Beyond General Relativity:

A Unified Gravitation Equation Across Quantum, Classical, Galactic, and Rapid-Transition Regimes

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Abstract

Einstein's general relativity describes how matter and energy determine the geometry of spacetime, and it has passed every precision test from the perihelion of Mercury to binary pulsars and gravitational waves. It does not identify the physical medium that carries gravitation to the point where it acts, and it cannot account for the extra gravity observed in galaxies and galaxy clusters without an unseen dark-matter component. This paper completes the account within the Big Flare-Up Theory (BFUT). It identifies the carrier of gravitation as the physical matter substrate that the author names the Spaticle field, and it identifies the Spaticle field as the dark matter that astronomy has inferred since the 1930s.

The paper starts from the field equations of Paper 17, in which the Einstein-Hilbert action is extended by the Spaticle field and the stress-energy of the Spaticle field enters Einstein's equation as a physical source. From these it derives the covariant carrier equation F1-cov, $g^{\mu\nu}\nabla_\mu\nabla_\nu(\delta\Psi) - \mu_s^2\delta\Psi = \kappa_s\, g^{\mu\nu}\nabla_\mu\nabla_\nu\Psi_{matter}$, with $\mu_s^2 = 3G\rho_s/c^2$. The static solution $\delta\Psi = -GM\, e^{(-\mu_s r)}/r$ satisfies F1-cov exactly: the verification in the CD21 code deposit returns a relative residual of order 10^{-50} at 60-digit precision. Newtonian gravity and weak-field general relativity are recovered as the settled limits for distances far below the carrier length L_s = 26.205 Gly, so every existing precision test of general relativity is preserved.

Every scale in the equation follows from one constant, the equilibrium density $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}, which Paper 16 derives from the proton mass through the condensation chain A, B, C, D → R_0 → ħ_vss → m_e_vss, α_vss → r_e_vss → ρ_s, with no astronomical input. The Spaticle field is an isotropic medium with pressure $p_s = \rho_s c^2/3$, which fixes the acceleration scale $a_s = \sqrt{(Gp_s)} = c\sqrt{(G\rho_s/3)} = 1.2084 \times 10^{-10}$ m s^{-2}. The deformation-domain (DDR) equation $Rd = (3M/(8\pi\rho_s))^{1/3}$ gives every mass a finite gravitational domain.

In organised rotating systems, the compressed, rotating Spaticle medium supplies the extra gravity described by the dark matter effects equation (DME): $v^2(R) = v\_b^2(R)[1 + a_sR/v\_b^2(R)]^{1/2}$. The law is applied to all 175 galaxies of the SPARC database and to the four KiDS-1000 weak-lensing stacks with no fitted parameter: a_s is fixed by ρ_s, and the stellar mass-to-light ratio is held at the standard Y = 0.5. SPARC gives shape agreement of 92.0 percent, flat classification of 98.8 percent and a median outer relative residual of 0.096. KiDS-1000 gives $\chi^2/N = 9.78$, against 32.82 for Newtonian gravity. The paper also sets out carrier reconfiguration residuals in rapid transitions, gravitational-wave memory, a finite carrier response time and a-priori event-class predictions, which give the framework further observational tests.

Keywords: Spaticle field; gravitation; dark matter; rotation curves; weak gravitational lensing; finite deformation domain; DDR; BFUT; carrier dynamics; KiDS-1000; SPARC; entrainment; substrate acceleration a_s; dark matter effects equation (DME); MOND

1. Introduction

Standard gravitational theory is an extraordinarily successful predictive framework [1][2][3]. From Newton's inverse-square law through Einstein's general relativity, the formalism predicts gravitational phenomena with remarkable accuracy. What it does not provide is an account of what immediate local physical entity is in a changed state when gravitation is actually measured at a detector. GR describes the source geometry and the curvature with precision. It does not identify the carrier. This is the ontological gap that the present work addresses. The question of what gravity is, as opposed to how it is successfully calculated, has been present at the foundations of the subject since Newton. Newton himself was famously unwilling to hypothesise a mechanism for his inverse-square force law, and his reticence proved wise: the empirical and predictive success of the law was independent of any ontological commitment about what was doing the pulling. General relativity made an enormous conceptual advance by replacing the idea of a force acting across empty space with the geometry of spacetime itself as the dynamical arena of gravitation. Yet the operational success of Einstein's theory has tended to foreclose the ontological question without answering it definitively. If general relativity predicts everything that is measured, it is easy, but not necessarily correct, to conclude that the theory's mathematical objects are all there is to say.

The operational success of standard gravitational theory leaves precisely one question open: what is the immediate local physical thing that is in a changed state at the point where gravitation is measured? This is not the same as asking what source-side quantities predict the magnitude or direction of the gravitational effect, nor what mathematical formalism describes the geometry of spacetime. It is an ontological question about the local carrier. A predictor is not automatically identical to a carrier. A source descriptor is not automatically identical to the medium whose local state produces the measurable effect.

Three central moves structure this paper. First, the carrier question is shown to be logically distinct from the questions addressed by Newtonian mechanics and general relativity, with neither framework's predictive success resolving it. Second, already-observed gravitational-wave phenomena are identified as strong existing evidence that a physically real local gravitational state propagates, oscillates, and changes in time, supporting the existence of a genuine carrier. Third, the BFUT reinterpretation is introduced: the Spaticle field is that carrier. In settled regimes, its state tracks conventional source-side descriptors so closely that standard theory is fully recovered. In rapid-transition regimes, short-lived carrier reconfiguration residuals may become separately observable in systems already monitored with high precision.

The central claim is that the local gravitational carrier is the physical matter substrate that the author names the Spaticle field. Its finite transitional dynamics produce short-lived observational residuals beyond the settled general-relativistic mapping.

The framework retains the tested predictions of Newtonian gravity and general relativity and identifies the local physical substrate whose state constitutes the gravitational condition at the observation point. It also defines an empirical programme for detecting transitional substrate behaviour.

This paper develops the dynamics and observational consequences of the physical matter substrate that the author names the Spaticle field. Paper 17 [4] presents the origin of gravitation, and Paper 16 supplies the adopted derivation of ρ_s. F1-cov is the general carrier equation. DME is the organised-regime equation used for disks and lensing stacks. Both use $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3} and $a_s = c^2\mu_s/3 = c\sqrt{(G\rho_s/3)} = 1.2084 \times 10^{-10}$ m s^{-2}, where $\mu_s^2 = 3G\rho_s/c^2$.

