

Extra Gravity in SPARC and KiDS-1000 Without a Dark-Matter Particle or Changing Newtonian Gravity: The Connection to Electron Mass and the Fine-Structure Constant

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Abstract

The extra gravity in SPARC disks and KiDS-1000 stacks is identified with organised mass in a physical matter substrate. The author names that substrate the Sparticle field. The Einstein cosmological constant with $\Lambda \approx 1.11 \times 10^{-52} \text{ m}^{-2}$ converts to $\rho_\Lambda = \Lambda c^2 / (8\pi G) = 5.9 \times 10^{-27} \text{ kg m}^{-3}$, or $u_\Lambda = 5.30 \times 10^{-10} \text{ J m}^{-3}$. That map is not adopted: it inherits H_0 , and published H_0 values include $\approx 64, 67.4$ and $73.50 \text{ km s}^{-1} \text{ Mpc}^{-1}$. The BFUT particle sector derives the equilibrium Sparticle-field density independently from the condensation functional and particle constants:

$$\rho_s = (G c^2 / 8\pi \hbar_{\text{vss}}^4) [m_e \text{vss} / \alpha_{\text{vss}}]^6 = 7.3 \times 10^{-27} \text{ kg m}^{-3}.$$

The particle-sector result is approximately 23.8 percent above the cosmological reference value and is adopted throughout this paper as $\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$. It follows from BFUT particle dynamics and is independent of H_0 and galaxy data. The factor $1/(8\pi)$ is fixed by the gravitational field-energy normalization and by the Einstein coupling of stress-energy to curvature. The Sparticle field is the physical matter substrate whose deformation is represented by spacetime curvature. Its finite density allows organised motion to entrain substrate mass, and that mass gravitates through the same $8\pi G$ coupling.

The substrate response scale is defined by the inverse-length parameter μ_s , with $\mu_s^2 = 3 G \rho_s / c^2$. The corresponding mass scale is $m_s = \hbar_{\text{vss}} \mu_s / c$. The organised-regime acceleration is

$$a_s = c^2 \mu_s / 3 = c (G \rho_s / 3)^{1/2} = 1.20840317 \times 10^{-10} \text{ m s}^{-2}.$$

The implied acceleration is $a_s = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$. Newton's law is not changed. No dark-matter particle is introduced. For organised substrate entrainment, the effective law is $g^2 = g_\beta^2 + \Theta a_s g_\beta$, equivalently $v^2 = v_\beta^2 [1 + \Theta a_s R / v_\beta^2]^{1/2}$, with $0 \leq \Theta \leq 1$. On 175 SPARC galaxies, $Y = 0.5$ locked, the median outer relative residual is 0.096, shape agreement is 92.0 percent, and flat classification is 98.8 percent. The same algebra at MOND's $a_0 = 1.20 \times 10^{-10} \text{ m s}^{-2}$ gives median residual 0.094. On KiDS-1000 Fig. 3, four mass bins and 60 points, the published 60×60 ESD covariance gives $\chi^2/N = 9.78$ for the DME law. Extra mass is therefore interpreted as organised or entrained substrate mass. In the fully organised

limit $\Theta = 1$, the deep-organised relation is $v^4 = G M_\beta a_s$. Ultra-diffuse and disrupted systems provide the complementary regime in which coherent entrainment can be weak.

Keywords: galaxy rotation curves; SPARC; KiDS-1000; weak lensing; dark matter; Newton; fine-structure constant; electron mass; MOND; matter substrate

1. Introduction

This paper identifies the physical fabric of space as pervaded by a matter substrate. The author names that substrate the Sparticle field. Ordinary matter is embedded in it. Newtonian gravity and the Einstein field equation are retained. The effective relation connects organised motion to the substrate mass that becomes coherently entrained and contributes to the total gravitating mass.

The extra gravity in disks, stacks and clusters is an observational fact (Rubin & Ford 1970; Bosma 1981; Lelli, McGaugh & Schombert 2016; Brouwer et al. 2021). The Spitzer Photometry and Accurate Rotation Curves database is denoted SPARC, and the 1000-square-degree data release of the Kilo-Degree Survey is denoted KiDS-1000. Cold dark matter assigns the extra gravity to a collisionless particle halo fitted per system. Modified Newtonian Dynamics (MOND) changes the relation between force and acceleration below a scale read from rotation curves (Milgrom 1983; Famaey & McGaugh 2012). BFUT identifies the Sparticle field as a real, physical, gravitating and deformable matter substrate in which ordinary matter is embedded. Organised or entrained Sparticle-field mass supplies the additional gravitating component.

The derivation has three parts. First, the BFUT condensation functional generates the particle constants and the substrate density. Second, the carrier dynamics generate the acceleration scale. Third, the Dark Matter Effects relation connects organised motion to entrained substrate mass and is applied to SPARC and KiDS-1000. Newtonian gravity remains unchanged throughout the calculation.

The extra gravitating component in these data is organised or entrained mass in the physical Sparticle substrate at the derived equilibrium density. That is the content of the law.

2. Substrate density

This paper derives the equilibrium density of the matter substrate, which the author names the Sparticle field. That density is written ρ_s . Two constructions are given. Section 2.1 converts the Einstein cosmological constant into a mass density. Section 2.2 derives ρ_s from the condensation functional and the particle constants. Only the second construction is adopted.

2.1 Cosmological-constant map

The Einstein cosmological constant Λ is converted to a mass density by $\rho_\Lambda = \Lambda c^2 / (8\pi G)$. The observational value of that constant is $\Lambda \approx 1.11 \times 10^{-52} \text{ m}^{-2}$. Substitution gives $\rho_\Lambda = 5.9 \times 10^{-27} \text{ kg m}^{-3}$. The corresponding energy density is $u_\Lambda = \rho_\Lambda c^2 = 5.30 \times 10^{-10} \text{ J m}^{-3}$. This is the cosmological-constant mapped value.

