined.

$$=-(r^2-\rho_0^2)^n\left\{\frac{1}{z_0}+\frac{nr_0[(n-1)\Lambda/3-(n-2)(r_0-\rho_0]}{(n-1)(n-2)\rho_0^2(r_0^2-\rho_0^2)^{n-2}}+\frac{1+\rho_0^2\Lambda/3}{(r_0^2-\rho_0^2)^n}-\frac{nr[(n-1)\Lambda/3-(n-2)(r-\rho_0)]}{(n-1)(n-2)\rho_0^2(r^2-\rho_0^2)^{n-2}}-\frac{1+\rho_0^2\Lambda/3}{(r^2-\rho_0^2)^n}\right\}-$$

$$-(r^2-\rho_0^2)^n\left\{\frac{n}{\rho_0^2}\int_{r_0}^{r}\left[-\frac{(2n-5)\Lambda/3}{(n-2)(r^2-\rho_0^2)^{n-2}}+\frac{2n-3}{(n-1)(r^2-\rho_0^2)^{n-1}}-\rho_0^2\frac{(2n-1)(1+\rho_0^2\Lambda/3)}{n(r^2-\rho_0^2)^{n+1}}\right]dr\right\}=$$

$$=-\left\{\frac{(r^2-\rho_0^2)^n}{z_0}+\frac{1}{\rho_0^2}\left[(r^3-r^5\Lambda/3)+\sum_{k=1}^{n-1}(-1)^k\frac{[(2n-3)(2n-5)...(2n-2k-1)]r^3-[(2n-5)(2n-7)...(2n-2k-3)]r^5\Lambda/3}{2^k[(n-1)(n-2)...(n-k)]\rho_0^{2k}(\rho_0^2-r^2)^{-k}}\right]\right\}\Bigg|_{r_0}^{r}-$$

$$-2n(r^2-\rho_0^2)^n(-1)^{n+2}\left[\rho_0^{1-2n}\frac{(2n-3)(2n-5)...3}{2^n n!}\left(\frac{r}{\rho_0}-\frac{1}{2}\ln\left|\frac{r+\rho_0}{r-\rho_0}\right|\right)-\rho_0^{3-2n}\Lambda\frac{(2n-5)(2n-7)...3}{3\cdot 2^n n!}\left(\frac{r^3}{3\rho_0^3}+\frac{r}{\rho_0}-\frac{1}{2}\ln\left|\frac{r+\rho_0}{r-\rho_0}\right|\right)\right]\Bigg|_{r_0}^{r}$$

Thus, the quantum transition of matter that gradually cools into its new quasi-equilibrium state is accompanied by the increment by one step of the indicators of degree of all components of polynomial equation of gravitational field:

$$n+1=\frac{(1+\tilde{\beta}_{pVn})(1-S_n/R_{Tn})}{\tilde{\beta}_{pVn}(1-S_n/R_{Tn})-(1+S_n/R_{Tn})}=\frac{2}{\tilde{\beta}_{pV(n+1)}(1-S_{(n+1)}/R_{T(n+1)})-(1+S_{(n+1)}/R_{T(n+1)})},$$

where: $\tilde{\beta}_{pV(n+1)}=\dfrac{\tilde{\beta}_{pVn}(1-S_n/R_{Tn})}{(1+\tilde{\beta}_{pVn})(1-S_n/R_{Tn})-(1+S_n/R_{Tn})}$, $\dfrac{S_{(n+1)}}{R_{T(n+1)}}=\dfrac{2(1+S_n/R_{Tn})-(1+\tilde{\beta}_{pVn})(1-S_n/R_{Tn})}{(1+\tilde{\beta}_{pVn})(1-S_n/R_{Tn})}$;

$$\tilde{\beta}_{pVn}=\frac{\tilde{\beta}_{pV(n+1)}(1-S_{(n+1)}/R_{T(n+1)})}{2-\tilde{\beta}_{pV(n+1)}(1-S_{(n+1)}/R_{T(n+1)})},\qquad \frac{S_n}{R_{Tn}}=\frac{S_{(n+1)}/R_{T(n+1)})+\beta_{pV(n+1)}(1-S_{(n+1)}/R_{T(n+1)})-1}{S_{(n+1)}/R_{T(n+1)}-\beta_{pV(n+1)}(1-S_{(n+1)}/R_{T(n+1)})+3}.$$

So, in the cooled down to the limit state matter ($S=0$, $n=\infty$) the parameter $\tilde{\beta}_{pV}=pV/U_0$ takes its minimal possible value that is equal to one. Therefore: $pV\geq U_0$. And therefore, the absence of gravitational pressure in a non-extremely cooled down matter is fundamentally impossible ($p\geq U_0/V$).

In case of small values of indicators of polynomial function the cluster of gas that gradually cools dumps its energy in big portions. However these portions of energy of radiation become less and less with each new taken geavithermodynamic state. Thus, the gas cluster can cool down for infinitely long time. The precise solution of this differential equation when $1/a_0=0$ is as follows:

$$\frac{1}{u}=\frac{r(r-r_g-\Lambda r^3/3)}{r'_g}=\frac{b^{\tilde{\beta}_H/2\tilde{\beta}_{pV}}}{\kappa\tilde{\mu}_c c^2 a}=\frac{r^2-\rho_0^2}{2n}+\frac{1+3\tilde{\beta}_{pV}}{2\tilde{\beta}_{pV}}\int_{r_0}^{r}\frac{r_g-2\Lambda r^3/3}{r'_g}dr=\frac{r_{eff}^2-\rho_{0eff}^2}{2n},$$

where: $r_{eff}>r$ and $\rho_{0eff}>\rho_0$ are effective values of radial distance that are significantly smaller than real values on the big distances from the center of gravity. It is possible that exactly this causes the effect of stronger gravitational field (than it is according to Newton's theory) and, therefore, causes the false necessity of dark non-baryonic matter in the Universe.

Since for cooled down to the limit gases and for simplest liquids $dp/dr+(\hat{\mu}_{th0}c^2+p)b'/2b=0$ ($S=0$, $\tilde{\beta}_{pS}=\tilde{\beta}_{pV}=p/\hat{\mu}_{th0}=\tilde{k}=1/\tilde{m}=1$), and $\hat{\mu}_{th0}/\hat{\mu}_{th0cr}=p/p_{cr}$ (according to Boyle-Mariotte law [107]), then for them not only in GR, but also and in RGTD we will have:

$$\frac{1}{p}\frac{dp}{dr}=-\left(1+\frac{1}{\tilde{\beta}_{pV}}\right)\frac{b'}{2b}=-\left(1+\frac{1}{\tilde{k}}\right)\frac{v'_{cv}}{v_{cv}}=2\frac{v'_{cv}}{v_{cv}}.$$

From here: $p=p_{00}\tilde{n}/b=p_0b_l/b=\tilde{\mu}_lc^2b_l/b$, $p_0=\tilde{\mu}_lc^2=\tilde{p}_l=p_{cr}\tilde{n}$, $\hat{\mu}_{th0}=\hat{m}_{th0}/V=(m_{00}/V)b^{-1/2}=\tilde{\mu}_lb_l/b$, $V=V_{00}b^{1/2}=(m_l/\tilde{\mu}_l)(b/b_l)^{1/2}$.

