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Self-rotation of emitting galaxies without dark matter

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Abstract Temporal derivatives of the attracting mass in Newton's law of distant interactions can balance the centripetal and centrifugal accelerations for the rotating periphery of a spiral galaxy. Thermal losses of the mass-energy integral inside the circle of rotation are the cause of the mega-vortex organization of the emitting galaxy. To reject dark matter in cosmic distributions, a conceptual modification of the Euler/Navier–Stokes hydrodynamics is required using adaptive tensor responses with metric waves but not gravimagnetic corrections from General Relativity.

1 Introduction

Modern cosmology [1] encourages various models of dark matter to explain the observed constancy of the azimuthal velocity of stars at ultra-large distances (up to 200 kpc) from the galactic axis, where gravity is very weak and space is Euclidean. Proponents of dark matter substantiated its existence through the Keplerian motion under the inverse square force, which is well-proven in the Solar System. The observed constancy of circular velocities of remote stars contradicts relevant estimates of the galaxy mass distribution and infers halo mass profiles with dark matter [2].

Many authors [3–6] propose to discuss rotation curves of spiral galaxies with a spin integral **S** via gravi-magnetic fields or spin-spin interactions in general relativity (GR) to avoid the dark matter mystery. Despite a lot of thematic discussions and research efforts, the dark matter problem is still "one the biggest puzzles in cosmology" [7].

This paper suggests to look at the time-varying mass in the Newton law of gravitation in order to explore the galaxy rotational curves in the conventional frames of mass-energy distributions without dark fractions. First, we try to prove that GR corrections of spinning masses cannot significantly change the Keplerian trajectories in the central field. To

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model the rotational constancy of galaxy's cold periphery for trivial reasons of non-relativistic mechanics, we consider only the wave energy transfer from the hot central regions.

2 GR geodesics for rotation curves

It was derived by Einstein in 1914 [8] that the 4-acceleration $c^2(du_\mu/ds) - c^2\Gamma_{\lambda,\mu\nu}u^\lambda u^\nu \equiv c^2 u^\nu \nabla_\nu u_\mu \equiv c^2 u^\nu \nabla_\nu u_\mu - c^2 u^\nu \nabla_\mu u_\nu \equiv c^2 u^\nu(\partial_\nu u_\mu - \partial_\mu u_\nu) = 0$ of probe points or scalar mass densities μ_o determines their geodesic motion in strong metric fields, where $u_\mu \equiv g_{\mu\nu}dx^\nu/ds = \{\gamma\sqrt{g_{oo}}; -\gamma[v_i - c(g_{oi}/\sqrt{g_{oo}})]/c\}$, $u^\nu \nabla_\mu u_\nu \equiv 0$, and $\gamma = 1/\sqrt{1 - v_i v^i/c^2}$. Probe point masses or rest-frame densities $\mu_o = \mu/\gamma$ with different values have the same (universal) geodesic acceleration in external metric fields,

$$\begin{cases} \mu_o\gamma v^j[c^2\partial_j(\gamma\sqrt{g_{oo}}) + \partial_t\gamma(v_j - cg_j)] \equiv \mu_o\gamma \mathbf{v} \cdot \mathbf{E} = 0, \\ \mu_o\gamma\sqrt{g^{oo}}[c^2\partial_i(\gamma\sqrt{g_{oo}})+\partial_t\gamma(v_i-cg_i)]=\mu_o\gamma v^j[\partial_i\gamma(v_j-cg_j)-\partial_j\gamma(v_i-cg_i)] \\ \text{or in the three-vector designations} \\ \mu c^2\boldsymbol{\partial}(\gamma\sqrt{g_{oo}}) + \mu\partial_t[(\mathbf{v}-c\mathbf{g})\gamma] = (\mu/\sqrt{g^{oo}})\mathbf{v} \times curl[(\mathbf{v}-c\mathbf{g})\gamma]. \end{cases}$$

(1)

The 3-vector $(curl\ a)^i \equiv e^{ijk}(\partial_j a_k - \partial_k a_j)/2\sqrt{|g_{ps}|}$ is dual to the tensor $(\nabla_j a_k - \nabla_k a_j)$ in Euclidean and curved 3-spaces. Four geodesic relations (1) for point masses or moving probe densities $\mu_o\gamma(x) = \mu(x)$ generalize both the proven condition for non-dissipative Bernoulli flows and the eddy acceleration of ideal Euler liquids in the metric fields $g_o \equiv \sqrt{g_{oo}}, g_i \equiv g_{oi}/g_o, g_\nu \equiv g_{o\nu}/\sqrt{g_{oo}}$.