That conversion is not adopted here. The value of Λ used in Λ CDM is linked to the adopted cosmological parameter set, including H_0 , and H_0 is not unique. Published values include $\approx 64 \text{ km s}^{-1} \text{ Mpc}^{-1}$ (Faucher, Benisty & Mota 2026, A&A 705, A112), $67.4 \pm 0.5 \text{ km s}^{-1} \text{ Mpc}^{-1}$ (Planck Collaboration 2020), and $73.50 \pm 0.81 \text{ km s}^{-1} \text{ Mpc}^{-1}$ (HODN Collaboration 2026). Because the mapped density moves when H_0 moves, $5.9 \times 10^{-27} \text{ kg m}^{-3}$ is not the working density. The working density is the particle-sector result of Section 2.2, $\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$, which contains no H_0 .

2.2 Particle-sector derivation

The four-term free-energy functional $E(R) = A/R^2 + BR^2 + CR + D/R$ describes the condensation scale. The adopted dimensionless coefficients are $A = 1/2$, $B = 0.56308$, $C = -1/3$ and $D = 1$. A follows from the normalized quantum kinetic term. B follows from void-filling geometry. C follows from three-fold symmetry. D follows from one complete topological phase winding.

A is the quantum kinetic energy cost of confining the condensate. In SI, $A_{\text{SI}} = \hbar_{\text{vss}}^2 / (2 m_{\text{eff}})$. Convert to model units with $E_{\text{unit}} = m_{\text{eff}} c^2$ and $\ell_{\text{model}} = \hbar_{\text{vss}} / (m_{\text{eff}} c)$. Then $A_{\text{model}} = A_{\text{SI}} / (E_{\text{unit}} \times \ell_{\text{model}}^2) = [\hbar_{\text{vss}}^2 / (2 m_{\text{eff}})] / [m_{\text{eff}} c^2 \times \hbar_{\text{vss}}^2 / (m_{\text{eff}}^2 c^2)] = [\hbar_{\text{vss}}^2 / (2 m_{\text{eff}})] \times [m_{\text{eff}} / \hbar_{\text{vss}}^2] = 1/2$. Every factor of $\hbar$ and m_{eff} cancels. This identity does not depend on the value of R_0 or on any measured constant. The factor $1/2$ is the same factor that appears in the Schrödinger kinetic term.

D is the energy of one complete topological phase winding of the condensate. In SI, $D_{\text{SI}} = \hbar_{\text{vssc}}$. With the same definition $m_{\text{eff}} = \hbar_{\text{vss}} / (c \ell_{\text{model}})$, $D_{\text{model}} = \hbar_{\text{vssc}} / (m_{\text{eff}} c^2 \ell_{\text{model}}) = 1$ exactly. $D = 2A$ exactly, reflecting their common origin.

C is the surface term. When the central interstice is expelled as the electron precursor, three co-rotating condensates compress toward a common centre and energy is released at the boundary, so the surface term is negative. The magnitude $1/3$ follows from the fact that there are exactly three condensates and they are identical: same substrate, same density, same orbital radius, each facing the void across the same 60-degree arc. There is no physical distinction between them. One expelled centre shared equally among three identical sectors gives $C = -1/3$ exactly, by C_{3v} symmetry.

B is the filling-deficit ratio of the normalized three-condensate cluster. Three mutually touching unit-radius condensates sit at orbital radius $d = 2/\sqrt{3}$ and enclose $A_{\text{void}} = \sqrt{3} - \pi/2$. The d condensate faces the void on-axis with component 1. Each u condensate faces it at 60° with component $1/2$, giving $\delta_d = 2\delta_u$. The void-filling constraint gives the d share $A_{\text{void}}/2$ and the symmetric share $A_{\text{void}}/3$, so the d extra is $A_{\text{void}}/6$. Therefore $B = [\pi(d+1)^2 - 3\pi + A_{\text{void}}] / [3\pi + A_{\text{void}}/6] = 0.56308208$, which gives the adopted coefficient $B = 0.56308$.

Using $A = 0.5$, $B = 0.56308$, $C = -0.333333$ and $D = 1$, stationarity gives $2BR_0^4 + CR_0^3 - DR_0 - 2A = 0$. Its positive real root is $R_0 = 1.27348221$, and the second derivative is positive at this root.

The measured proton charge radius $r_p = 0.8414 \times 10^{-15} \text{ m}$ fixes the physical length represented by one model-radius unit: $\ell_{\text{model}} = r_p / R_0 = 6.60708091 \times 10^{-16} \text{ m}$.

With the measured proton mass $m_p = 1.67262192369 \times 10^{-27} \text{ kg}$, this length gives the BFUT-derived reduced Planck constant: $\hbar_{\text{vss}} = m_p c \ell_{\text{model}} / \pi = 1.05457687 \times 10^{-34} \text{ J s}$.

The BFUT-derived electron mass and fine-structure constant are $m_{e_vss} = m_p/(6\pi^5) = 9.10955518 \times 10^{-31}$ kg and $\alpha_{vss} = e^2/(4\pi \epsilon_0 \hbar_{vss} c) = 0.00729731763044$, with $\alpha_{vss}^{-1} = 137.036655199$.

The corresponding dimensional consistency check is $R_0 = r_p m_p c/(\pi \hbar_{CODATA}) = 1.27348831$, within 0.00048 percent of the stationary root.

The characteristic particle-sector mass is $m^*_{vss} = m_{e_vss}/\alpha_{vss} = 1.24834297 \times 10^{-28}$ kg.

Its reduced Compton wavelength equals the classical electron radius: $\lambda^* = \hbar_{vss}/(m^*_{vss} c) = \alpha_{vss} \hbar_{vss}/[m_{e_vss} c] = r_{e_vss} = 2.81788728 \times 10^{-15}$ m.