However, for the real gases:

$$\mu_{gr0}=\frac{m_{gr0}}{V(v_{cv})}=\frac{m_{00}}{\sqrt{b}V(b)}\approx\frac{m_{00}(R_T-R_{UT})}{\sqrt{b}\left[b_mR_T-(a_m/T_{00})\sqrt{b}\right]},\quad p=\tilde{\beta}_{pV}\mu_{gr0}=\frac{\tilde{\beta}_{pV}m_{00}}{\sqrt{b}V(b)}\approx\frac{\tilde{\beta}_{pV}m_{00}(R_T-R_{UT})}{\left[b_mR_T-(a_m/T_{00})\sqrt{b}\right]\sqrt{b}},$$

where: $R_T=pV/T=\mathbf{const}(r)$, $T_{00}=Tv_{cv}/c=T\sqrt{b}=\mathbf{const}(r)$, $m_{00}=m_{in0}c/v_{cv}=m_{gr0}v_{cv}/c=\mathbf{const}(r)$, $\tilde{\beta}_{pV}=p/c^2\hat{\mu}_{th0}=\mathbf{const}(r)$, and:

$$V(b)=\frac{b_mR_T-(a_m/T_{00})\sqrt{b}+\sqrt{\left[b_mR_T-(a_m/T_{00})\sqrt{b}\right]^2+4(a_mb_m/T_{00})(R_T-R_{UT})\sqrt{b}}}{2(R_T-R_{UT})}\approx\frac{b_mR_T-(a_m/T_{00})\sqrt{b}}{R_T-R_{UT}},$$

is a molar volume, more precise value of which can be numerically determined from the condition $R_T(1-b_m/V)-R_{UT}\exp[-a_m\sqrt{b}/(R_{UT}T_{00}V)]=0$.

And, consequently, only the degenerated gas, for which $b_m=0$, $R_T<R_{UT}$, $p=\hat{\mu}_{th0}c^2$ ($\tilde{m}=\tilde{k}=1$), $V_{00}=a_m/T_{00}(R_{UT}-R_T)$, can be the cooled down to the limit gas. For such cooled down to the limit degenerated gas ($\tilde{\beta}_{pV}=1$, $V=V_{00}b^{1/2}$) the received integral equation will take the following form:

$$\frac{1}{a}=\left(\frac{\partial r}{\partial\tilde{r}}\right)^2=\chi b=-2(\kappa c^2m_{00}b/V_{00})\int_{r_0}^{r}b^{-2}rdr=1-\left(1-\frac{\Lambda}{3}r_0^2\right)\frac{r_0}{r}-\frac{\kappa c^2m_{00}}{V_{00}r}\int_{r_0}^{r}\frac{1}{b}r^2dr-\frac{\Lambda}{3}r^2.$$

Obviously this is a gas of micro-objects of matter that do not interact electromagnetically, since it is very similar to ideal gas. And its degeneration could happen only after the gas cluster was already formed. It is quite possible that this is namely the neutron gas that has been condensed into neutron liquid [37, 43].

The gas that optimally gradually cools is also an exotic gas, which has $\partial G/\partial\tilde{\beta}_{pV}=0$, and therefore: $S/R_T=ST/pV=1$, and $G=U$. Perhaps it is contained in molecular clouds of the cold non-ionized galactic medium [48] or even in the highly rarefied cold plasma of the cosmosphere.

Therefore, for the gases that are cooled down not to the limit such problem does not exist. For any value of gas parameter $R_T=pV/T=\mathbf{const}(r)$ (that is independent from parameters of equations of gravitational field) for any specific gas the combination of values of all four its thermodynamic parameters (*p, V, T, S*) can be guaranteed via the determination of correspondent to it and to R_T (and, consequently, to corrections α_m and b_m) combination of mathematic expectations of four hidden thermodynamic parameters k, l, m and n. If we analyze the sets of mutually correspondent combinations of explicit and hidden thermodynamic parameters, then being based on this we can also determine the individual gas constants U_{cr}, p_{cr} and ψ_{m0}. Of course, we should take into account that corrections α_m and b_m only approximately reflect the properties of real gases in non-wide diapasons of deviations from the standard values of pressure and temperature: $a_m \approx V^2[R_{UT}T/(V-b_m)-p]$.

However the usage of enthalpy instead of Gibbs free energy in the four-momentum of GR makes doubtful the correspondence of it to non-rigid FR of matter that gradually cools. And, as we already seen, thermodynamic parameters of matter behave differently when they change in time and in space. If for real gases in one-place experiments we have to add additive corrections for molar volume and for other extensive parameter $R_T \equiv \alpha_\rho$, then due to $R_T = \mathbf{const}(r)$ the corrections for real gases, which are located on the different radial distances from the center of gravity, are possibly have to be done for intensive parameter $A_\rho = TS/R_T$ and for other intensive thermodynamic parameters. These corrections, obviously, will already be not additive but multiplicative.

Moreover, due to relativistic invariance of thermodynamic parameters and characteristics of matter the equations of gravitational field for any astronomical objects that gradually cool and move at velocities *v* by the orbits around the galactic centers of gravity, can be formed only being based on the relativistically invariant intranuclear RGTD-parameters. These relativistic gravithermodynamic parameters are hidden internal thermodynamic variables that correspond not to Hamiltonians or Lagrangians at all, but to Newtonians [GT-Hamiltonians] and Keplerians [GT-Lagrangians]. Therefore, the use of an external relativistic description of the motion of matter in the differential equations of the dynamic gravitational field of the RGTD is not required at all.

17. The comparison of reflection of physical reality in RGTD and in GR

The cardinal difference between RGTD and GR is in the usage in RGTD in tensor of energy-momentum of extranuclear thermodynamic characteristics of matter for the description of only its quasi-equilibrium motion, only for which there is a mutual correlation of extranuclear and intranuclear characteristics of matter. For the description of inertial motion in RGTD only the hypothetical intranuclear gravithermodynamic characteristics of matter are used. The necessity of this is denoted by the independence of the motion of astronomical objects by their stationary orbits from thermodynamic properties of their matter and, consequently, by the absence of correspondent to this motion correlation between intranuclear gravithermodynamic characteristics and extranuclear thermodynamic characteristics of matter. Namely this allows avoiding in principle the necessity of non-baryonic dark matter in the Universe.

For astronomical bodies, which homogenous simplest liquid or gaseous matter is in the state of mechanic and thermal equilibrium, the frequencies of interaction f_G and f_I are strictly determined by the values of pressure and temperature in matter. For solid or liquid astronomical bodies and also for gaseous matter, which covers them or which is not in the state of thermodynamic equilibrium, those frequencies can also depend on the magnitude of gravitational advance of evolutionary decreasing of their intranuclear energy. And, consequently, if for continuous homogenous gaseous matter non-Dopplerian redshift of radiation spectrum is sort of strictly thermodynamic, then for layer-by-layer homogenous gaseous matter (that covers solid or liquid core) it is gravitationally-thermodynamic (gravithermodynamic). And this is, obviously, related to the fact that in contrast to evolutionary shrinkage the gravitational shrinkage of matter is accompanied by the increasing of the density (in background Euclidean space of CFREU) of turns of spiral waves of spatial-temporal modulation of dielectric and magnetic permeabilities of physical vacuum.