1.1 The Field Equations of Gravitation from Paper 17

Paper 17 [4] derives gravity as the first force to emerge from the Spaticle field and sets out its field equations. This paper starts from those equations and develops their complete gravitational content. The covariant action combines the Einstein-Hilbert term, matter, the Spaticle field Ψ and their interaction:

$$S = \int d^4x \sqrt{(-g)}\, [c^4R/(16\pi G) + {}_{m} + \tfrac{1}{2}\partial\mu\Psi\partial\hat{\ }\mu\Psi - V(\Psi) + {}_{s}\text{\_int}(\Psi, \text{matter})], \quad V(\Psi) = \lambda\, \Psi^4/4$$

Variation with respect to the metric gives the stress-energy tensor of the Spaticle field:

$$T\mu\nu^{(s)} = \partial\mu\Psi\partial\nu\Psi - g\mu\nu[\tfrac{1}{2}\partial\alpha\Psi\partial\hat{\ }\alpha\Psi - V(\Psi)]$$

The full field equation follows, with the Spaticle field entering Einstein's equation as a physical source, and the combined stress-energy is conserved:

$$G\mu\nu = (8\pi G/c^4)[T\mu\nu^{(m)} + T\mu\nu^{(s)}], \quad \nabla\hat{\ }\mu[T\mu\nu^{(m)} + T\mu\nu^{(s)}] = 0$$

In the weak-field limit the matter source reduces to the Poisson relation $\nabla^2\Psi\_\text{matter} = 4\pi G\rho\_\text{matter}$. From these equations Section 8 derives the covariant carrier equation F1-cov, Section 9 the deformation-domain (DDR) equation, and Section 10 the dark matter effects equation (DME) for organised rotating systems. Sections 10 and 12 test the result on SPARC and KiDS-1000.

2. Derivation and Adoption of the Spaticle Field Density

2.1 Cosmological-constant route. In general relativity [10], the cosmological-constant energy density is $u\_\Lambda = \Lambda c^4/(8\pi G)$, and the corresponding mass density is $\rho\_\Lambda = u\_\Lambda/c^2 = \Lambda c^2/(8\pi G)$. Using the density parameters gives the equivalent chain $\rho c = 3H_0^2/(8\pi G)$ and $\rho\_\Lambda = \Omega\_\Lambda\rho c = 3\Omega\_\Lambda H_0^2/(8\pi G)$. With $H_0 \approx 70$ km s^{-1} Mpc^{-1} and $\Omega\_\Lambda \approx 0.69$, this gives $\rho\_\Lambda \approx 6.35 \times 10^{-27}$ kg m^{-3}.

This cosmological value is not adopted as ρ_s because it depends on H_0. The Hubble parameter is observationally inferred, changes with cosmic epoch, and currently has more than one reported present-day value. Paper 18 therefore records the cosmological-constant route as a comparison and uses the particle-sector derivation from Paper 16.

2.2 Adopted particle-sector route from Paper 16 [24]. The dimensionless free-energy coefficients are A = 0.5, B = 0.56308, C = -1/3, and D = 1. They define $E(R) = A/R^2 + B R^2 + C R + D/R$. Solving $dE/dR = 0$ gives the dimensionless equilibrium condensation radius $R_0 = 1.27348221$.

The measured proton charge radius and proton mass fix the physical dimensions: $rp = 0.8414 \times 10^{-15}$ m (CODATA 2018) and $mp = 1.6726219 \times 10^{-27}$ kg. The condensation length is $\ell\_model = rp/R_0 = 6.607081 \times 10^{-16}$ m. The BFUT reduced Planck constant is $\hbar\_vss = mpc\ell\_model/\pi = 1.0545769 \times 10^{-34}$ J s.

Symbol	Definition	Value / Expression
Fundamental Spaticle Field Constants		
ρ_s	Intrinsic equilibrium density of the Spaticle field	7.3×10^{-27} kg m^{-3}
$\Psi(r,t)$	Spaticle carrier field / gravitational potential	Carrier potential
$\delta\Psi$	Carrier perturbation	$\delta\Psi = \Psi - \Psi_{vac}$
Ψ_{vac}	Vacuum equilibrium configuration	$\lambda_s \Psi vac^2 = \rho_s c^2$
λ_s	Quartic Spaticle-field self-interaction coefficient	Fixed by the selected field normalization
κ_s	Source-to-substrate coupling coefficient	$\kappa_s = 1/c^2$
μ_s	Carrier inverse-length response	$\mu_s^2 = 3G\rho_s/c^2$; $\mu_s = 4.03358955 \times 10^{-27}$ m^{-1}

	scale	
Carrier Field Timescales and Lengths		
τ_c	Local carrier response time	Transient response parameter; $L_{rlx} = c\tau_c$
L_{rlx}	Local carrier relaxation length	$L_{rlx} = c\tau_c$
L_s	Cosmological coherence length	$L_s = c/\sqrt{(3G\rho_s)}$
ξ	Dimensionless transition parameter	$\xi(t) = \tau c \, \lvert(dS_{GR}/dt)/S_{GR}(t)\rvert$
R_d	Deformation domain radius (DDR equation)	$R_d = (3M/(8\pi\rho_s))^{1/3}$
R_eff	Domain radius with rotational mass enhancement	$R\_eff = R_d[1 + vrot^2/c^2]^{1/3}$; DDR rotational boundary term
a_s	Substrate acceleration used in the DME equation	$a_s = c^2 \mu_s / 3 = c (G \rho_s / 3)^{1/2} = 1.2084 \times 10^{-10}$ m s^{-2}
DME	Dark Matter Effects equation	$v^2(R) = vb^2(R) [1 + a_s R / vb^2(R)]^{1/2}$; SPARC uses resolved vb; KiDS uses $vb^2 = G\,Mgal / R$
Carrier Field Equations		
F1-cov	Fully covariant carrier field equation	g^μν∇_μ∇_ν(δΨ) - m_eff^2 x δΨ = κ x ∇^2 Ψ_matterGeneral covariant carrier equation (programme-level)
Observational Signals		
$S_{obs}(t)$	Actual measured gravitational signal	$= S_{GR}(t) + \delta S_{carrier}(t)$
$\delta S_{carrier}(t)$	Carrier reconfiguration residual	Finite local carrier response governed by τ_c
Rotation Curves and Lensing		
	KiDS / SPARC use the same a_s as above	
KiDS	DME applied to stacked weak	Same a_s; flat equivalent speed; v proportional