The weak-field gravitational energy-density magnitude is $u_g = g^{*2}/(8\pi G)$. At radius r_{e_vss} , the gravitational field of m^*_{vss} is $g^* = Gm^*_{vss}/r_{e_vss}^2$. Substitution gives $u_g = Gm^*_{vss}^2/(8\pi r_{e_vss}^4)$.

$$u_g = G[m_{e_vss}/\alpha_{vss}]^2/(8\pi r_{e_vss}^4) = 6.56355667 \times 10^{-10} \text{ J m}^{-3}.$$

The factor 8π is fixed at both levels of the gravitational description. In the weak-field energy density it appears in $u_g = g^2/(8\pi G)$. In the covariant description the Spaticle field supplies physical stress-energy to $G_{\mu\nu} = (8\pi G/c^4)T_{\mu\nu}$. The Spaticle field is the matter substrate whose bending, compression and waves are represented by spacetime geometry. Because it has the definite density ρ_s , organised motion entrains a definite amount of substrate mass. The gravitational contribution of that entrained mass carries the same Einstein coupling. This fixes $8\pi G$ as the physical normalization of the density derivation.

$$\text{Dividing the particle-sector gravitational energy density by } c^2 \text{ gives } \rho_s = u_g/c^2 = G[m_{e_vss}/\alpha_{vss}]^2/(8\pi r_{e_vss}^4 c^2) = (Gc^2/8\pi \hbar_{vss}^4)[m_{e_vss}/\alpha_{vss}]^6.$$

$\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$. The adopted working value is $\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$, equivalent to $u_g = 6.56355667 \times 10^{-10} \text{ J m}^{-3}$ or 4.096 GeV m^{-3} .

3. Acceleration from the carrier mass term

The local gravitational carrier is the deformation of the Spaticle substrate. The carrier perturbation $\delta\psi_{vss}$ obeys the covariant carrier equation

$$g^{\{\mu\nu\}} \nabla_\mu \nabla_\nu (\delta\psi_{vss}) - \mu_s^2 \delta\psi_{vss} = (1/c^2) g^{\{\mu\nu\}} \nabla_\mu \nabla_\nu \Psi_{\text{matter}}.$$

Here μ_s is the inverse-length response scale of the carrier. The BFUT carrier mass term is $\mu_s^2 = 3G\rho_s/c^2$, so $\mu_s = \sqrt{(3G\rho_s/c^2)}$. The organised acceleration associated with this response scale is $a_s = c^2\mu_s/3$. Substitution gives $a_s = c\sqrt{(G\rho_s/3)} = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$. Thus the dependency chain is $\rho_s - \mu_s^2 - \mu_s - a_s$, with no galaxy quantity entering the derivation.

The carrier dynamics therefore derive the acceleration scale directly from the particle-sector Spaticle-field density.

The associated coherence length is $L_s = 1/\mu_s = c/(3G\rho_s)^{1/2} \approx 26.2 \text{ Gly}$. Its scale is far larger than a galaxy and leaves local inverse-square behaviour unchanged. SPARC and KiDS-1000 use the organised-gravity relation for the entrained mass.

3.1 Physical interpretation of the substrate scale

The Spaticle field is a real, gravitating and deformable substrate of space. Its equilibrium density is derived in Section 2. Ordinary matter is embedded in this substrate. Organised motion entrains a portion of the substrate, and that entrained mass is the extra gravitating component.

Ordinary matter condenses from the Spaticle field and remains embedded within it. The substrate bends, compresses and waves. Gravitational effects are deformations of this physical matter substrate. Physical disturbances and forces propagate through the same substrate.

The Spaticle field is not the nineteenth-century luminiferous ether. The luminiferous ether was introduced primarily as a carrier for light. The Spaticle field has a broader physical role: it is the matter substrate from which ordinary matter condenses, in which matter remains embedded, whose organised mass contributes gravitationally through entrainment, and through which electromagnetic and gravitational disturbances propagate.

The microscopic length in the density construction is the classical electron radius, $r_e = \alpha \hbar / (m_e c)$. The equality $\lambda_* = \hbar / (m_* c) = r_e$ follows from $m_* = m_e / \alpha$. That is the substrate reference length. The electron is not a constituent of the field. The length is the electromagnetic matching scale already fixed by m_e and α .

The factor 8π is fixed by the gravitational field-energy normalization and the Einstein coupling $G_{\mu\nu} = (8\pi G/c^4)T_{\mu\nu}$. The Spaticle field carries physical stress-energy, and its organised, entrained mass contributes through this coupling. The factor 3 in $\mu_s^2 = 3G\rho_s/c^2$ is the BFUT carrier mass coefficient and propagates directly into $a_s = c^2\mu_s/3$.

The inverse-length parameter μ_s is distinct from a particle mass. Defining $\mu_s^2 = 3G\rho_s/c^2$ gives dimensions of length^{-2} . If a particle-like mass notation is desired, it is $m_s = \hbar_{vss} \mu_s / c$. Algebraically, consistency with this definition requires $a_s = c^2 \mu_s / 3 = c\sqrt{G\rho_s/3}$. This dimensional distinction avoids treating the inverse-length parameter as a mass-squared quantity.

3.2 Time, propagation capacity, and the unification of time dilation

In the BFUT framework, time is a physical consequence of propagation within the Spaticle field. The field has a finite propagation capacity. The universal speed c is the full propagation budget available to a massless excitation. For a massive object, spatial motion uses part of this finite budget, leaving the remainder available to internal propagation.

$$c^2 = v_{\text{spatial}}^2 + v_{\text{internal}}^2$$

so that

$$v_{\text{internal}} = \sqrt{c^2 - v_{\text{spatial}}^2}.$$

If $d\tau$ is proper time and dt is coordinate time, the internal propagation fraction gives

$$d\tau/dt = v_{\text{internal}}/c = \sqrt{1 - v_{\text{spatial}}^2/c^2},$$

and therefore

$$dt/d\tau = 1/\sqrt{1 - v_{\text{spatial}}^2/c^2} = \gamma.$$

Thus kinematic time dilation follows from the finite propagation budget. With $v_{\text{spatial}} = 0$, the complete budget is available internally, so $v_{\text{internal}} = c$ and $d\tau = dt$.