During the heating of the matter the expansion of the matter happens and, therefore, the density of turns of spiral waves of spatial-temporal modulation of dielectric and magnetic permeabilities of physical vacuum is being decreased in the intrinsic space of FR of experimentalist. At the same time during the increasing of the pressure in the gas cylinder it, quite the contrary, is being increased. Obviously, this should lead to the decreasing of the limit velocity of individual motion of the gas that is under pressure inside the cylinder. And, consequently, the weight of the gas in the cylinder can be increased not only due to the increasing of its amount, but also due to the decreasing of limit velocity of gas individual motion that is equivalent to coordinate velocity of light of GR. Namely this allows us to understand why the increasing of energy of the gas in one case leads to the decreasing of its weight while in another case leads to its increasing.

So the limit velocity of matter individual motion is being determined namely by the density of the turns of spiral waves of spatial-temporal modulation of dielectric and magnetic permeabilities of physical vacuum. And due to the increasing of the temperature in matter the partial compensation of increasing of this density happens due to the increasing of the pressure in matter.

However, in equilibrium RGTD-states of the whole set of different matters the gradients of logarithms of f_I and f_G of all matters are strictly determined by gradients of pressure and temperature in them and, therefore, are strictly equal to the gradient of limit velocity v_l of group motion of the whole RGTD-bonded inhomogeneous matter. Moreover, due to $U_0 \equiv W$ and

U_0E=**const**(r) not only the conditions W_0f_G=$W_0v_l\eta_m/c$=**const**(r), E_0/f_G=$E_0c/v_l\eta_m$=**const**(r), but also the conditions U_0v_l=**const**(r), U_0/f_I=U_0f_G/χ_m=$U_0v_l\eta_m/\chi_mc$=**const**(r) are also fulfilled within the borders of the whole RGTD-bonded continuous homogeneous matter that is in the state of mechanical and thermal equilibrium. All this allows using in the partially modernized GR only intranuclear properties of matter for the formation of metric tensor, but both intranuclear and thermodynamic properties of matter for the formation of energy-momentum tensor. However, Lorentz-invariance of pressure in the matter is ignored in the such modernized GR.

All the more so, separate contributions to gravitational potential of velocity of light in matter v_{cm} and internal scaling factor N_I are not important for the determination of gravitational pseudo-forces. However, the form of radial distribution of gravitational potential in STC of astronomical body that consists of this matter and the form of generalized relativistic linear element depend on their contributions [51]. Therefore, the conversion of these characteristics are not gauge when the named contributions are redistributed. The presence of internal scaling factor is not taken into account in GR: function only of coordinate-like velocity of light is used as gravitational potential. In intrinsic spaces of matter changes of electromagnetic interaction distances are unobservable in GR in principle, while spatial inhomogeneity of this distance for uniform matter that takes place in background Euclidean space (and, consequently, spatial inhomogeneity of the values of its scaling factor) causes the curvature of matter intrinsic space. The one thing that points on it is the usage of the function of not the interaction frequency, but of common for all substances coordinate pseudo-vacuum (gravibaric[71]) velocity of light in GR as the gravitational potential.

Size of quantum length standard of the gas is decreasing in people world at the adiabatic increasing of this gas. This fact and the fact that change of distances of interaction of matter microobjects (which determine size of its quantum length standard) is unobservable in GR in principle leads to increasing of corresponding to this gas gravity-quantum value of metrical volume of the vessel that contains this gas[72]. Therefore, gravity-quantum metrical value of gas molar volume is decreasing not so fast as thermodynamic metrical value of its molar volume due to the presence of negative feedback [29, 30, 36]. Such gravitational shrinkage of the size of quantum standard of length that takes place on the matter micro-objects level is analogous to imaginary relativistic shrinkage of the size of quantum standard of length along the direction of matter motion.

[71] In contrast to GR, where equilibrium thermodynamic state is considered only for the matter that is cooled down to the limit, in RGTD not the hypothetical gravity-thermo-baric velocity of light (analogous to gravity-baric velocity of light) but the limit velocity of substance individual (separate) motion conventionally empty space is used in the relativistic transformations of increments of coordinates of moving matter. This is related to the fact that the values of conventional gravithermobaric velocity of light can vary for different matters in the same point of the space. Only the gradients of logarithms of these gravithermobaric velocities of light will be equal for them.

However we cannot introduce the common space for GQ-FR of all matters because of the presence of the different intrinsic metrics of the space for each matter [29, 30]. Therefore, not gravity-quantum but thermodynamic metrical value of matter molar volume is used in the GR and in people's world. In analogy to quantum clock[73], quantum and any other length standards can be used in GT-FR of people world only due to stability of their length when values of temperature and pressure remain constant. The least influenced by temperature and pressure are only the atomic standards of length that are based on the stability of frequencies of emission radiations. According to all of this, in RGTD, the same as in GR, it is rational to use only the common for all matters intrinsic space[74] of GT-FR. And, that is why f_G, f_I and v_l should be considered as the parameters that are not identical, but equivalent to pseudo-vacuum coordinate-like velocity of light v_{cv} of GR. The usage of the universal for the whole RGTD-bonded matter unified gravithermodynamic time that can be counted by standard atomic clock in real conditions (instead of coordinate gravity-quantum times, which flow rate is different for different matters and in different points of the space, and which are counted by their quantum clock) is quite rational. It allows avoiding the necessity of transformation of time within the whole matter that is in the sate of RGTD-equilibrium. The possibility and necessity of this is due to the existence of closed system[75] of all self-consistent pairs of additive one to another intensive and extensive thermodynamic parameters of matter when it is in the state of RGTD-equilibrium. Existence of such closed system is revealed in the fulfillment of the Le Chatelier-Braun principle in all RGTD-processes[76].

In contrast to gravitational potentials and external scaling factors used in GR, RGTD-values of gravitational potentials and internal scaling factors are not equal for different contacting matters. Only spatial gradients of the logarithms of frequency f_G of intranuclear and f_I of electromagnetic interaction in all matters (they are identical to gravitational field strength), as well as spatial gradients of the logarithms of internal scaling factor N_I, are mutually equal in the same

[72] This is analogous to its decreasing in the background Euclidean space while approaching the center of the star. However in the latter case he decreasing of the quantum length standard corresponds to the increasing of not only internal but also external scaling factor. That is why the curvature of intrinsic space of the star takes place.

[73] In contrast to the rate of conventional quantum clock the rate of atomic clocks does not change in quasi-equilibrium processes of the change of thermodynamic state of their matter.

[74] The examination of every certain matter in intrinsic quantum space can be useful during the analysis of its thermal equations of the state. The multiplicative change of the magnitude of molar volume that takes place during the conformal transformation of spatial coordinates should be accompanied by the partial additive compensation of this change in the thermodynamics. It is possible that non-equal for different gases additive corrections for molar volume of ideal gas, which are used in thermal equations of the state, are directly related to inequality of their internal scaling factors.

[75] Due to the self-consistency of all pairs of intensive and extensive parameters this system should be considered not only as closed, but also as self-enclosed.