stacks	lensing	to $Mgal^{1/4}$; residual beyond R_d assigned to $N(\Sigma_i)$
Shared Physical Constants		
G	Gravitational constant	6.674×10^{-11} m³ kg⁻¹ s⁻²
c	Speed of light	2.998×10^{8} m s⁻¹
T_μν	Stress-energy tensor	Source-side energy, momentum, pressure, and stress tensor
$\mathscr{J}$[T_μν]	Source-to-substrate forcing functional	Maps the source tensor into carrier forcing
$N(\Sigma_i)$	Nested-domain contribution	Weighted sum of active nested domains
w_i	Nested-domain boundary weight	Dimensionless weight of domain i
N_{dom}	Number of active nested domains	Count used in $N(\Sigma_i)$
M_{eff}	Rotation-enhanced effective mass	$M_{eff} = M(1 + v_{rot}^2/c^2)$
R_{object}	Physical radius of an extended object	Used with vrot = ωR_{object}
$v_b(R)$	Baryonic circular speed	SPARC or KiDS baryonic input
$v_{obs}(R)$	Observed circular speed	Measured rotation-curve speed
g_b	Baryonic acceleration	$g_b = vb^2/R$
g_{DME}	DME acceleration	$gDME = gb[1 + a_s/gb]^{1/2}$
M_{extra}	DME extra effective mass	$Mextra = Mb\{[1 + a_sR^2/(GMb)]^{1/2} - 1\}$
Y	Stellar mass-to-light ratio	Y = 0.5 for the SPARC 3.6 μm convention
f_b	Baryonic velocity fraction	$f_b = \langle vb/v_{obs} \rangle$
$G_{eff}(k)$	Scale-dependent effective gravitational response	$Geff/G = k^2/(k^2 + 1/L_s^2)$
K_c	Causal response kernel	Kernel governed by τ_c

$\delta\Psi_{noise}$	Ambient carrier-noise floor	DDR boundary condition

The electron mass and fine-structure constant follow as $m\_e\_vss = mp/(6\pi^5) = 9.1095552 \times 10^{-31}$ kg and $\alpha\_vss = e^2/(4\pi\varepsilon_0\hbar\_vssc) = 0.007297318 = 1/137.036655$. The characteristic particle mass is $m^*\_vss = m\_e\_vss/\alpha\_vss = 1.2483430 \times 10^{-28}$ kg.

The classical electron radius is $r_e\_vss = \alpha\_vss\hbar\_vss/(m\_e\_vssc) = 2.8178873 \times 10^{-15}$ m. Its particle-sector gravitational self-energy density is $ug = G(m\_e\_vss/\alpha\_vss)^2/(8\pi r_e\_vss^4) = 6.5635567 \times 10^{-10}$ J m^{-3}. The equilibrium Spaticle-field mass density is therefore $\rho_s = ug/c^2 = 7.3 \times 10^{-27}$ kg m^{-3}. The working value used throughout this paper is $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}. Intermediate carrier-scale calculations retain the unrounded internal density used in the Paper 16 derivation; the paper-facing equilibrium density is reported as 7.3×10^{-27} kg m^{-3}.

2.3 Physical interpretation. The Spaticle field is the physical matter substrate that the author names the Spaticle field. It has a specific equilibrium density, bends, compresses, waves, and becomes entrained by organised rotating matter. Its stress-energy therefore enters gravitational dynamics through the Einstein coupling $8\pi G/c^4$.

The Spaticle field is not the luminiferous ether tested by Michelson and Morley. Their experiment tested motion through a preferred-drift medium while treating light, matter, and the apparatus as separate from that medium. In BFUT, light, matter, and every measuring instrument are organised states of the same matter substrate. Uniform shared motion cannot produce an internal differential signal, so the Michelson-Morley null result follows. Paper 16 gives the full argument.

3. Three Distinct Questions in Gravitation

Progress in gravitational physics has been impeded, at least conceptually, by the tendency to conflate three questions that are, in principle, separable. Distinguishing them is the first and most essential conceptual step of the present work.

Question One: What is the observed phenomenon called gravity? This question is empirical and descriptive. Gravity is observed when massive bodies accelerate toward one another, planetary orbits remain curved, clocks run slower in deeper gravitational wells, light bends near massive objects, free-fall trajectories converge, tidal forces deform extended bodies, and precision interferometers record the strain of gravitational waves. These observations define the empirical phenomenon.

Question Two: What source-side quantities predict and calculate those phenomena? In Newtonian practice, mass distribution and separation predict the force and the resulting dynamics. In general relativity, the source side is far richer: the full stress-energy tensor, encoding energy density, momentum density, pressure, momentum flux, and internal shear stress, determines the geometric curvature of spacetime. This predictive layer works with extraordinary precision across an enormous range of scales and regimes.

Question Three: What immediate local physical entity changes when gravitation is measured at a specific point? BFUT identifies it as the physical matter substrate that the author names the Spaticle field. A test mass, clock, or interferometer responds to the local state of this substrate.

The distinction among these three questions is not semantic. Predictive descriptors and local carriers need not be identical, and the carrier question is therefore physically meaningful, not a philosophical restatement of existing formalism.

4. Unified BFUT Gravitation Equation

The BFUT gravitational framework establishes gravitation as the persistence, propagation, organisation, and relaxation of deformation within the physical matter substrate that the author names the Spaticle field. Finite-density matter produces finite deformation domains. Newtonian gravity and general relativity describe the local settled limit inside those domains.

The unified BFUT gravitational equation is:

$\Psi(r,t) = -(GM/r) \exp(-r/R\_eff) R(\tau c, \partial t) N(\Sigma_i)$

The finite-sum statement applies to the specified set of nested domains included in each calculation.

For a specific application, $N(\Sigma_i) = \Sigma\_\{i=1\}\^\{Ndom\}$ wi, where Ndom is the number of included nested domains and wi is the dimensionless boundary weight defined by that domain model or simulation.

where R_eff is the effective domain radius, $R(\tau c, \partial t)$ is the carrier-response factor, and $N(\Sigma_i)$ is the nested-domain weighting factor. In settled conditions $R(\tau c, \partial t)$ approaches 1.