Gravity produces the corresponding effect through deformation of the Sparticle field, which changes the local propagation conditions experienced by a clock. For a static spherical gravitational field, the time relation is

$$d\tau = dt \sqrt{1 - 2GM/(rc^2)},$$

or

$$dt/d\tau = 1/\sqrt{1 - 2GM/(rc^2)}.$$

For a weak gravitational field,

$$d\tau/dt \approx 1 - GM/(rc^2).$$

The special-relativistic and gravitational expressions therefore have a common physical interpretation in BFUT: time is governed by the propagation budget of the Sparticle field. Spatial motion uses part of that budget, while gravitational deformation changes the local propagation state of the substrate. For weak gravity and low spatial velocity, the combined relation is

$$d\tau/dt \approx 1 - GM/(rc^2) - v_{\text{spatial}}^2/(2c^2).$$

This unifies gravitational and kinematic time dilation as two manifestations of the same underlying propagation dynamics.

The massless limit follows from the substrate propagation capacity itself. In the absence of a massive object's spatial-motion demand, the full propagation capacity is c . A massless disturbance therefore propagates through the Sparticle substrate at c . Electromagnetic and gravitational disturbances are disturbances of the same physical Sparticle substrate and consequently share this propagation speed.

4. The Dark Matter Effects relation

Let $v_\beta(R)$ be the Newtonian circular speed of the observed baryons. The Dark Matter Effects (DME) relation is

$$v^2(R) = v_\beta^2(R) [1 + \Theta(R) a_s R / v_\beta^2(R)]^{1/2}.$$

Equivalently,

$$g^2(R) = g_\beta^2(R) + \Theta(R) a_s g_\beta(R),$$

$$\text{where } g_\beta(R) = v_\beta^2(R)/R = GM_\beta(R)/R^2.$$

For an approximately constant Θ in the deep-organised regime, $v^4 = \Theta G M_\beta a_s$. The fully organised limit $\Theta = 1$ therefore gives $v^4 = G M_\beta a_s$.

On a component i of a merging system the extra mass is

$$M_{\text{extra},i} = M_{\beta,i} \{ [1 + \Theta_i a_s R_i^2 / (G M_{\beta,i})]^{1/2} - 1 \},$$

where $0 \leq \Theta_i \leq 1$ measures the degree of coherent entrainment. $\Theta_i = 1$ is the fully organised limit and $\Theta_i \rightarrow 0$ is the unorganised limit.

For the two-component merger application, $\Theta_{\text{gal}} = 1$ and $\Theta_{\text{gas}} = 0$: entrained extra mass remains with the organised galaxies and drops from the shocked gas.

5. Comparison with MOND

MOND uses the galaxy-calibrated scale $a_0 = 1.20 \times 10^{-10} \text{ m s}^{-2}$ (Milgrom 1983; Famaey & McGaugh 2012; McGaugh, Lelli & Schombert 2016). The BFUT particle-sector derivation gives $a_s = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$, a relative difference of 0.7 percent. This independent agreement provides a numerical consistency check on the derived acceleration scale. BFUT retains Newtonian gravity and identifies the additional gravitating component as organised or entrained Sparticle-field mass governed by Θ . SPARC and KiDS-1000 test this particle-derived acceleration scale and its organised-gravity relation.

6. SPARC

Sample: 175 disks with Spitzer photometry and resolved rotation curves (Lelli, McGaugh & Schombert 2016; see also McGaugh, Lelli & Schombert 2016). Stellar mass-to-light ratio $Y = 0.5$ at $3.6 \mu\text{m}$, locked for the whole sample (the SPARC $3.6 \mu\text{m}$ convention, not fitted here). Baryonic speed:

$$v_\beta^2 = v_{\text{gas}} |v_{\text{gas}}| + Y v_{\text{disk}}^2 + Y v_{\text{bulge}}^2.$$

Outer-half points have R at least half the last measured radius. A curve is classed flat when outer-half standard deviation over mean is below 0.12. The galaxy residual is the median of $|V_{\text{pred}} - V_{\text{obs}}| / V_{\text{obs}}$ on the outer half.

The SPARC calculations use the fully organised value $\Theta = 1$ and $a_s = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$. Shape agreement is 92.0 percent (161/175). Flat classification is correct for 98.8 percent (159/161), and non-flat classification is correct for 14.3 percent (2/14). The median outer residual is 0.096. The residual is below 0.20 for 132 galaxies and below 0.25 for 147 galaxies. The same relation at $a_0 = 1.20 \times 10^{-10}$ gives median residual 0.094. Newtonian baryons at the same Y give median residual 0.495. Figure 1 shows the three residual histograms. The galaxy table is Appendix A.

Most observed-non-flat, predicted-flat cases already have a flat baryonic curve under the same outer-scatter rule. Non-negative extra mass cannot force a decline when V_{bar} is already flat. The same locked- Y set was compared with NFW. A zero-parameter halo uses Moster et al. (2013) abundance matching for $M_{200}(M_\beta)$ and the Dutton & Macciò (2014) $c(M_{200})$ relation. Median outer residual: Newton 0.495, abundance-matching NFW 0.308, DME 0.096. Full-curve χ^2 on 3391 points with published Verr: Newton 1.49×10^6 , NFW 1.85×10^6 , DME 2.05×10^5 . Inner points with $1\text{--}2 \text{ km s}^{-1}$ errors dominate χ^2 in every model. The designed metric remains the outer-half residual. A two-parameter NFW fit per galaxy (350 extra numbers) can push that residual to 0.029. That is a fit. Figure 2 is the zero-parameter comparison.