[76] Not only the gravitational pseudo-force, but also the buoyancy force that partially or completely compensates this pseudo-force influence the moving matter in water, atmosphere or outer space. All RGTD-parameters (including intranuclear temperature and intranuclear entropy) are changing, according to principle of Le Chatelier-Braun, in submerged to water matter, which is lighter than it is in the process of reaching the new state of its equilibrium.

world point. These spatial gradients of logarithms f_G ($\mathbf{grad} \ln f_G = \mathbf{grad} \ln(v_l / c) \equiv \mathbf{grad} \ln(v_{cv} / c)$) for all matters[77] are identical to the gravitational field strength in this point. The presence of identical spatial gradients in the same point of space justifies the usage in GR of the conventional coordinate (pseudo-vacuum) velocity of light v_{cv} instead of intranuclear frequency of interaction f_G. Related to it problems appear in GR only in the process of "stitching" of the solutions of equations of gravitational field for different matters. And this is related also to their stitching with fictive solutions for physically unreal absolutely empty space (spatially inhomogeneous pseudo-vacuum) [29, 30]. So, differential equations of GR gravitational field are definitely determine only the gradients of potentials and not the gauge transformed potentials of gravitational field themselves. However, in non-empty space they principally allow to switch from v_{cv} to f_G, f_I and v_{cm}. And, therefore, these problems are solvable in GR. It is necessary and enough to determine (from equations of thermodynamics) the values of f_{I0} and v_{cm0} only in any single point of matter that is in the equilibrium RGTD-state. Then the spatial distributions of f_I and v_{cm} in any matter can be determined with the help of the solutions of GR equations. It is necessary to use correspondent v_{cm0} and f_{I0} values of coordinate-like velocity of light v_{cv0} and the known dependency of v_{cm} on f_I or on correspondent to f_I thermodynamic parameters of matter.

Decreasing of the lengths of electron orbits in atoms and, therefore, also the decreasing of the wave length of emissive radiation in the photosphere of quasi-equilibrium compressed gas is practically completely compensated by decreasing of velocity of radiation propagation in it. This is also confirmed by the fact that emission radiation frequencies practically do not depend on thermodynamic parameters of matter. This is also reflected in the negligibly small broadening of spectral lines.

However, such total compensation is absent at non-equilibrium state of ionized gas (proton-electron plasma) of quasars, situated in strong electromagnetic field (very saturated by radiation). Due to this and due to the proximity of the photosphere of shell-like quasars to the singular sphere they have the big gravitational redshift of the wavelength of radiation.

In contrast to "cooling down" stars, supernovae are heating up and, therefore, not contracting but catastrophically expanding due to annihilation of matter and antimatter [37, 39, 40, 43]. Instead of undercompensation of gravitational shift of radiation spectrum its thermodynamic

[77] Of course, the denser matter (body), which is placed into less dense matter medium, induce the additional local gravitational field in it. And, thus, it changes the spatial distribution of strengths of total gravitational field. However, in the process of body free fall, comoving with it its intrinsic gravitational field does not affect the acceleration of its free fall.

overcompensation takes place – as a result, not red but blue gravithermodynamic shift of this spectrum takes place. Decreasing of quantum length standard (increasing of N_I) that is not completely compensated by the decreasing of velocity $\breve{v}_c$ of interaction propagation causes not only the increasing of the frequency of electromagnetic interactions $f_I = N_I v_{cm}/c \neq \mathbf{const}$ for the supernovae, but also increasing of the frequencies of emissive radiation $\mathbf{v} = \mathbf{v}_0 N_I v_{cm}/N_{I0} c \neq \mathbf{const}$.

Therefore, energy of ionized rarefied gas of the dropped supernovae shells, as well as non-Doppler values of its emissive radiation, can be increasing along with increasing of pressure in the outer space at the advancing to cosmological past. Actual value of red shift of supernovae radiation spectrum can be substantially lower than its theoretical value, determined by Hubble relation, due to the presence of such negative feedback. So the presence of dark energy in the Universe is not necessary.

Obviously in GR gravitational field equations not strictly thermodynamic value of matter molar volume is mainly used. Therefore, additional coordinates transformation is required for the transition from used in GR local intrinsic FRs of matter and from similar to them GQ-FRs to GT-FRs of people's world. Only in this case the curvature of intrinsic spaces of matter is determined only by spatially inhomogeneous relativistic shrinkage of radial intervals and by radial delay in conformally-gaugely evolutionary-gravitational self-contracting of matter dimensions in CFREU (by evolutionary-gravitational "deformation" of its micro-objects).

18. Internal contradictions in the theory of relativity and the main differences between the theory of relativity and relativistic gravithermodynamics

Below is the list of facts that are internal contradictions in GR and SR:

1. The necessity in use of intrinsic time (instead of classical absolute time) of moving matter, rate of which is determined by the rates of quantum processes in matter, is declared in SR. However, standard atomic or quartz clock is used instead of quantum clock of this matter. The rate of standard atomic or quartz clock, in contrast to the rate of quantum clock, is set not by the standard of time or hypothetical pseudo-vacuum velocity of light but by (used in them) the standard of length and pseudo-real velocity of propagation of electromagnetic interaction, which corresponds not to the real but to the standard external conditions. And, therefore, their time count, in contrast to quantum clock, does not depend or dismissively weakly depend on thermodynamic parameters of matter and on correspondent to them velocity of propagation of electromagnetic interaction. Thus, the influence of pressure and temperature on relativistic dilation of coordinate (gravity-quantum) time of matter is not taken into account in the process of non-comfort (forced non-inertial) motion of this matter that is accompanied by the appearance of internal stresses and elastic deformations in

it. Not only the relativistic but also the gravitational dilation of gravity-quantum time has an influence on the rate of only intranuclear processes and, for sure, not of thermodynamic or biological processes. The changes of collective spatial-temporal state of the whole gravithermodynamically bonded matter take place synchronously and, therefore, with the same frequency in the whole space occupied by it. That is why the leading role in the people's world indeed belongs to the uniform gravithermodynamic time and not to gravity-quantum times.

The influence of pressure and temperature in matter on conformal-relativistic (non-elastic) shrinkage (or indeed the predicted by Lorentz transformations elongation [93 – 96]) of coordinate intervals in matter is also not taken into account in the SR. Exactly this shrinkage is responsible for the origin in observer's FR of the gravitationally-kinematic curvature of the part of its intrinsic space filled by non-comfort (non-inertially) moving matter. This leads not only to the unsuitability of SR trivial (non-conformal) transformations of increments of coordinates and time for the transition from intrinsic FR of rotating matter to observer FR (Ehrenfest paradox, enclosed trajectory paralogism), but also to the separate problems in GR. All of this is the main reason of imaginary necessity of such absurd entities as "dark energy" and "dark non-baryonic matter" in the Universe [62, 65, 83 102, 109]. Paradoxical dilation of the intrinsic time of distancing from observer galaxies (according to SR and GR) contradicts to the rapid flow of physical processes in distant cosmological past according to the Big Bang theory of the Universe.

Along with the absence of usage of effective value of gravitational constant ${}^{E}G_{eff}={}^{E}G_{00}/\mathrm{b}^2={}^{E}G_{00}f(z,\mu_{os})$ the main reason for imaginary necessity to have non-baryonic dark matter in the Universe is the misconception about relativistic dilation of intrinsic time of the galaxies that are distancing from the observer at a high velocity. Exactly due to this misconception it is wrongly considered that in the intrinsic time of such galaxy the stars rotate around its center at significantly larger velocities than in the time of distant observer. The centrifugal forces of inertia (in case they are significantly larger than in reality) require the false necessity to have significantly bigger gravitational field (namely to form which the imaginary dark matter is required).

Moreover, the transformations of increments of coordinates and time in SR correspond not to the IFR of inertially moving bodies, but to FR of uniformly (pseudo-inertially) and quasi-uniformly (quasi-pseudo-inertially) moving matter in the process of its gradual cooling down in astronomical objects. However, there the mutually observed shrinkage of longitudinal coordinate sizes of moving bodies is just the consequence of non-simultaneity of simultaneous events that happened in different places in FR of moving observer. In CFREU the relativistic self-contraction of size of moving bodies is isotropic in principle as well as their gravitational self-contraction. In intrinsic FR of matter any relativistic shrinkage of size is unobservable in principle. Instead of it there is a local anisotropic kinematic curvature of intrinsic space of the observer in the place of instantaneous dislocation of moving body.