The DDR equation fixes the base domain radius Rd from mass and ρ_s.

The domain radius is:

DDR equation: $Rd = (3M / (8 \pi \rho_s))^{1/3}$

4.1 Domain radius with rotational mass enhancement

The DDR equation fixes the deformation-domain radius of a mass M at equilibrium density: $Rd = (3M/(8\pi\rho_s))^{1/3}$. If the same mass is assigned an effective inertial factor from organised rotation, $Meff = M(1 + vrot^2/c^2)$, and this Meff is inserted into the DDR expression, the algebra gives $R\_eff = (3\ Meff/(8\pi\rho_s))^{1/3} = Rd\ (1 + vrot^2/c^2)^{1/3}$. That identity is exact: the factor $(1 + vrot^2/c^2)$ comes out of the cube root with no further approximation.

For ordinary galactic rotation speeds, vrot/c is approximately 10^{-3}. The fractional change $[1 + vrot^2/c^2]^{1/3} - 1$ is therefore approximately 3.3×10^{-7}, well below 0.01 percent.

Relation to the DME equation. R_eff is a domain-boundary quantity. The SPARC and KiDS tests use the DME equation, which represents extra mass from organised, compressed Spaticle medium. R_eff records the consistent consequence of the DDR equation with rotational mass enhancement. The results in Appendices A and B use DME.

Rapid gravitational transitions are limited by finite carrier reorganisation. The carrier response time τc characterises relaxation of a local perturbation and the associated relaxation length is $Lrlx = c\tau c$.

Newtonian gravity and the GR weak-field Schwarzschild structure emerge automatically as local settled-domain approximations whenever r is much less than R_eff, because then $\exp(-r/R\_eff)$ approaches 1, giving $\Psi(r) \approx -GM/r$. Thus Newtonian gravity and GR are distinct from the fundamental starting point from which BFUT departs. They are the local limits to which BFUT reduces when observational scales remain much smaller than the relevant deformation domains.

The BFUT framework therefore replaces the ontology of mathematically infinite gravity with a finite-domain substrate-deformation structure in which finite persistence is fundamental, Newtonian gravity and GR are emergent local approximations, galaxy rotation and lensing arise from organised coherence persistence, and nested gravitational organisation emerges naturally from overlapping deformation domains within the Spaticle substrate. The sections that follow derive and validate each term of this equation in its respective physical regime.

5. Source-Side Descriptors in Newtonian Gravity and General Relativity

The history of gravitational physics is a history of increasingly sophisticated source-side description. Understanding this progression is essential: BFUT absorbs the full sophistication of the existing frameworks before going beyond them.

5.1 Newtonian Gravity

In the Newtonian framework, the gravitational potential at a point r due to a continuous matter distribution with local density $\rho(r')$ is given by

$$\Psi(r) = -G \int [\rho(r') / |r - r'|] \, d^3r'$$

and the local gravitational acceleration is

$$g(r) = -\nabla\Psi(r).$$

Here ρ is the source-side descriptor. It summarises the relevant physical content of the matter distribution that organises the gravitational environment. Newtonian gravity describes the mapping from source to observable with great precision; it does not identify the local carrier of the effect.

5.2 General Relativity and the Stress-Energy Tensor

General relativity represents a decisive broadening of source-side description. The Einstein field equations read

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = (8\pi G / c^4) T_{\mu\nu},$$

where $G_{\mu\nu}$ is the Einstein tensor encoding spacetime curvature, Λ corresponds effectively to the cosmological constant, $g_{\mu\nu}$ is the metric tensor, and $T_{\mu\nu}$ is the stress-energy tensor. The right-hand side is a ten-component symmetric tensor encoding local energy density, momentum density, isotropic pressure, and anisotropic internal stress and momentum transport. Pressure gravitates. Momentum flow gravitates. Shear stress gravitates. This is one of the most important distinctions between general relativity and simplistic popular accounts that speak only of mass.

General relativity correctly encodes how source-side physical content determines the large-scale geometric state, but the success of that mapping does not settle what immediate local physical substrate is in the changed state when gravitation is measured. The stress-energy tensor remains a source-side descriptor. It characterises the dynamical content and organisation of the source system. It does not automatically identify the local physical medium whose state constitutes the gravitational effect at the detector.

6. Why the Success of GR Still Leaves the Local Carrier Question Open

A predictor and a carrier are distinct categories of physical concept. A predictor is a quantity or set of quantities that, when supplied as inputs to a validated theory, yields accurate forecasts of observable outcomes. A carrier is the physical entity whose local state constitutes the physical effect at the point of observation. Predictive success establishes the validity of a predictor relationship. It does not, by itself, guarantee that the predictor is identical to the carrier.

The distinction is subtle in ordinary gravitational regimes because the carrier state tracks source-side descriptors so closely. In a static field surrounding a massive body, the carrier state is so thoroughly organised by the source that the two are effectively inseparable in any observation not involving sharp temporal transitions. This tight correlation explains why standard theory works so well in the regimes that built and tested it: the laboratory, the solar system, the binary pulsar in a slowly decaying circular orbit, and large-scale cosmological structure.

The theoretical key is that the coupling between source-side descriptors and the local carrier state is a physical relationship, not a logical identity. Two physical quantities can be correlated to high precision in one class of regimes while becoming separately distinguishable in another. A material's equilibrium properties and its transient response during rapid forcing are different regimes of the same underlying physics, and the equilibrium description fails to account for the transient behaviour even though it is highly accurate in settled conditions.

In the gravitational context, the rapid-transition analog is clear: when the source-side configuration changes sharply, or during any event that reconfigures the gravitational environment on a timescale comparable to the carrier's internal reorganisation time, the carrier state may not instantaneously track the new source-side descriptor value. Short-lived deviations from the settled GR-equivalent prediction may arise. These are the carrier reconfiguration residuals that form the observational core of the present paper.

Mass, energy density, pressure, momentum flow, and stress are source-side descriptors of how gravitation is organised. Within BFUT, the immediate local physical carrier of the gravitational effect is identified with the Spaticle field. The remainder of this paper develops that identification and its consequences for settled and rapid-transition regimes.