The upper condition for the local energy conservation (or zero work in the metric motion, $\mu\mathbf{v} \cdot \mathbf{E} = 0$) is a direct consequence (or convolution with the 3-velocity components $v^i \equiv cdx^i/g_\nu dx^\nu$) of the three equations of motion for the 3-momentum. The lower equation operates with the mechanic analogue, $\mathbf{b}(x) \equiv curl(\gamma\mathbf{v} - c\gamma\mathbf{g})$ of the magnetic field. The curl-derivatives of the 3-momentum balance reveal $\partial_t\mathbf{b}(x) \equiv curl[\mathbf{v} \times \mathbf{b}(x)/\sqrt{g^{oo}}]$ that results in the Helmholtz theorem for 3-velocity circulations over a closed contour.

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The exact geodesic equations (1) can describe the non-relativistic acceleration $d\mathbf{v}/dt \equiv \partial_t \mathbf{v} + (\mathbf{v} \cdot \boldsymbol{\partial})\mathbf{v} \equiv \partial_t \mathbf{v} + \boldsymbol{\partial} v^2/2 - \mathbf{v} \times curl\mathbf{v}$ of the probe density μ at the low-field periphery of a galaxy,

$$\begin{cases} \partial_t \mathbf{v} + \boldsymbol{\partial} v^2/2 - \mathbf{v} \times curl\mathbf{v} \\ \quad = -c^2 \boldsymbol{\partial}\sqrt{g_{oo}} - c\mathbf{v} \times curl\mathbf{g} + c\partial_t \mathbf{g} \\ \quad \approx c^2 \boldsymbol{\partial}[GM/c^2 r] + \mathbf{v} \times [\mathbf{S} - 3\hat{\mathbf{r}}(\mathbf{S} \cdot \hat{\mathbf{r}})]2G/c^2 r^3 \\ \quad -[\hat{\mathbf{r}} \times \partial_t \mathbf{S}]2G/c^2 r^2, \end{cases} \quad (2)$$

where one can use $1 - \sqrt{g_{oo}(r)} \approx GM(r)/r \ll 1$ and $v_r = v^r$, $v_\varphi = v^\varphi$, $v_z = v^z = 0$ for Euclidean 3-space. Far from the disk center, $r \gg GM(r)/c^2$ and $|\mathbf{g}(r)| \ll 1$, the Kerr four-potential $g_\mu \equiv \{g_o; \mathbf{g}\} = \{1 - (GM/c^2 r); -2G[\hat{\mathbf{r}} \times \mathbf{S}]/c^3 r^2\}$ of rotating masses [9] depends on the galaxy mass M and its angular momentum $\mathbf{S}$, with $|\mathbf{S}| \leq GM^2/c$.

The gravi-magnetic force, $-mc\mathbf{v} \times curl\mathbf{g} = m[\boldsymbol{\omega} \times \mathbf{r}] \times [\mathbf{S} - 3\hat{\mathbf{r}}(\mathbf{S} \cdot \hat{\mathbf{r}})]2G/c^2 r^3$, is vanishing at the Galaxy periphery as r^{-2}. This relativistic correction cannot explain the observed constancy of azimuthal velocities as well as the Newton force of inverse square distances from a constant mass. The non-stationary acceleration $2G[\hat{\mathbf{r}} \times \partial_t \mathbf{S}]/c^2 r^2$ of probe masses appears only for wobbling or precessing galaxies in external fields-forces, when $\partial_t \mathbf{S} \neq 0$. But, these non-stationary forces are normal to the galaxy spin $\mathbf{S} = (0, 0, S)$ and the unit vector $\hat{\mathbf{r}} = (1, 0, 0)$. They cannot contribute to the radial balance of stationary accelerations with $\partial_t v_r = 0$ and $\partial_r ([r\omega(r)]^2/2) - r\omega(r)curl[r\omega(r)] = -r\omega^2(r)$ in (2):