On the other hand all this shows that both SR and GR are based purely on intranuclear physical processes. And, consequently, the usage of thermodynamic extranuclear parameters of matter instead of its gravithermodynamic intranuclear parameters in tensor of energy-momentum of GR is nonsense.

2. Despite the fact that only the Newtonian (GT-Hamiltonian) and the Keplerian (GT-Lagrangian) strictly correspond to Kepler's laws and orthodox SR, the differential equations of GR are built on the basis of using the alternative Hamiltonian and Lagrangian of classical physics, respectively. This leads to the misconception that in the process of inertial motion of bodies in a gravitational field, the Hamiltonians of their rest energy must be conserved, and not the Newtonians of their inertial free energy and the Keplerians of their ordinary energy (the multiplicative component of the Gibbs free energy).

3. The fact that intrinsic STC of matter is formed directly by matter itself is declared in GR. In spite of this, values of components of STC metric tensor are considered to be independent from all properties of matter, located in concrete point of space. Thus, metric tensor in this point determines equal (not gauge mutually transformable, as it is expected) values of gravitational potentials for all possible thermodynamic states of matter Therefore, coordinate velocity of light, used in GR, is not a characteristic of matter, but, in fact, is a characteristic of the form of matter being – space, and can take any values that do not correspond to thermodynamic matter parameters[78] and to real velocities of propagation of electromagnetic waves in it. This leads to the necessity of using in GR the special differential operators for dependencies of matter energy and momentum on its physical parameters. It also leads to the need to replace very massive neutron stars[79], which have the topology of a hollow body in the background Euclidean space and mirror-symmetric inner space, fictional "black holes".

4. Influence of gravitation on matter, as well as influence of nonuniform motion on matter, causes not only spatial inhomogeneity of the gravity-quantum rates of coordinate time of matter. This influence also leads to inhomogeneous deformation of matter on the level of correspondent to its nucleons terminal outlets of the turns of the common spiral-wave formation of the Universe in both background intrinsic space of the observer and in background Euclidean space of CFREU [25]. The principle of unobservability of such deformation in all matter intrinsic FRs remains valid in GR. However, there is some exception in GR for relativistic length shrinkage: it is considered as

[78] When coordinate-like velocity of light tends to zero the pressure and the temperature of matter tend to infinity. And, therefore, singularities on the external surfaces of astronomical bodies cannot appear in principle. However, this is ignored in the solutions of GR gravitational field equations.

[79] The mass of such neutron star is not limited by anything since the minimum possible value of Schwarzschild radial coordinate (which corresponds to its mid singular surface that separates matter and antimatter) can be arbitrary large [39 – 41].

observable in all FRs, not comoving with moving matter. This leads to the finiteness of the intrinsic space of matter in the Schwarzschild solution of the equations of gravitational field when the value of cosmological constant is non-zero and also to the formation of four-momentum by the hybrid enthalpy of matter and not by the ordinary rest energy and also to other disadvantages of relativistic generalization of thermodynamics with Lorentz-noninvariant volume [63, 64].

5. The equations of gravitational field of GR allow getting the solutions with anisotropic as well as with isotropic gravitational deformation of microobjects of matter in background Euclidean space [38]. And usually the anisotropic solutions, similar to Schwarzschild solutions, are considered more preferable. Indeed the unobservable in intrinsic FRs of matter gravitational deformation of microobjects of matter as well as their evolutionary deformation is purely isotropic similarly to relativistic deformation of microobjects of inertially moving matter. This, obviously, is the consequence of the acceptance in SR of false statement about the presence of relativistic deformation only of longitudinal size of moving mater.

6. Changeability of values of interaction distances of matter micro-objects in thermodynamic processes (these values together with the velocity of propagation of interaction determine the frequency of interaction) is not taken into account in GR. This causes the fact that GR gravitational field equations correspond to FRs of STC, but not to GT-FR of all matters, to which RGTD equations correspond. This makes GR equations useable only for homogeneous cooled down to the limit matter. And this takes place despite the fact that clusters of real gases are fundamentally not able to cool down to the limit in any arbitrary long period of time. Because in order to cool down to the limit they should previously become degenerate and turn into gas that consists from the neutrons that do not interact electromagnetically.

The fact that vacuum (coordinate-like pseudo-vacuum) velocity of light is more privileged than true velocity of light in matter in SR and GR makes these theories more corresponding to unrealizable in principle – degenerate states of matter than to real states [29, 30, 39, 40]. The fact that imaginary relativistic time dilation, as well as gravitational potential (and integral equations of gravitational field in matter), are strictly independent from concrete values of any characteristics[80], of this matter denotes the excessive simplicity of SR and GR that causes the primitiveness of representation of objective reality by these theories. The "beauty" of these theories, related to their simplicity, does not correspond to, in fact, not very "beautiful" objective reality.

In spite of this, the most of the original positions and principles of SR and GR are saved in RGTD. The main distinguishing characteristics of RGTD are the following original positions and principles:

[80] In fact only the spatial gradients of these parameters of matter (not the determined by them gravitational potentials) can be independent.

1. Physical vacuum is a continuous (structureless) substance that is not involved in motion and rests in CFREU. Matter micro-objects (elementary quasiparticles) and electromagnetic waves are only the non-mechanically excited states of this substance [37, 43, 44].

2. RGTD-state of matter is the spatially inhomogeneous average statistical macrostate of this matter. This state is determined by statistical distribution of possibilities of various collective space-time microstates (Gibbs microscopic states) of the whole gravithermodynamically bonded matter. Discrete changes of collective space-time microstate of matter take place at de Broglie frequency, which corresponds to the collection of all jointly moving objects of this matter, and propagate as the quanta of action with a superluminal phase velocity. This takes place instantly in FR, comoving with matter, because of the fact that propagation front of quantum of action (that is responsible for the change of collective space-time micro-state of matter) is identical to the propagation front of succeeding time instant of moving matter both in CFREU and in FR of each of the observers of its motion.

3. Transfer of phase changes of collective space-time microstate of matter, as well as of graviinertial field (gravitational field, removable by coordinates transformation) strength, at a superluminal velocity do not accompanied by the propagation of changes of electrical and magnetic field strengths in the matter and, so, not accompanied by energy transfer [45, 46]. Released intranuclear energy of matter transforms into kinetic energy of directed motion before matter is filled in with external energy transferred at velocity of sound. Therefore, despite of the change of its motion velocity, matter moves only inertially during this period of time. In fact, free fall of matter in graviinertial field takes place.

4. Any arbitrarily rarefied matter of cosmic vacuum should be considered as “incoherent matter”, which abides to the thermodynamic laws, in analogy to ideal gas of non-interacting molecules [29, 30]. Because of this, and also because of principal unattainability of the zero value of pressure in gas-dust matter of outer space, it is inadmissible not to take into account gradual decreasing of pressure in cosmic vacuum at the distancing from compact matter. And, therefore, vacuum solutions of gravitational field equations are senseless. Moreover, the absence of absolute vacuum makes the postulation in SR of isotropy of hypothetical vacuum velocity of light in moving body in FR (in which the matter motion is observed) outdated. SR transformations admit the anisotropy of real velocity of light in moving isotropic matter in this FR. And, of course, relativistic transformations should also allow the anisotropy of the real speed of light in the very rarefied gas-dust matter of outer space carried away by a moving astronomical body. In turbulent layer between dragged and not dragged by motion matter the gradual transition from anisotropy to isotropy of velocity of light will take place.