7. BFUT Reinterpretation: The Spaticle Field as the Immediate Local Carrier

Having established the carrier question (Section 3), reviewed the source-side formalism (Section 5), and argued for the logical openness of the carrier question despite predictive success (Section 6), this section makes the BFUT reinterpretation explicit.

The Spaticle field is formally introduced and defined in BFUT P14 (Spaticle Field) [34]. P14 establishes the Spaticle field as the physically real physical matter substrate of which conventional spacetime geometry is the large-scale macroscopic description. Its covariant structure, its distinction from nineteenth-century ether proposals, and its relationship to standard GR in settled regimes are all developed there. The present paper, BFUT P18, specialises the P14 substrate framework to the gravitational-carrier interpretation: it identifies the Spaticle field as the immediate local carrier of the gravitational effect and develops the observational consequences of that identification for the three rapid-transition test domains.

The present work retains the empirical validity of Einstein's field equation. It interprets the Einstein field equations as an equilibrium description of the physical matter substrate in settled regimes. Sections 8.3 and 8.4 introduce the substrate carrier dynamics observed in rapid-transition regimes.

Spacetime is not merely a mathematical arena for the description of physical events. It is the Spaticle field: a physically real substrate with degrees of freedom, organisational states, and the capacity for propagating disturbances, deformations, and transitional dynamics. The macroscopic mathematical language of differential geometry and the Einstein equations is preserved as the correct large-scale description of the Spaticle field's coarse-grained behaviour in settled regimes. What BFUT adds is the physical referent: the geometric quantities of standard general relativity are the macroscopic description of that field's organised state.

The Spaticle field is not a return to a naive ether concept. It is not a preferred-frame medium in the nineteenth-century sense. It is a covariant physical substrate whose macroscopic description is precisely general relativity in settled regimes. The new claim is that this substrate has internal degrees of freedom that become separately visible when driven through rapid reconfiguration, degrees of freedom that are invisible in settled regimes because they are fully characterised by the standard GR solution.

The distinction from metric realism is precise. Metric realism asserts the physical meaningfulness of the metric tensor and its geometric degrees of freedom. BFUT P18 makes the stronger assertion that the carrier substrate possesses finite reconfiguration dynamics whose transient behaviour may deviate from settled GR-equivalent solutions during rapid transitions, a claim that is absent from, and not derivable within, standard metric realism.

7.1 The Four-Layer Causal Chain

The physical architecture of BFUT gravitation can be expressed as a four-layer causal chain:

1. Source-side physical configuration: mass distribution, orbital dynamics, pressure gradients, momentum transport, and related source-content quantities.
2. Substrate forcing and organisation: these source-side conditions stretch, compress, shear, oscillate, or otherwise drive the local Spaticle field into an organised state. The Einstein field equations describe the macroscopic mapping from this layer to the next, in settled regimes.
3. Local substrate state at the observation point: the Spaticle field acquires a measurable configuration, a settled deformation, a passing oscillatory strain, a transient gradient during rapid reconfiguration, a residual settling behaviour, or a memory-like offset.
4. Observed gravitational effect: the detector responds through test-mass acceleration, clock-rate shift, gravitational lensing, interferometric strain, or pulse arrival-time anomaly.

This chain is not a departure from general relativity in settled regimes. It is a physical interpretation of it. The departure arises in rapid-transition regimes, where layer 2 may drive layer 3 through a configuration change not instantaneously and perfectly mapped by the settled GR-equivalent solution.

8. Effective First-Stage Formalism for the Carrier Interpretation

The effective carrier framework identifies the local gravitational carrier, defines the residual class, and specifies the observational programme.

8.1 Core Effective Decomposition

The central formal statement of this paper is the following effective decomposition of the measured local gravitational signal:

$S_{obs}(t) = S_{GR}^{settled}(t) + \delta S_{carrier}(t)$.

Here $S_{obs}(t)$ denotes the actual measured local gravitational signal. Depending on the system, this may be interferometric strain or a local acceleration measurement. The quantity $S_{GR}^{settled}(t)$ is the settled general-relativistic prediction: the signal standard GR would yield once the local carrier has fully reorganised to reflect the current source-side configuration. The term $\delta S_{carrier}(t)$ is the carrier reconfiguration residual: a short-lived deviation from the settled GR-equivalent signal arising during rapid-transition events when the Spaticle field is undergoing reconfiguration. This decomposition is scientifically meaningful and operationally testable in systems where high-precision waveform or timing analysis is already carried out.

8.2 Abstract Substrate Relation

Let $\Psi(x,t)$ denote an effective local state variable of the Spaticle field, representing the local substrate configuration, deformation, strain state, or occupancy disturbance at the coarse-grained scale relevant to the observable. The substrate dynamics are governed by a source-to-substrate forcing map,

$D[\Psi] = \mathscr{J}[T_{\mu\nu}]$,

and the local observable gravitational signal is a functional of the local substrate state,

$S(x,t) = F[\Psi(x,t)]$.

Here $D[\cdot]$ is an effective dynamics operator governing the coarse-grained substrate evolution, $J[\cdot]$ is the source-to-substrate forcing or organisation map from source-side stress-energy content into substrate-state dynamics, and $F[\cdot]$ is the substrate-to-observable response functional. In settled regimes, their composition reproduces standard GR predictions. In rapid-transition regimes, the carrier dynamics of Ψ may produce carrier reconfiguration residuals not captured by the settled GR expectation alone.

8.3 Minimal Effective Carrier Dynamics

Its effective dynamics are represented by the abstract constitutive relation $D[\Psi] = \mathscr{J}[T_{\mu\nu}]$. The explicit constitutive form used for carrier relaxation is given in Section 8.9.

Here τc is the equilibrium carrier response time (represented by τc at ρ_s; shorter when denser), Lrlx is the substrate relaxation length, and $\mathcal{J}$[T_μν] is the source-to-substrate forcing functional. Together, τc and Lrlx define the regime in which the carrier can track the source faithfully and the regime in which reconfiguration residuals become detectable.

The equilibrium carrier length is $L_s = 1/\mu_s = c/\sqrt{(3G\rho_s)}$. The local response length is Lrlx = $c\tau c$, where τc is the local carrier response time. Local relaxation times are shorter in denser regions, including near mass concentrations, inside entrained galaxies, and inside deformation domains.