Figure 1. SPARC galaxy-by-galaxy median outer relative residual. Newton at locked $Y = 0.5$ (grey), DME at $a_s = 1.20840317 \times 10^{-10}$ (ink), same algebra at $a_0 = 1.20 \times 10^{-10}$ (gold step).

Figure 2. SPARC median outer residual at locked $Y = 0.5$. Newton; zero-parameter abundance-matching NFW using Moster et al. (2013) with the Dutton & Macciò (2014) concentration relation; DME at $a_s = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$.

7. KiDS-1000

The public Figure 3 excess surface density (ESD) files of Brouwer et al. (2021) contain four isolated-lens stellar-mass bins. Their Equation 23 converts ESD to equivalent circular speed, $v_{\text{circ}} = \sqrt{(4G\Delta\Sigma R)}$. The baryonic contribution is represented as a point mass, $v_{\beta}^2 = GM_{\text{gal}}/R$, with $\log_{10}(M_{\text{gal}}/M_{\odot}) = \{10.14, 10.57, 10.78, 10.96\}$. The data contain 60 radial points from 0.035 Mpc to 2.60 Mpc.

The KiDS-1000 calculations use the fully organised value $\Theta = 1$. The published 60×60 ESD covariance of Brouwer et al. is the primary estimator. The reported DME result is $\chi^2/N = 9.78$ for the 60 measurements. The equivalent-speed profiles are flat and rank as $M^{1/4}$, as required by $v^4 = GM a_s$. Figure 3 shows the four bins. Appendix B gives the point table.

Figure 3. KiDS-1000 Fig. 3 equivalent circular speed. Points: ESD converted by Brouwer Eq. 23. Gold: DME at $a_s = 1.20840317 \times 10^{-10}$. Dashed: Newton point-mass baryons.

8. Mergers and low-rotation systems

The two-component entrainment relation applies directly to a cluster collision. Before the merger, the gas shares organised motion with the galaxies, with $\Theta_{\text{gas}} = \Theta_{\text{gal}} = 1$. During the collision, the galaxies retain their organised motion while the gas is stripped and shock-heated, giving $\Theta_{\text{gal}} = 1$ and $\Theta_{\text{gas}} = 0$. Lensing follows the galaxies (Clowe et al. 2006; Paraficz et al. 2012). Figure 5 is the official JWST and Chandra composite (Cha et al. 2025; NASA/STScI/CXC). Intracluster plasma outweighs the stars by about six to seven (Clowe et al. 2006). The JWST aperture masses inside 250 kpc are centred on the brightest cluster galaxies (BCGs), at approximately 1.59×10^{14} and $0.87 \times 10^{14} M_{\odot}$ (Cha et al. 2025). The entrainment relation predicts this offset from the shocked X-ray gas.

NGC 1052-DF2 has a published dynamical mass consistent with the stars alone (van Dokkum et al. 2018; Emsellem et al. 2019). That mass is consistent with $\Theta = 0$ and strongly disfavours the fully organised $\Theta = 1$ limit. Figure 4 shows that comparison. NGC 1052-DF4 and FCC 224 lie on the same no-halo line (Buzzo et al. 2025).

Figure 4. NGC 1052-DF2 inside 2.7 kpc. Gold band: published M_{dyn} . Ink bar: DME with $\Theta = 0$. Grey bar: DME forced at $\Theta = 1$.

Figure 5. Official JWST NIRCcam and Chandra composite of 1E 0657-56 (NASA/ESA/CSA/STScI/CXC; processing J. DePasquale; scientific analysis Cha et al. 2025). Yellow and white show galaxies and intracluster light (ICL), with $\Theta = 1$. Pink shows X-ray gas, with $\Theta = 0$. Blue shows the published lensing mass centred on the galaxies. The entrained Spaticle-field mass follows the organised galaxy component.

9. The same architecture in any rotating medium

A rotating galaxy is an organised flow in a physical medium. The vortex analogy describes its kinematics. The Spaticle field retains the constitutive dynamics defined by BFUT.

Standard core identities: $V_c = \Omega_c r_c$, $\Gamma = 2\pi \Omega_c r_c^2$, $Re_c = \Omega_c r_c^2 / \nu$. Dimensionless controls include $\Pi_R = r_c / R$, $\Pi_h = h / r_c$, $\Pi_\rho = \rho / \rho_{ref}$, and a gravity-rotation number $\Pi_\Omega = \Omega_c^2 r_c^3 / (G M_c)$ only when the restoring field is Newtonian gravity of mass M_c . A water tank is held by hydrostatic pressure and the free surface. There the matching number is a Froude number $V_c^2 / (g h)$. A tornado uses swirl ratio and buoyancy. Copying Π_Ω with G into those systems without that swap is a category error.

The test profile is $V_\theta(r) = V_{base}(r) + [V_{flat} - V_{base}(r)]S(\Pi)$. $S = 0$ gives the ordinary non-flat vortex, and S approaching 1 gives a flat outer belt. Faller (2001) produced a laboratory water vortex with $\partial V / \partial r = 0$ outside a small core, held during decay by a turbulent Bödewadt layer. Flat tangential speed therefore occurs in an organised fluid flow. Rankine free vortices retain the $1/r$ outer profile.

10. Discussion

The factor 8π is fixed by the gravitational field-energy density and the Einstein coupling $G_{\mu\nu} = (8\pi G/c^4)T_{\mu\nu}$. The Spaticle field supplies the physical stress-energy represented by spacetime curvature, and its finite density permits organised motion to entrain gravitating substrate mass. The BFUT carrier coefficient $\mu_s^2 = 3G\rho_s/c^2$ and the carrier response $a_s = c^2\mu_s/3$ give $a_s = c\sqrt{(G\rho_s/3)}$. The scale $10^{-10} \text{ m s}^{-2}$ follows from $[m_e v_{ss}/\alpha_{vss}]^6$ together with G , c and h_{vss} . The locked-Y SPARC comparison gives median outer residuals of 0.495 for Newton, 0.308 for the zero-parameter abundance-matching Navarro-Frenk-White (NFW) halo, and 0.096 for DME. The Bullet Cluster, DF2, DF4 and FCC 224 test the predicted dependence on organised motion.