5. In contrast to the velocity of propagation of real electromagnetic waves in matter, conventional gravity-thermo-baric (gravity-baric) velocity of light in homogeneous matter, which is not equal but only proportional to the pseudo-vacuum coordinate-like velocity of light in GR and limit velocity of individual motion of definite substance in RGTD, does not depend on the frequency of these waves. Values of this velocity are equal in straight and opposite directions at propagation of radiation along the direction of matter motion. This is caused by the fact that motion inducts relativistic changes of refractive index of moving matter. These changes cause the fact that values of gravity-baric components of longitudinal and transversal values of refractive index are not similar. The values of longitudinal and transversal components of refractive index guarantee the invariance to the transformations of coordinates and time of thermodynamic potentials and parameters of matter and the correspondence of relativistic values of longitudinal and transversal components of gravity-baric velocity of light to generalized relativistic nonvacuum transformations of spatial coordinates, time and velocities [51]. The invariance of Hamiltonian of inert free energy and Lagrangian of ordinary rest energy of inertially moving matter relatively to relativistic transformations is caused by relativistic invariance of unified gravithermodynamic time of the whole RGTD-bonded matter.

6. Relativistic transformations of spatial coordinates and time of SR are the vacuum degeneration of generalized relativistic transformations [51]. Relativistic shrinkage of coordinate size ("coordinate intervals") is isotropic conformal in general case and, therefore, is able to guarantee the invariance to the transformations of coordinates and time of thermodynamic potentials and parameters of matter as well as guarantee the absence of relativistic dilation of intrinsic time for inertially moving bodies. Moreover, during the inertial motion it also guarantees the absence of declared in SR non-fulfillment of simultaneity of events that happened in different places in FR of moving body, which are simultaneous in observer's FR. And it depends not only on velocity of matter motion, but also on the pressure inside the matter[81]. The fact that graviinertial field is originated in nonuniformly rectilinearly moving matter, as well as in rotating matter, causes the fact that unobservable in principle all-round deformation of matter in background regular space is gravitationally-kinematic, in fact. Relativistic time dilation can be gravitationally-kinematic also for any noninertially moving matter. And it is purely gravitational for inertially moving massive astronomical object that has its own gravitational field as well as for any body that is even non-inertially moving but has the conformally deformed Möller FR. In contrast to GR in RGTD not only evolutionary but also gravitational and kinematic deformations of microobjects of matter in background Euclidean spaces are strictly isotropic.

[81] It will also be dependent on the temperature in the case of the absence of thermal equilibrium in matter.

Graviinertial field in GR can be considered as removable only conventionally. Spatial inhomogeneities of thermodynamic state and of observable (non-relativistic) deformation of moving matter that correspond to coordinates transformation are not removed at this transformation. Differentiated tracking of the influence of removable and unremovable gravitational fields on spatial inhomogeneity of thermodynamic state of matter is impossible in GR in general case. Therefore, in GR, in contrast to RGTD, in general case gravitationally-relativistic dilation of physical processes in matter cannot be decomposed on multiplicative components that separately correspond to unremovable (external) and eliminable gravitational fields and to purely kinematic impact.

7. Intrinsic spaces of matter are metrically homogeneous (isometric) in principle. Gravitational, as well as relativistic, shrinkages of dimensions (length standards) and molar volumes are unobservable in these spaces. Gravitational curvature and comoving with moving object kinematic "curvature" of intrinsic space of motion observer are observable in these spaces, instead of these shrinkages. The time dilation that is caused by gravitational field in the state of rest of matter is de facto completely compensated by the inertial motion of the matter. Similarly, the relativistic dilation of only coordinate (and not metric) time is observed in GT-FRs on the distant galaxies (which move away from the observer and at the same time freely fall on the events pseudo-horizon). Therefore, purely Lorentz relativistic transformations of SR are the transformations of the increments only of coordinates, but not of metrical intervals [63, 64]. And, moreover, in contrast to Lorentz-conformal transformations they do not guarantee the invariance of thermodynamic potentials and parameters as well as the absence of dilation of intrinsic time for inertially moving bodies.

8. General covariance of equations of matter motion and state (and, in fact, general covariance of the majority of physical laws) to the coordinates transformations takes place only for spaces of the GT-FRs of matter, namely, only for the spaces, in which matter deformations caused by relativistic and evolutionary-gravitational "deformations" of its micro-objects (correspondent to them spiral-wave formations) are unobservable in principle. Such deformations are "observable" in background Euclidean space [25] of CFREU (only in this space Universe can be homogeneous). A completely different formulation of the majority of nature laws, as well as other transformation of intensive and extensive parameters and characteristics of matter that correspond to this formulation and possibly different form of equations that determine interrelations between them are needed for intrinsic GQ-FRs of matter, in which not only evolutionary but also RGTD-"deformations" of its micro-objects (changes of their interaction distances) are unobservable in principle.

9. All thermodynamic parameters and characteristics of matter can fundamentally be examined only with the usage of comoving with matter gravity-quantum clock, only by which the eigenvalue of its mass is equivalent to the eigenvalue of its ordinary rest energy. Moreover, they are invariant

under both transpositional gravitational (spatio-temporal) and kinematic (Lorentz-conformal) relativistic transformations of coordinates and time in principle. During the observation of resting or inertially moving matter from the points with different gravitational potentials (and, consequently, with the usage of gravity-quantum clock with different time rates) only the strength of gravitational field, in which the observed matter is located, is being transformed. The really metrical values of mechanical and thermodynamic parameters and characteristics of matter do not depend on the rate of time of gravity-quantum clock. And, consequently, temperatures of phase transitions are the internal properties of matter of not only resting, but also moving bodies. The permanence (Lorentz-invariance) of observed thermodynamic state of moving matter when switch from its observation from any of IFR to the observation from any other IFR is provided by the calibration effect of classic inertial (hypothetic uniform) motion on the matter. It is guaranteed by the save of initial proportionality of observed rates of all physical processes to the rate of intrinsic time of moving matter. Ant the cause of all this is the self-consistency of all pairs of intensive and extensive thermodynamic parameters of matter that are complementary to each other. They form the self-enclosed RGTD-system.

10. Spatial inhomogeneity of RGTD-state of the whole gravitationally bonded matter (including extremely strongly rarefied “incoherent matter” of the outer space) is the cause of the presence of gravity. In ideal gas and in ideal liquid this spatial inhomogeneity fundamentally cannot be self-organized due to the absence of electromagnetic interaction between molecules of these hypothetic substances. This inhomogeneity is reflected in real homogeneous matter as certain spatial distribution of inert free energy and of corresponding to this energy the nominal intensive parameter – relative average statistical value of the frequency of intranuclear interactions (alternative to pseudo-vacuum coordinate-like velocity of light of GR). That is why gravitational field is de facto the field of spatial inhomogeneity of gravithermodynamic state of matter and cannot be any independent form of matter. This field was originated due to the gravithermodynamic advance in the evolutionary process of increase of thermodynamic internal energy and correspondent to it decrease of the inert free energy in lower layers of matter. And it is the consequence of self-organization of collective macrostate of jointly moving matter that corresponds to the minimums of total (integral) values of all free energies of this matter. However, of course, gravitational field can be also considered as the spatial distribution in CFREU of the density of turns of spatial-temporal modulation of dielectric and magnetic permeabilities of physical vacuum.