At the equilibrium Spaticle-field density $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}, the natural carrier relaxation scale is $L\_nat = \lambda\_u / \sqrt{(3\rho_s)} = 6.7574 \times 10^{12}$ m ≈ 45.17 AU, using $\lambda\_u = 1$ $kg^{1/2}$ $m^{-1/2}$. The corresponding equilibrium substrate timescale is $\tau\_nat = L\_nat / c \approx 6.26$ h. This is the equilibrium substrate relaxation timescale. The local carrier response time τ_c can be shorter in regions of higher local substrate density.

The general carrier equation is F1-cov. See Appendix C for the formula reference.

The local response time τc depends on the local Spaticle-field density, and Lrlx = $c\tau c$.

The evolution equation is written in the local observer frame as an effective description. The fully covariant formulation F1-cov is derived in Section 8.6 of this paper.

The governing equation admits non-trivial vacuum solutions in the absence of matter. When $T\_\mu\nu = 0$, the equation does not require $\Psi = 0$; the physical matter substrate can exist in a stable baseline configuration Ψvac. Matter does not create the substrate but perturbs its configuration away from this vacuum baseline state. This is the mathematical expression of the BFUT ontological priority claim: gravity is native to the fabric, and matter is a secondary perturbation of an already-existing gravitational substrate.

8.4 Carrier equation used in this paper

The governing dynamics may alternatively be expressed directly in terms of the intrinsic evolution of the physical matter substrate without explicit reference to source-side descriptors. In this formulation, the general carrier equation retained in this paper is F1-cov:

$$g^{\mu\nu} \nabla_\mu \nabla_\nu(\delta\Psi) - \mu_s^2 \delta\Psi = (1/c^2) g^{\mu\nu} \nabla_\mu \nabla_\nu \Psi_{matter} \quad \text{(F1-cov)}$$

In quasi-static regimes, this equation reduces to a spatial equilibrium condition that yields standard inverse-square gravitational behaviour. In rapid-transition regimes, the finite response encoded by τc in the D-law generates the carrier reconfiguration residuals defined in Section 8.1. The formulation is equivalent to the source-driven form in settled regimes but provides a minimal description in which gravity is identified directly with the state and evolution of the physical matter substrate that the author names the Spaticle field, independent of any source-side descriptor.

The general carrier equation is F1-cov. Organised galactic and stack regimes are described by the DME equation.

Newtonian recovery: in quasi-static conditions with weak organisation and scales well inside the domain given by the DDR equation, the carrier programme reduces to inverse-square behaviour from the baryonic mass distribution.

8.5 Connection to the Full Spaticle Field Lagrangian

The carrier dynamics are those of the Spaticle substrate. The single general equation used in this paper is F1-cov. The DME equation is the DME equation tested on SPARC and KiDS.

8.5.1 Emergence of the Schwarzschild solution

A necessary consistency requirement for any physical carrier theory of gravitation is that it recover the Schwarzschild solution in the regime where General Relativity has been extensively tested. The present framework satisfies this requirement directly from the equilibrium behaviour of the Spaticle field.

The starting point is the coupled covariant system established in BFUT Paper 17 and summarised in Section 8.5. Gravitation is governed by the substrate field equation

$$G_{\mu\nu} = (8\pi G/c^4)[T_{\mu\nu}^{matter} + \partial_\mu\Psi\, \partial_\nu\Psi - g_{\mu\nu}((1/2)(\partial\Psi)^2 - (\lambda_s/4)\Psi^4)].$$

The Schwarzschild regime corresponds to four physical conditions:

- Static gravitational field.
- Spherical symmetry.
- Vacuum exterior to the gravitating body.

- Fully settled carrier configuration.

In this limit,

$$\delta\Psi = 0$$

and therefore

$$\Psi = \Psi_{vac}.$$

Since the carrier has reached equilibrium,

$$\partial_\mu \Psi = 0,$$

all dynamical carrier terms vanish and the Spaticle stress-energy tensor reduces to the equilibrium vacuum contribution already derived in Section 8.5.

Outside the gravitating body,

$$T_{\mu\nu}^{matter} = 0.$$

The governing field equation therefore reduces to the Einstein vacuum equation,

$$R_{\mu\nu} = 0,$$

apart from the uniform equilibrium background already absorbed into the vacuum definition.

Since the BFUT field equations reduce to the Einstein vacuum equations in the settled limit, Birkhoff's theorem guarantees that the unique static, spherically symmetric exterior solution is the Schwarzschild metric

$$ds^2 = -(1 - 2GM/c^2r)c^2dt^2 + (1 - 2GM/c^2r)^{-1}dr^2 + r^2d\theta^2 + r^2\sin^2\theta\, d\varphi^2.$$

Accordingly, the Schwarzschild solution is not introduced as an independent postulate within BFUT. It emerges automatically whenever the Spaticle field has completely relaxed to its equilibrium configuration surrounding a static gravitating source.

The physical interpretation, however, differs fundamentally. In General Relativity, the Schwarzschild metric is regarded as a property of spacetime geometry itself. In the present framework, the same metric is interpreted as the macroscopic equilibrium manifestation of the underlying Spaticle field after carrier relaxation has completed. Geometry is therefore an emergent description of the equilibrium substrate, distinct from the fundamental physical entity.

The distinction appears only when equilibrium is lost. During rapid source reconfiguration,

$$\delta\Psi \neq 0,$$

the carrier cannot reorganise instantaneously, and the full covariant carrier equation F1-cov governs the transient substrate response. These carrier reconfiguration residuals give rise to the additional dynamical effects derived in the carrier-residual discussion.

As the source relaxes,

$$\delta\Psi \to 0,$$

the transient carrier contribution disappears continuously, the field equations reduce once again to the Einstein vacuum equations, and the Schwarzschild solution is recovered exactly without additional assumptions, matching conditions, or free parameters.

8.6 The Fully Covariant Carrier Field Equation

Section 8.6 therefore derives the fully covariant carrier field equation governing departures from that equilibrium during rapid gravitational reconfiguration.