DME and MOND give closely aligned disk accelerations because $a_s = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$ and $a_0 = 1.20 \times 10^{-10} \text{ m s}^{-2}$. The BFUT value follows from the particle-sector density. Systems that lose organised rotation test the entrained-mass interpretation through Θ .

11. Conclusions

The BFUT particle sector derives the Spaticle-field density as $\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$ and adopts $\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$ for the applications. The Spaticle field is the physical matter substrate whose stress-energy produces spacetime curvature through the Einstein coupling. Its finite density permits organised motion to entrain gravitating substrate mass. The carrier coefficient $\mu_s^2 = 3G\rho_s/c^2$ and the response relation $a_s = c^2\mu_s/3$ give $a_s = c\sqrt{(G\rho_s/3)} = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$. The DME relation $g^2 = g_\beta^2 + \Theta a_s g_\beta$ describes the macroscopic entrainment, and its deep-organised limit is $v^4 = \Theta G M_\beta a_s$. SPARC, KiDS-1000, the Bullet Cluster and low-rotation galaxies provide complementary applications of the same particle-derived density and organised-mass mechanism.

Appendix A. SPARC galaxy table

Columns: Galaxy; number of radial points; characteristic observed speed (km s^{-1}); observed flat; predicted flat; shape match; median outer relative residual.

Galaxy	N	V_char	ObsF	PredF	Shape	Med rel
CamB	9	20.1	N	Y	N	1.092
D512-2	4	37.2	Y	Y	Y	0.116
D564-8	6	25.0	Y	Y	Y	0.246
D631-7	16	58.5	Y	Y	Y	0.047
DD0064	14	46.9	Y	Y	Y	0.044
DD0154	12	48.2	Y	Y	Y	0.036
DD0161	31	67.5	Y	Y	Y	0.250
DD0168	10	55.0	Y	Y	Y	0.022
DD0170	8	62.2	Y	Y	Y	0.232
ESO079-G014	15	178.0	Y	Y	Y	0.106
ESO116-G012	15	112.0	Y	Y	Y	0.153
ESO444-G084	7	63.1	Y	Y	Y	0.267
ESO563-G021	30	321.0	Y	Y	Y	0.182
F561-1	6	50.4	Y	N	N	0.656
F563-1	17	112.5	Y	Y	Y	0.160
F563-V1	6	29.5	Y	Y	Y	1.196
F563-V2	10	118.0	Y	Y	Y	0.178
F565-V2	7	83.1	Y	Y	Y	0.124
F567-2	5	52.2	Y	N	N	0.470
F568-1	12	142.0	Y	Y	Y	0.245
F568-3	18	120.0	Y	Y	Y	0.024
F568-V1	15	118.0	Y	Y	Y	0.167
F571-8	13	144.0	Y	Y	Y	0.293
F571-V1	7	84.3	Y	Y	Y	0.040
F574-1	14	99.7	Y	Y	Y	0.077
F574-2	5	40.0	Y	Y	Y	1.207
F579-V1	14	114.0	Y	Y	Y	0.032
F583-1	25	86.9	Y	Y	Y	0.155
F583-4	12	69.9	Y	Y	Y	0.063
IC2574	34	67.5	N	Y	N	0.229
IC4202	32	250.0	Y	Y	Y	0.089
KK98-251	15	34.6	Y	Y	Y	0.329
NGC0024	29	110.0	Y	Y	Y	0.194
NGC0055	21	87.4	Y	Y	Y	0.161
NGC0100	21	91.2	Y	Y	Y	0.069
NGC0247	26	108.0	Y	Y	Y	0.010
NGC0289	28	194.0	Y	Y	Y	0.132
NGC0300	25	97.0	Y	Y	Y	0.088

NGC0801	13	238.0	Y	Y	Y	0.155
NGC0891	18	234.0	Y	Y	Y	0.025
NGC1003	36	115.0	Y	Y	Y	0.032
NGC1090	24	176.0	Y	Y	Y	0.062
NGC1705	14	73.2	Y	Y	Y	0.267
NGC2366	26	53.7	Y	Y	Y	0.188
NGC2403	73	136.0	Y	Y	Y	0.098
NGC2683	11	212.0	Y	Y	Y	0.071
NGC2841	50	323.0	Y	Y	Y	0.212
NGC2903	34	216.0	Y	Y	Y	0.071
NGC2915	30	86.5	Y	Y	Y	0.232
NGC2955	24	276.0	Y	Y	Y	0.028
NGC2976	27	88.7	N	Y	N	0.026
NGC2998	13	214.0	Y	Y	Y	0.014
NGC3109	25	67.3	Y	Y	Y	0.132
NGC3198	43	157.0	Y	Y	Y	0.059
NGC3521	41	220.0	Y	Y	Y	0.119
NGC3726	12	169.0	Y	Y	Y	0.018
NGC3741	21	51.6	Y	Y	Y	0.079
NGC3769	12	126.0	Y	Y	Y	0.109
NGC3877	13	171.0	Y	Y	Y	0.070
NGC3893	10	194.0	Y	Y	Y	0.076
NGC3917	17	138.0	Y	Y	Y	0.041
NGC3949	7	169.0	Y	Y	Y	0.037
NGC3953	8	224.0	Y	Y	Y	0.023
NGC3972	10	134.0	Y	Y	Y	0.103
NGC3992	9	272.0	Y	Y	Y	0.068
NGC4010	12	129.0	Y	Y	Y	0.029
NGC4013	36	198.0	Y	Y	Y	0.034
NGC4051	7	161.0	Y	Y	Y	0.135
NGC4068	6	41.9	N	Y	N	0.279
NGC4085	7	136.0	Y	Y	Y	0.034
NGC4088	12	182.0	Y	Y	Y	0.186
NGC4100	24	195.0	Y	Y	Y	0.065
NGC4138	7	195.0	Y	Y	Y	0.025
NGC4157	17	201.0	Y	Y	Y	0.029
NGC4183	23	115.0	Y	Y	Y	0.073
NGC4214	14	80.6	Y	Y	Y	0.247
NGC4217	19	191.0	Y	Y	Y	0.023
NGC4389	6	110.0	N	Y	N	0.464
NGC4559	32	124.0	Y	Y	Y	0.090
NGC5005	18	265.0	Y	Y	Y	0.066
NGC5033	22	225.0	Y	Y	Y	0.035
NGC5055	28	206.0	Y	Y	Y	0.117
NGC5371	19	242.0	Y	Y	Y	0.188
NGC5585	24	92.3	Y	Y	Y	0.034
NGC5907	19	235.0	Y	Y	Y	0.024
NGC5985	33	305.0	Y	Y	Y	0.229
NGC6015	44	166.0	Y	Y	Y	0.070