$$\begin{cases} -r\omega^2(r) = c^2 \partial_r \left[\dfrac{GM(r)}{c^2 r} \right] + \dfrac{2GS\omega(r)}{c^2 r^2}, \\ r\omega = -\dfrac{GS\omega}{c^2 r^2} \pm \sqrt{\dfrac{G^2 S^2 \omega^2}{c^4 r^4} - r\partial_r \left[\dfrac{GM(r)}{r} \right]} \\ \quad \approx \pm\sqrt{\dfrac{G(M - r\partial_r M)}{r}} - \dfrac{GS\omega}{c^2 r^2}. \end{cases} \quad (3)$$

This geodesic balance of stationary accelerations predicts very low shifts of the Kepler angular frequency $\sqrt{GM/r^3}$ at large rotation radii.

One can say that the geodesic relations of 1914 are incomplete because they do not take into account a finite spin $\mathbf{s}$ of probe bodies. However, spinning relativistic particles are also well studied in metric fields of external sources. Neither linear spin solutions,

$$\begin{cases} m\dfrac{Du_\mu}{ds} = -\dfrac{1}{2}R_{\mu\nu\alpha\beta}u^\nu s^{\alpha\beta} - \dfrac{D}{ds}\left(s_{\mu\nu}\dfrac{Du^\nu}{ds} \right) \\ \approx -\dfrac{1}{2}R_{\mu\nu\alpha\beta}u^\nu s^{\alpha\beta}, \quad \ddot{\mathbf{x}} \approx -\dfrac{GM\hat{\mathbf{n}}}{x^2} \\ -3\dfrac{GM}{mc^2 x^3}\left[\mathbf{v} \times \mathbf{s} - (\hat{\mathbf{n}}\mathbf{v})\hat{\mathbf{n}} \times \mathbf{s} - 2\hat{\mathbf{n}}(\hat{\mathbf{n}} \cdot [\mathbf{v} \times \mathbf{s}]) \right], \\ \hat{\mathbf{n}} \equiv \dfrac{\mathbf{x}}{x}, \quad \mathbf{x} \equiv \mathbf{r} - \dfrac{1}{2mc^2}\mathbf{v} \times \mathbf{s}, \end{cases} \quad (4)$$

of the Papapetrou equation for spinning bodies, for example [10,11], nor high-order spin corrections can explain the constancy of orbital velocities due to the vanishing contribution to Keplerian asymptotic. Ultimately, the well-studied GR amendments of Newtonian dynamics for point masses

in empty space cannot dominate at the weak field periphery of spiral galaxies with the surprising constancy of rotation curves.

3 Vortex self-organization due to wave energy transfer

Prior to the experimental search for dark matter, one could look at self-organizations of laboratory fluids to suggest more trivial reasons for centripetal accelerations in eddy macro-structures. Contrary to relativistic corrections and dark matter profiles in elastic metric systems, we propose to modify the galaxy rotation curves through inelastic options for radiation energy exchange and losses with metric (or electromagnetic) waves of warm black bodies. Indeed, the mass-energy content in the sphere of effective interactions r for a probe body is never constant, $\partial_t [GM(r, t)/c^2] \equiv \partial_t \int_o^r \int 2\pi r' G\rho(r', z, t)dr'dz/c^2 \neq 0$, in the thermal Universe due to the fundamental black-body spectra and heat exchange of hot galaxy centers with cold periphery densities and distant absorbers in the Metagalaxy. In the absence of dissipative processes, there are no gravitational collapses of the static gravitational field arising from the elastic metric organization of the mass-energy integral with the equilibrium Christoffel connections. Einstein's theory of positive mechanical energies $\gamma mc^2 \sqrt{g_{oo}}$ requires periodic falls and take-offs of probe masses in metric fields in the absence of inelastic collisions [12]. Only dissipative energy exchanges or external forces can reshape the time-averaged densities in a steady self-assembling system of distributed kinetic energies.