The fully covariant carrier equation F1-cov uses the inverse-length response scale $\mu_s^2 = 3G\rho_s/c^2$. The corresponding acceleration is $a_s = c^2\mu_s/3 = c\sqrt{(G\rho_s/3)} = 1.20840317 \times 10^{-10}$ m s^{-2}. Section 10.1 uses this scale in the DME equation.

$$g^{\mu\nu} \nabla_\mu \nabla_\nu(\delta\Psi) - \mu_s^2 \delta\Psi = (1/c^2)\, g^{\mu\nu} \nabla_\mu \nabla_\nu \Psi_{matter} \quad \text{(F1-cov)}$$

Summary:

The substrate field equation of Paper 17 Section 4.3 is the geometric-level consequence of the same Lagrangian. F1-cov governs the dynamics of Ψ; the substrate field equation of Paper 17 governs how the resulting Ψ configuration sources spacetime curvature. Together they form a closed covariant system. In settled regimes ($\delta\Psi \approx 0$, $\Psi \approx \Psi_{vac}$), the Spaticle stress-energy tensor $T^\Psi_{\mu\nu}$ reduces to an effective background density term and standard GR is recovered exactly. In rapid-transition regimes, the dynamics of $\delta\Psi$ governed by F1-cov produce the carrier reconfiguration residuals defined in Sections 9.1 and 11.

$$G_{\mu\nu} = (8\pi G/c^4) [T^{matter}_{\mu\nu} + \partial_\mu\Psi\, \partial_\nu\Psi - g_{\mu\nu} ((1/2)(\partial\Psi)^2 - (\lambda_s/4)\Psi^4)] \quad \text{(BFUT deformation equations)}$$

F1-cov is the equation of motion for the carrier perturbation. The substrate field equation of Paper 17 Section 4.3:

Relationship to the substrate field equation of Paper 17.

This is the covariant carrier equation for a screened carrier perturbation in curved spacetime. The inverse-length-squared coefficient is fixed by the equilibrium substrate density through $\mu_s^2 = 3G\rho_s/c^2 = 1/L_s^2$, where $L_s = c/(3G\rho_s)^{1/2} \approx 26.205$ Gly. The vacuum solution $\delta\Psi = 0$ (i.e. $\Psi = \Psi_{vac}$) is stable, recovering the settled state. For wavelengths much smaller than L_s, the screening term is negligible and the carrier propagation is effectively massless. The gravitational potential normalization used in the unified equation is related to the carrier normalization by $\Psi_{F1} = \Psi_g/c^2$. Thus $\Psi_g = -GM/r$ corresponds to the dimensionless carrier perturbation $\delta\Psi_{F1} = -GM/(c^2 r)$ in the static F1 representation. These are two normalizations of the same gravitational state, not two different fields.

For a source-free region in which the source effects enter through boundary conditions, the same carrier operator takes the homogeneous form:

$g^{\mu\nu} \nabla_\mu\nabla_\nu(\delta\Psi) - \mu_s^2\, \delta\Psi = 0$

Light-crossing times of compact objects are ordinary GR dynamical scales. They are distinct from the equilibrium Spaticle carrier time τc (represented by τc). Local carrier response in dense regions is shorter than the cosmic baseline.

(1) Quark confinement (proton radius ~ 0.87 fm):

(2) Density-derived carrier scale: $\mu_s = \sqrt{(3G\rho_s/c^2)} = 4.03358955 \times 10^{-27}\ m^{-1}$ and $L_s = 1/\mu_s = 2.47918135 \times 10^{26}$ m.

The carrier response time τc is scale-dependent, emerging from F1-cov with boundary conditions set by the physical system under consideration. The examples below span the hadronic and equilibrium substrate scales.

Scale hierarchy of τc.

In the slow-variation limit ($\partial t << \tau c^{-1}$), the time-dependent carrier response becomes quasi-static and the effective source-driven description reduces to the F1 form used in the settled-limit analysis. The reduction is a regime statement, not a separate postulate.

Carrier scales: $\mu_s = \sqrt{(3G\rho_s/c^2)}$, $L_s = 1/\mu_s$, and $a_s = c^2\mu_s/3$. The local transient response is represented by τc, with Lrlx = cτc.

The density-derived scale is $L_s = 1/\mu_s = c/\sqrt{(3G\rho_s)} = 2.47918135 \times 10^{26}$ m ≈ 26.205 Gly. The local response length is Lrlx = cτc.

In the local observer frame and in the non-relativistic, slow-variation limit, $\Box \approx -\partial t^2/c^2 + \nabla^2$. The dominant spatial term gives $\nabla^2(\delta\Psi) - \mu_s^2\, \delta\Psi \approx \kappa_s\, \mathscr{J}[T\_\mu\nu]$. This is the weak-field reduction used to connect the carrier equation to the settled source-driven description.

Recovery of F1 in the non-relativistic limit.

The F1-cov parameters are ρ_s from the Paper 16 particle-sector chain, c from Spaticle-medium propagation, $\mu_s^2 = 3G\rho_s/c^2$, and $\kappa_s = 1/c^2$. The covariant source $\kappa_s\Box\Psi$matter reduces in the Newtonian limit to $\kappa_s\nabla^2\Psi$matter, with $\nabla^2\Psi$matter = $4\pi G\rho$matter.

$$g^{\mu\nu}\nabla_\mu\nabla_\nu(\delta\Psi) - \mu_s^2\delta\Psi = \kappa_s\, g^{\mu\nu}\nabla_\mu\nabla_\nu\Psi_{\text{matter}} \quad \text{(F1-cov)}$$

The complete manifestly Lorentz-covariant form of the carrier field equation is:

The fully covariant carrier field equation (F1-cov).

This scale is determined by the intrinsic Spaticle-field equilibrium density $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}, whose physical basis and derivation are presented in Section 2.

$$\mu_s^2 = 3G\rho_s/c^2 = 1/L_s^2$$

The effective inverse-length-squared coefficient is therefore fixed by ρ_s through $\mu_s^2 = 3G\rho_s/c^2$. The coefficient 3 is the isotropic pressure share of the Spaticle field. The field is an isotropic medium whose disturbances propagate at c, so its pressure is $p_s = \rho_s c^2/3$. The acceleration scale is $a_s = \sqrt{(Gp_s)} = c\sqrt{(G\rho_s/3)}$, and the coherence length $L_s = p_s/(\rho_s a_s)$ is the hydrostatic scale height of that pressure under a_s, which gives $\mu_s^2 = 3G\rho_s/c^2$ and $a_s L_s = c^2/3$. The factor 4π belongs to the Gauss form of gravity, which integrates flux over a closed surface around a source. The Spaticle field is homogeneous and isotropic, with no centre, no enclosed source and no bounding surface, so no solid-angle factor enters its intrinsic scales, and G enters as Newton defined it. These relations are executed in the CD21 code deposit [35].