NGC6195	23	258.0	Y	Y	Y	0.052
NGC6503	31	121.0	Y	Y	Y	0.021
NGC6674	15	291.0	Y	Y	Y	0.077
NGC6789	4	60.4	N	Y	N	0.417
NGC6946	58	181.0	Y	Y	Y	0.038
NGC7331	36	257.0	Y	Y	Y	0.017
NGC7793	46	116.0	Y	Y	Y	0.094
NGC7814	18	265.0	Y	Y	Y	0.217
PGC51017	6	20.5	Y	Y	Y	1.378
UGC00128	22	134.0	Y	Y	Y	0.055
UGC00191	9	83.8	Y	Y	Y	0.059
UGC00634	4	108.0	Y	Y	Y	0.051
UGC00731	12	74.0	Y	Y	Y	0.096
UGC00891	5	63.8	Y	Y	Y	0.028
UGC01230	11	113.0	Y	Y	Y	0.261
UGC01281	25	56.9	Y	Y	Y	0.042
UGC02023	5	58.8	N	Y	N	0.202
UGC02259	8	90.0	Y	Y	Y	0.126
UGC02455	8	61.0	N	Y	N	0.744
UGC02487	17	383.0	Y	Y	Y	0.200
UGC02885	19	305.0	Y	Y	Y	0.073
UGC02916	43	218.0	Y	Y	Y	0.079
UGC02953	115	319.0	Y	Y	Y	0.147
UGC03205	48	237.0	Y	Y	Y	0.087
UGC03546	30	262.0	Y	Y	Y	0.047
UGC03580	47	131.0	Y	Y	Y	0.022
UGC04278	25	92.8	N	N	Y	0.152
UGC04305	22	37.3	Y	Y	Y	0.942
UGC04325	8	92.7	Y	Y	Y	0.157
UGC04483	8	24.3	Y	Y	Y	0.221
UGC04499	9	74.3	Y	Y	Y	0.060
UGC05005	11	100.0	Y	Y	Y	0.112
UGC05253	73	248.0	Y	Y	Y	0.031
UGC05414	6	61.4	Y	Y	Y	0.087
UGC05716	12	74.7	Y	Y	Y	0.059
UGC05721	23	82.6	Y	Y	Y	0.191
UGC05750	11	78.9	Y	Y	Y	0.262
UGC05764	10	55.8	Y	Y	Y	0.139
UGC05829	11	68.6	N	N	Y	0.137
UGC05918	8	44.5	Y	Y	Y	0.064
UGC05986	15	116.0	Y	Y	Y	0.206
UGC05999	5	100.0	Y	Y	Y	0.029
UGC06399	9	87.6	Y	Y	Y	0.077
UGC06446	17	84.9	Y	Y	Y	0.053
UGC06614	13	205.0	Y	Y	Y	0.041
UGC06628	7	42.3	Y	Y	Y	0.872
UGC06667	9	85.7	Y	Y	Y	0.221
UGC06786	45	229.0	Y	Y	Y	0.242
UGC06787	71	276.0	Y	Y	Y	0.269

UGC06818	8	74.4	N	Y	N	0.037
UGC06917	11	111.0	Y	Y	Y	0.063
UGC06923	6	81.1	Y	Y	Y	0.019
UGC06930	10	109.0	Y	Y	Y	0.075
UGC06973	9	180.0	Y	Y	Y	0.058
UGC06983	17	113.0	Y	Y	Y	0.031
UGC07089	12	79.1	Y	Y	Y	0.168
UGC07125	13	65.6	Y	Y	Y	0.568
UGC07151	11	76.2	Y	Y	Y	0.029
UGC07232	4	44.0	N	Y	N	0.098
UGC07261	7	76.1	Y	Y	Y	0.029
UGC07323	10	85.6	N	Y	N	0.055
UGC07399	10	106.0	Y	Y	Y	0.328
UGC07524	31	83.8	Y	Y	Y	0.067
UGC07559	7	32.1	Y	Y	Y	0.310
UGC07577	9	17.8	N	Y	N	1.091
UGC07603	12	64.0	Y	Y	Y	0.162
UGC07608	8	69.3	Y	Y	Y	0.170
UGC07690	7	60.7	Y	Y	Y	0.081
UGC07866	7	33.1	Y	Y	Y	0.282
UGC08286	17	84.3	Y	Y	Y	0.143
UGC08490	30	80.1	Y	Y	Y	0.112
UGC08550	11	57.8	Y	Y	Y	0.089
UGC08699	41	202.0	Y	Y	Y	0.131
UGC08837	8	48.0	Y	Y	Y	0.266
UGC09037	22	160.0	Y	Y	Y	0.144
UGC09133	68	289.0	Y	Y	Y	0.050
UGC09992	5	34.3	Y	Y	Y	0.532
UGC10310	7	73.2	Y	Y	Y	0.096
UGC11455	36	291.0	Y	Y	Y	0.032
UGC11557	12	85.0	Y	Y	Y	0.380
UGC11820	10	84.5	Y	Y	Y	0.135
UGC11914	65	305.0	Y	Y	Y	0.175
UGC12506	31	255.0	Y	Y	Y	0.118
UGC12632	15	73.2	Y	Y	Y	0.095
UGC12732	16	98.0	Y	Y	Y	0.054
UGCA281	7	29.5	Y	Y	Y	0.061
UGCA442	8	57.8	Y	Y	Y	0.036
UGCA444	36	38.3	Y	Y	Y	0.133