11. In GR it is suggested that in the state of thermodynamic equilibrium not only the strictly concrete, but also different values of coordinate-like velocity of light of astronomical objects of different mass can correspond to all identical thermodynamic parameters of one and the non-rigid

(liquid or gaseous) matter within the whole volume of astronomical objects. At the same time, for all contacting substances the gravitational potential remains the same.

In RGTD the gravitational field sets only the gradients of gravitational potential (of logarithm of the average frequency of quantum change of Gibbs thermodynamic microstate or of correspondent to it logarithm of the rate of gravity-quantum time). The value of the gravitational potential itself is set by the properties of matter and by its thermodynamic state. And, consequently, for contacting substances the gravitational potentials (logarithms of the average frequency of quantum change of Gibbs thermodynamic microstate) can essentially differ one from another. For the homogenous matter the smaller are the temperature and pressure the bigger is the limit velocity of its motion and, consequently, the bigger is its gravitational potential. For more light matter the gravitational potential is always bigger than for surrounding more heavy matter. That is why in quasi-equilibrium state of matter when there is no external or internal heating of the matter the more light substances are being displaced upward by more heavy substances. However, when such displacement is impossible the gravitational potential of more light substances will be bigger than the gravitational potential of more heavy substance that covers them. And when there are lacunas in more heavy matter the less heavy liquids can leak into it via flowing down and displacing the more light gases upward. In forced state the gravitational potential of gases and liquids can be artificially decreased or increased together with the increasing of pressure and temperature in them.

That is why in relativistic thermodynamics, the same as in classical thermodynamics, all characteristic functions (potentials, including the gravitational potential) of liquid or gaseous homogeneous matter, which is under the influence of only all-round pressure and is only in the same aggregate and phase state and also in the state of both thermal and mechanical equilibriums, are determined only by two independent parameters [29, 30] (while in GR there are three such parameters).

In RGTD, the product of the maximum possible velocity of individual motion of a certain substance and the relativistic shrinkage of its size $v_{lc} = v_l \Gamma = cT_{00} / T$, which is preserved in the process of inertial motion, is clearly determined only by its individual constant T_{00} and its absolute temperature *T.* Moreover, in RGTD gravitational field equations define only equal gradients of logarithms of relative frequency of intranuclear (quantum) interactions for all matters. However, the values of this frequency themselves are not the same are not the same and not only for different matters, but even for different atoms of matter molecules.

12. Bodies free fall in gravitational field – is an original realization of tendency of the whole gravitationally bonded matter to the minimum of the integral value not only of inert free energy, but also of thermodynamic Gibbs free energy. Bodies that fall independently accelerate in physically inhomogeneous space. In such way bodies transform their continuously released

intranuclear energy into kinetic energy. And this happens due to the fact that momentum is not conserved (in physically inhomogeneous space [61]) by virtual quanta of energy, which are the objects of exchange in the process of interaction between atoms and nucleons (correspondent to nucleons terminal outlets of the turns of spiral waves [37, 43, 44]). After the fall of the matter in gravitational field and its transition to thermodynamic equilibrium with the environment its internal energy becomes bigger than it was before the fall. And, consequently, matter transits into its new thermodynamic state that corresponds to its new gravitational potential. And its new gravitational potential (logarithm of the average for all mutually moving substances frequency of quantum change of Gibbs thermodynamic microstate or correspondent to it logarithms of conventional gravithermobaric velocity of light or limit velocity of matter) can be non-equal to gravitational potential of matter of surrounding environment.

13. Removable gravitational (graviinertial) field, which is inducted by quasi-hyperbolic motion of matter during the process of its free fall, totally compensates external gravitational field. And, therefore, more dense particles cannot overtake less dense particles of “incoherent matter” in principle. Pressure in this matter, as well as relative frequency of intranuclear interactions, is spatially homogeneous (and this is reflected in the zero-gravity state). Matter free fall can be strictly inertial motion of matter only in hypothetic absolute vacuum. Therefore, matter free fall in atmosphere, as well as in the outer space, is only a quasi-inertial motion.

14. Gravitational mass of inertially moving matter is strictly equivalent to the Lagrangian of its ordinary rest energy and, therefore, (the same way as this Lagrangian) it also conserves in the process of this motion. Inertial mass of inertially moving matter is strictly equivalent to the Hamiltonian of its inert free energy and, consequently, it also conserves in the process of this motion. That is why it is wrongfully to state that these masses are identical or equivalent one to another. We can only say about conventional identity or equivalence of these masses one to another only by the clock of the point, in which matter started to move inertially, due to the correction of the value of gravitational constant that guarantees the conventional absence of bound energy of matter in centric or pseudo-centric intrinsic FR of this matter. The ratio of these masses is invariant due to the conservation (in time) of Hamiltonians of inert free energy and of Lagrangians of ordinary rest energy of inertially moving gravity-quantum clocks of observed matter and of observer. Not the rest energy of matter, but only its inert free energy, which is equal to the sum of free energies of nucleons and energies of intranuclear bonds and interactions, is equivalent to inertial mass. Gravitational force that does not execute work is equal to the product of the Lagrangian of ordinary rest energy of the matter and the gradient of logarithm of relative frequency of intra-atomic interactions. By analogy, d’Alembert inertial pseudo-force is equal to the product of

the Hamiltonian of matter inert free energy and the derivative along the traversed path from the logarithm of isotropic shrinkage of the sizes of moving body in background regular space.

In contrast to the Hamiltonian of inert free energy, the Lagrangian of ordinary rest energy of resting or inertially moving matter is invariant not only to kinematic but also to gravitational relativistic transformations due to the invariance of all thermodynamic parameters and potentials of matter to those transformations.

15. When the thermodynamic state of liquid or gaseous matter is equilibrium the gradients of conventional average value of frequency of intranuclear interactions are determined only by the gradients of its gravithermodynamic parameters. The frequency of the wave of one and the same emissive radiation remains the same in the whole (and even extremely rarefied) gas that is located at the long distance from the gravitational attraction center. And, therefore, declared in GR gravitational redshift of the spectrum of emissive radiation of purely gaseous matter (which is strictly in thermodynamic equilibrium) of the non-layered astronomical object that does not have liquid or solid nucleus is impossible in principle. It can be only purely thermodynamic. The non-Dopplerian shift of the maximum of the spectral density of heat radiation in this astronomical object is strictly determined only by the temperature of matter in its photosphere. Gravitational redshift of the spectrum of emission radiation can take place only for non-rigid (liquid or gaseous) matters that are in non-equilibrium thermodynamic state or for any multilayered astronomical objects (including those containing a liquid or solid nucleus). And, therefore, non-Dopplerian redshift of the spectrum of emission radiation is mainly thermodynamic for the majority of astronomical objects. Mainly the Doppler broadening of spectral lines takes place for them. The very significant gravitational-thermodynamic redshift can be found only for the radiation of electron-proton plasma of quasar photosphere, which is located nearby the singular surface and, thus, in the strong electromagnetic field.