One can model radiation losses of mass-energy inside a finite galaxy disk through a phenomenological variable $\gamma_M(r, t) \equiv c^2 \partial_t [GM(r, t)/c^2]/GM(r, t) < 0$ in the simplest case of symmetrical densities in the disk integral $M(r)$. To calculate non-stationary self-accelerations $\partial_t v_r \neq 0$ on almost circular orbits at the galaxy periphery, we suggest using the non-relativistic virial theorem [9], $2\delta E_k(r, t) + \delta E_p(r, t) = 0$, for the adiabatic motion $\delta E/\delta t \equiv (\delta E_k/\delta t) + (\delta E_p/\delta t) = -(\delta E_k/\delta t) = \delta E_p(r, t)/2\delta t = (GM/2r^2)[(\delta r/\delta t) - r(\delta GM/\delta t)/GM] = 0$. Such a path-averaged evaluation of the radial speed $v_r \equiv \partial_t r = r\gamma_M(r, t)$ and acceleration $\partial_t v_r = r\Omega_M^2(r, t)$ introduces the tornado self-intensity $\Omega_T^2(r, t) \equiv \gamma_M^2(r, t) + \partial_t \gamma_M(r, t)$ in the non-stationary generalization of the steady vortex balance (3),

$$\begin{cases} r\Omega_T^2(r, t) - r\omega^2(r, t) = c^2 \partial_r \left(\dfrac{GM(r,t)}{c^2 r} \right) + \dfrac{2GS\omega(r,t)}{c^2 r^2}, \\ r\omega(r, t) \approx \pm\sqrt{\dfrac{G[M(r,t) - r\partial_r M(r,t)]}{r} + r^2 \Omega_T^2(r, t)} - \dfrac{GS\omega(r,t)}{c^2 r^2}. \end{cases} \quad (5)$$

Here, the Kepler law is modified for a large rotation radius $r \geq R_T \equiv (GM/\Omega_T^2)^{1/3}$ due to mass-energy losses in the central region of the self-organized mega-vortex. The non-

Keplerian auto-rotation curves $v_\varphi = r\omega \approx \pm r\sqrt{\Omega_T^2}$ obey the tornado regime, $r\omega^2(r,t) - r(\gamma_M^2 + \partial_t \gamma_M) = 0$, when the centripetal self-force, $-\mu r(\gamma_M^2 + \partial_t \gamma_M)$, from non-stationary masses locally balances the centrifugal force, $+\mu\omega^2 r$, for the periphery density μ.

Accepting equal relative losses $c^2 \partial_t (GM/c^2)/GM \approx \partial_t r_{Sun}/r_{Sun} = -6.13 \times 10^{-14} s^{-1}$ [13] for the Galaxy mass $M \approx 7 \times 10^{11} M_{Sun}$ and the Sun mass M_{Sun}, with $r_{Sun} \equiv GM_{Sun}/c^2 \approx 1.5 \times 10^3 m$, one can phenomenologically estimate the scale $R_T = [7 \times 10^{11} r_{Sun}(2.99 \times 10^8/6.13 \times 10^{-14})^2]^{1/3} \approx 2.6 \times 10^{19} m \approx 0.8\,kpc$ for the tornado mode transition in the Milky Way periphery, where $v_\varphi(r > R_T) \approx r\sqrt{\gamma_M^2 + \partial_t \gamma_M}$. The centripetal acceleration of the Solar System, concentrated at a distance of $8\,kpc$ from the axis of the Galaxy, is formed by both time and space derivatives of Newton's potential, $-GM(r,t)/r$. The available rotation data and their interpretation (5) make it possible to numerically evaluate the galaxy functions $r_M(r,t) \equiv GM(r,t)/c^2$, $\partial_r r_M(r,t)$, and $\partial_t r_M(r,t)$ in order to verify (or falsify) the model of mass-energy losses as an alternative to the dark matter introduction.

The specific rate of heat transfer $\gamma_M(r,t)$ through the energy radiation has been insufficiently studied not only in astronomical distributions, but also in the atmospheric tornado and the Ranque–Hilsch vortex tube [14]. Unlike the slow diffusion of energy in the heat conduction equation for inertial carriers, the transfer of wave energy is very fast in an air tornado and giant ocean whirlpools. The rapid exchange of black-body radiation between dense parts of thermal distributions should take place everywhere, both in astronomical organizations and in the whirlpool in the home bath (if the lowered temperature of the outgoing water in the drain funnel is measured accurately).