Appendix B. KiDS-1000 Fig. 3 point table

v_{obs} from Brouwer Eq. 23. V_{Newt} is $G M / R$. V_{DME} uses $a_s = 1.20840317 \times 10^{-10} \text{ m s}^{-2}$. Primary fit: published 60×60 ESD covariance, $\chi^2/N = 9.78$ for the 60 measurements.

Bin	log M	R_Mpc	V_obs	Verr	V_Newt	V_DME	rel
1	10.14	0.0354	123.6	35.3	41.0	122.4	0.010
1	10.14	0.0481	137.9	31.6	35.1	122.2	0.114
1	10.14	0.0654	141.5	30.8	30.1	122.1	0.137
1	10.14	0.0889	153.8	28.5	25.8	122.0	0.207
1	10.14	0.1208	147.1	30.0	22.2	122.0	0.170
1	10.14	0.1643	136.9	32.5	19.0	122.0	0.109
1	10.14	0.2233	116.5	38.5	16.3	122.0	0.047
1	10.14	0.3035	99.2	45.6	14.0	122.0	0.229
1	10.14	0.4126	103.6	44.1	12.0	122.0	0.177
1	10.14	0.5609	136.1	34.0	10.3	122.0	0.104
1	10.14	0.7625	164.4	28.7	8.8	122.0	0.258
1	10.14	1.0365	151.1	31.8	7.6	122.0	0.193
1	10.14	1.4089	132.5	37.2	6.5	122.0	0.080
1	10.14	1.9152	102.4	48.9	5.6	122.0	0.191
1	10.14	2.6035	106.4	47.7	4.8	122.0	0.147
2	10.57	0.0354	142.6	41.6	67.2	157.5	0.105
2	10.57	0.0481	153.3	38.3	57.6	156.9	0.024
2	10.57	0.0654	162.4	36.2	49.4	156.6	0.036
2	10.57	0.0889	172.8	34.2	42.4	156.4	0.095
2	10.57	0.1208	173.2	34.4	36.4	156.3	0.097
2	10.57	0.1643	171.4	35.1	31.2	156.3	0.088
2	10.57	0.2233	208.2	29.1	26.8	156.3	0.250
2	10.57	0.3035	200.3	30.5	22.9	156.2	0.220
2	10.57	0.4126	215.9	28.6	19.7	156.2	0.276
2	10.57	0.5609	183.9	34.0	16.9	156.2	0.150
2	10.57	0.7625	193.3	32.9	14.5	156.2	0.192
2	10.57	1.0365	217.7	29.7	12.4	156.2	0.283
2	10.57	1.4089	164.0	40.2	10.6	156.2	0.047
2	10.57	1.9152	145.6	46.0	9.1	156.2	0.073
2	10.57	2.6035	107.2	63.1	7.8	156.2	0.457
3	10.78	0.0354	142.8	44.4	85.6	178.7	0.252
3	10.78	0.0481	184.1	34.0	73.4	177.6	0.035
3	10.78	0.0654	191.6	32.6	63.0	177.0	0.076
3	10.78	0.0889	182.4	34.7	54.0	176.7	0.031
3	10.78	0.1208	194.7	32.7	46.3	176.5	0.093
3	10.78	0.1643	210.2	30.5	39.7	176.4	0.161
3	10.78	0.2233	169.2	38.3	34.1	176.4	0.043
3	10.78	0.3035	228.1	28.6	29.2	176.3	0.227
3	10.78	0.4126	200.9	32.9	25.1	176.3	0.122
3	10.78	0.5609	226.5	29.5	21.5	176.3	0.222
3	10.78	0.7625	214.5	31.6	18.4	176.3	0.178
3	10.78	1.0365	228.4	30.1	15.8	176.3	0.228
3	10.78	1.4089	203.1	34.5	13.6	176.3	0.132

3	10.78	1.9152	228.3	31.2	11.6	176.3	0.228
3	10.78	2.6035	163.2	44.2	10.0	176.3	0.080
4	10.96	0.0354	167.5	38.3	105.3	199.5	0.191
4	10.96	0.0481	192.5	32.5	90.3	197.7	0.027
4	10.96	0.0654	212.5	29.4	77.4	196.7	0.074
4	10.96	0.0889	241.3	26.1	66.4	196.2	0.187
4	10.96	0.1208	199.6	32.0	57.0	195.9	0.018
4	10.96	0.1643	224.5	28.7	48.9	195.7	0.128
4	10.96	0.2233	259.2	25.1	41.9	195.6	0.245
4	10.96	0.3035	218.8	30.0	35.9	195.6	0.106
4	10.96	0.4126	235.7	28.2	30.8	195.6	0.170
4	10.96	0.5609	243.1	27.6	26.4	195.6	0.196
4	10.96	0.7625	227.8	29.9	22.7	195.6	0.142
4	10.96	1.0365	237.0	29.2	19.5	195.6	0.175
4	10.96	1.4089	241.6	29.2	16.7	195.5	0.191
4	10.96	1.9152	198.9	36.1	14.3	195.5	0.017
4	10.96	2.6035	186.5	39.0	12.3	195.5	0.048

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