Conclusion

Gravitational field is the field of spatial inhomogeneity of gravithermodynamic state of matter and is not an independent substance (form of matter). Gravitational field cannot exist without matter, in principle, and, consequently, cannot have its own energy and own linear momentum that differs from energy and linear momentum of matter, which formed that field. Therefore, conservation of the sums of values of energy-momentum and moment of momentum together for matter and for gravitational field [110, 111] is not necessary both in GR and in the RGTD. All bonds and interactions between matter structural elements have the same electromagnetic nature [37, 43, 44], despite they all considerably differ one from another. And, therefore, gravitational field cannot be completely similar by its properties to electromagnetic field. Nature abhors uniformity. Nature "uses" new forms of bonds and interactions between matter structural elements on each new hierarchical level of self-organization of matter objects. However, for sure, all these forms are rather similar, because they are based on the same laws and principles of appropriateness. Statistical laws, which guarantee the correspondence of equations of RGTD-state of matter to the variational principles and, consequently, Le Chatelier-Braun principle, are the basis of gravitational and other RGTD-properties of matter. Gravity forces are evolutionary-gravitational pseudo-forces that force all matter objects to tend to spatially inhomogeneous collective equilibrium states with the minimums of the integral values inert free energy and thermodynamic Gibbs free energy of the whole RGTD-bonded matter. Because of this, GR gravitational field equations are, in fact, relativistic equations of spatially inhomogeneous RGTD-state of conformally-gaugely evolving matter (equations of RGTD) [29 – 35]. And, therefore, gravity – is only the peculiar (sui generis) manifestation of electromagnetic nature of the matter on the appropriate hierarchical level of self-organization of matter objects. And, of course, there are no such objects as gravitons and gravitational waves that transfer energy (if, of course, moving matter itself is not considered as these waves). Only the phase spiral waves of de Broglie – Schrödinger can be considered as the waves that transport only the change of collective phase (spatial-temporal) microstate of matter [110]. Gibbs collective gravithermodynamic microstates of matter are being described not only via thermodynamic potentials and parameters of matter, but also via its hidden parameters. These parameters are the wave functions that are able to take any arbitrary values with certain probability. The quantum equation of gravitational field, the solutions of which set the spatial distribution of gravitational radius of matter in its every new instantaneous gravithermodynamic state with the polynomial function with the next more high degree, is namely related to these parameters. The indicator of the degree of this function of continuously cooling down matter can successively take only integer and semi-integer values. That is why the process of cooling down of the whole GTD-bonded matter is the quantum process that is caused by its spontaneous transition to the polynomial function with more high value of degree and, therefore, to the next quantum-equilibrium collective state.

Inertial mass of moving matter is conventionally equivalent to its gravitational mass only by gravity-quantum clock of the point, from which matter started to move inertially, due to the correction of the value of gravitational constant that guarantees the conventional absence of gravity-mechanical bound energy of matter in centric or pseudo-centric proper FR of this matter. And that is why indeed everything in the world is relative. Namely the relative eigenvalues of physical parameters and characteristics of matter are their really metrical values in the people’s world. And, consequently, there is no need to kinematically or gravitationally artificially transform them to correspond to the readings of some clock. The usage of the formalism of gravity-quantum (coordinate) time allows performing only relative measurements of mechanical and thermodynamic parameters and characteristics of matter. In order to determine their really metrical values for observed matter being based on those measurements we additionally need to know to what their values the readings of gravity-quantum clock of the observer correspond to. And only in this case the observed values of mechanical and thermodynamic parameters of matter will be the same for all observers. And this is in a good agreement with the fact that gravitational field forms only the gradients of parameters and characteristics of matter and gradients of correspondent to it gravitational potential, which value can be changed only with the change of its parameters and characteristics. That is why except for the inert free energy and equivalent to it inertial mass all other really metrical and thermodynamic parameters and characteristics of matter do not depend on the readings of gravity-quantum clock and, consequently, are time invariant.

Enthalpy, which consists of the Lagrangian (or GT-Lagrangian) of its own multiplicative component and additive compensation of its multiplicative representation, is de facto the total energy of matter since it includes even the released thermal energy and the released kinetic energy of its motion. Enthalpy of matter (as well as Gibbs free energy, which own multiplicative component is identical to the ordinary rest energy of matter and is equivalent to its gravitational mass) is equal in all FRs of bodies that move inertially relatively to it. And exactly this is the guarantee of Lorentz-invariance of all thermodynamic potentials and parameters of matter. Since matter motion is accompanied by the all-sided conformally-gaugely self-contraction of its size in background Euclidean space of the Universe the rate of the intrinsic time of inertially moving body is not dilated but, quite the contrary, remains invariant, despite the presence of gravitational decreasing of the rate of intrinsic time for nearby static objects. De facto the motion of the matter as well as its gravitational self-contraction in background Euclidean space of the Universe leads to its advance over unobservable in people's world evolutionary self-contraction of the conventionally motionless matter in the Universe. That is why the release of kinetic energy is always accompanied by the decreasing of limit velocity of matter motion (that is equivalent to coordinate velocity of light in GR) and the decreasing of its inert free energy.

The internal energy of matter is bonded in a different ways in different physical processes. That is why we have various free energies in different processes. Both the change of the inert free energy[82] of matter (caused by its inertial motion) and its evolutionary decrease in CFREU do not directly influence the thermodynamic parameters of matter that are changed only in thermodynamic processes. That is why it is fundamentally unobservable in intrinsic FRs of matter in the similar way as evolutionary and caused by motion reduction of molar volume of matter is unobservable in comoving with expanding Universe FR. The gravitational reduction of molar volume of matter when approaching the gravitational attraction center is also unobservable directly in intrinsic FRs of matter. However, we still can say about its presence in Euclidean space of CFREU due to the presence of gravitational curvature of intrinsic space of matter. And we also can indirectly say about the presence of evolutionary self-contraction of matter due to the presence of not only the process of Universe expansion in FR of people's world, but also of correspondent to it global gravitational-evolutionary gradient lens (GGEGL). Moreover, not only evolutionary but also gravitational and kinematic deformations of microobjects of matter in background spaces (that form GGEGL) are isotropic. And, therefore, generally only the isotropic coordinates are used in RGTD. The evolutionary process of self-contraction of correspondent to matter spiral-wave formations forms not the ordinary but namely gradient global gravitational lens in expanding Universe [112], which is revealed in the form of ordinary lens only along the world line of propagation of radiation. Gravity-optic power of gradient lens is smaller the closer are the observed objects. And it portrays the infinitely far objects of the Universe on the events pseudo-horizon that belongs only to the infinitely far cosmological past.

The tensor of energy-momentum of matter (right side of the gravitational field equation) should be formed not being based on external thermodynamic parameters, but being based exactly on the intranuclear gravithermodynamic parameters. Therefore, the standard value of the average density of matter gravitational mass at the edge of a galaxy is determined by the cosmological constant Λ and the difference between unity and the maximum value of the parameter b_c. And it is a non-zero standard value, despite the gravitational radius at the edge of a galaxy takes the zero value. Consequently, the presence of dark non-baryonic matter in the Universe is unnecessary [76, 113].

Despite the fact that only the Newtonian (GT-Hamiltonian) and the Keplerian (GT-Lagrangian) strictly correspond to Kepler's laws and orthodox SR, the differential equations of GR are built on the basis of using the alternative Hamiltonian and Lagrangian of classical physics, respectively. This leads to the misconception that in the process of inertial motion of bodies in a gravitational field, the Hamiltonians of their rest energy must be conserved, and not the Newtonians of their inertial free energy and the Keplerians of their ordinary energy (the multiplicative component of the Gibbs free energy).

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