Tornado theories do not use dark matter profiles, but rather ascribe radial pressure to the medium to formally balance centrifugal and centripetal forces. In our opinion, the Euler/Navier–Stokes modeling of forced accelerations as 3-vector gradients of scalar pressure cannot adequately describe the nonlocal self-organization of moving adaptive densities with the tensor inertial feedback for vortex self-accelerations. The 4-vector responses of stress-energy densities on accelerating force densities depend on the tensor dynamics of metric stresses according to the findings of General Relativity. The one-line counterbalance of forces and accelerations (Newton's second law) is valid only for the whole body or the volume integral of inertial mass, but not for non-locally correlated densities in adaptive distributions of this fixed integral.

Advanced astrophysics of adaptive space-time organizations, including self-rotating galaxies, requires that Newton's model for collinear vector responses to applied pressure gradients be modified in Euler fluids by adaptive responses of tensor densities. Vector convolutions of tensor densities in a modified feedback with adaptive self-accelerations should lead to both parallel and normal inertial reactions to applied vector forces. Such a multidirectional response of tensor densities in their spatial transfer predicts the enhanced heat release perpendicular to the inertial jet streams. The adaptive response tends to dynamical equipartition of kinetic energies over all available degrees of freedom, but not to rectilinear acceleration of Navier–Stokes fluids without physical limitations. Turbulent feedback of moving tensor densities and their tornado self-organization arise in (5) due to the nonlocal properties of a slowly dissipating medium, since the volume integral of correlated energy densities should remain constant for the practically isolated Galaxy, with $\partial_t \ln(GM/c^2) \approx -6 \times 10^{-14}/s \approx -2 \times 10^{-6}/year$.

4 Conclusion

In advanced theories of mass-energy self-organization, thermal radiation of black-bodies should be associated with inelastic metric waves. These wave exchanges and elastic metric stresses should be nonlocally correlated with self-accelerations of inertial densities throughout an isolated macrosystem or megasystem, like in nonlocal matter of a quantum microcosm. Nonlocal correlations in cosmic organizations are already confirmed by many observations, e.g. [15,16]. The velocity dispersion in galaxy clusters confirms the mega-scale correlation of mass-energy distributions in the epoch before the first stars were formed. At that time, black-body radiation has already managed heat-energy exchanges between dense material regions. Nowadays, thermal waves (or metric waves in the geometrical space-time) between black-bodies warm accelerated asteroids and control heat exchanges between planets and their moons with volcanic activity in the almost isolated Solar System.

Instantly correlated elastic stresses and local self-accelerations of material densities in the metric space-time arise from the strict requirement for integral conservations of energy, momentum, and angular momentum in an isolated mechanical system, regardless of its spatial scale and time moment. These instantaneous correlations of elastic metric fields in nonlocal organizations are consistent with Laplace's estimate [17] of the unexplained stability of the Solar System and the elastic stability of other cosmological formations. The inelastic self-dynamics of mega vortexes in (5) depends on the phenomenological self-intensity $\Omega_T^2(r,t)$. A consistent theory of structural auto-assembling with wave exchanges between eddy densities at the constant first integrals for the whole system will analytically describe this self-intensity and galaxy rotation curves for different ages of the stellar population. In other words, the adaptive space-time theory for distributed self-organizations of the non-local

mass-energy should describe temporal increments and decrements of tornado processes in emitting galaxies before and after their spiral stages.

To abandon dark matter in cosmology, it is necessary to modify the Euler fluid equation using inertial feedback of tensor densities in order to then develop a nonlocal tornado theory for auto-twisting flows with adaptive radiation exchange and the non-equilibrium redistribution of thermal energy. Following this conceptual path without dark matter, the thermal mechanics of cosmic distributions would probably be designed in geometrical terms for adaptive self-assembly of continuous densities with correlated stresses and metric waves in the volume integral of nonlocal mass-energy.

Data Availability Statement This manuscript has no associated data or the data will not be deposited. [Authors' comment: This work is a purely theoretical study, which used already published data of the NASA MESSANGER mission in ref [13].]

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