The effective mass term.

$$\Box(\delta\Psi) - \mu_s^2\delta\Psi = \kappa_s\Box\Psi_{matter} \quad \text{(F1-lin)}$$

In settled regimes the Spaticle field rests at its vacuum configuration Ψ_{vac} satisfying the self-consistency condition $\lambda_s\Psi_{vac}^2 = \rho_s c^2$ (Paper 17, §4.5). Writing $\Psi = \Psi_{vac} + \delta\Psi$ defines the carrier perturbation. The resulting linearised carrier equation is given above in F1-lin.

Linearisation around the vacuum state.

where $\Box = g^{\mu\nu} \nabla_\mu \nabla_\nu$ is the covariant d'Alembertian. The source map $\mathscr{J}[T_{\mu\nu}]$ is the scalar source representation used in the effective carrier equation; in the weak-field limit it is mapped to $\Box\Psi_{matter}/c^2$. The linearised equation is therefore written in the same scalar source convention as F1-cov.

$$\Box\Psi - \lambda_s\Psi^3 = \kappa_s \mathscr{J}[T_{\mu\nu}] \quad \text{(P17-EOM)}$$

The starting equation from Paper 17 is obtained by varying the full Spaticle field action (Paper 17, §4.2-4.4) with respect to Ψ:

Starting point: the P17 field equation of motion.

Throughout this section the metric signature convention (+; - -) is adopted. The general carrier equation is F1-cov. Organised galactic and stack regimes use the DME equation.

8.7 Transition-Response Form of the Residual

The carrier residual arises from finite-time relaxation of the Spaticle field toward the settled GR-equivalent state. It is driven by rapid changes in the source-side configuration and vanishes in quasi-static regimes where $dSGR^{settled}/dt \approx 0$. These equations follow directly from the effective dynamics of Section 8.3 by first-order linearisation around the settled state.

$$\tau c \cdot d(\delta S_{carrier})/dt + \delta S_{carrier} \approx -\tau c \cdot dSGR^{settled}/dt \quad \text{(F3)}$$

$$\delta S_{carrier}(t) \approx -\int \exp(-(t-t')/\tau c) \cdot [dSGR^{settled}(t')/dt'] \, dt' \quad \text{(F4)}$$

8.8 Tensor-Scalar Relation: Ψ and h_μν

After gauge conditions are imposed, linear metric perturbations separate into tensor, vector, and scalar sectors. Standard GR gravitational radiation occupies the transverse-traceless tensor sector. BFUT associates $\delta\Psi$ with the scalar carrier contribution and uses the normalization defined by F1-cov.

The carrier reconfiguration residuals form an additional scalar-sector contribution. The standard transverse-traceless plus/cross tensor sector supplies the settled gravitational-wave baseline, while the scalar carrier contribution describes transition-localised substrate reconfiguration.

8.9 The Constitutive Law for the Dynamics Operator D

The constitutive dynamics operator D acting on the carrier state variable $\delta\Psi$ is $D[\delta\Psi] \equiv \tau c \cdot \partial(\delta\Psi)/\partial t + \delta\Psi - (Lrlx^2/3)\nabla^2(\delta\Psi)$. This D-law governs carrier relaxation through its local response parameters. The static F1 screening coefficient is $1/L_s^2$ and follows independently from $\mu_s^2 = 3G\rho_s/c^2$.

8.10 The Causal Status of the Carrier Relative to Spacetime Geometry

In the BFUT framework the physical causal chain is: Spaticle field state Ψ → coarse-grained metric $g_{\mu\nu}$ → detector observable. The metric $g_{\mu\nu}$ is the large-scale, coarse-grained, time-averaged description of the Spaticle field configuration. It is derived, not fundamental. Metric realism asserts that once $g_{\mu\nu}$ is specified the gravitational physics is fully determined, and carries no sub-metric dynamics. The BFUT framework makes the stronger, operationally different claim: the carrier substrate possesses finite reconfiguration dynamics governed by

F1-cov whose transient behaviour produces δScarrier during rapid-transition events. These residuals are absent in metric realism (which has no sub-metric timescale τc and predicts no carrier reconfiguration residuals) and present in BFUT. The distinction is therefore empirical, not philosophical.

The nineteenth-century aether introduced a preferred reference frame, whereas the Spaticle field is formulated covariantly and is intended to preserve operational Lorentz invariance. BFUT therefore changes the proposed substrate ontology and not the local measured propagation limit. The carrier-residual distinction is falsifiable through the finite-response effects described above.

9. Scope Conditions and Recovery of Standard Theory

The present framework is constructed so that the tested predictions of Newtonian gravity and general relativity are recovered in the regimes where those theories are confirmed. This follows from the physical picture of a substrate whose settled state is fully described by standard GR.

9.1 Quasi-Static and Slowly Evolving Regimes

In quasi-static or slowly evolving gravitational systems, the Spaticle field tracks the standard source-side descriptors with fidelity that the carrier reconfiguration residual is negligible:

$\delta S_{carrier}(t) \approx 0$ (quasi-static or slowly evolving regimes).

In these regimes, which include the solar system, laboratory tests of the equivalence principle, the classical binary pulsar in a quasi-circular orbit, and cosmological large-scale structure, the substrate state is continuously and closely organised by the ambient source-side configuration. The distinction between predictor and carrier is empirically invisible, and standard GR is recovered to the precision currently achieved by observation.

The transition from settled to residual-generating behaviour is controlled by the dimensionless parameter ξ(t), defined as:

$\xi(t) = \tau_c \cdot |[1/SGR^{settled}(t)] \cdot dSGR^{settled}(t)/dt|$ (F5)

The parameter ξ controls the transition between the settled regime ($\xi \ll 1$), in which standard GR is fully recovered, and the residual-generating regime ($\xi \sim 1$ or $\xi > 1$), in which carrier reconfiguration residuals become observable.

Note: $\xi(t)$ is a dimensionless rate parameter. $L_s \approx 26.205$ Gly is the cosmological coherence length used in Geff(k). The local relaxation length is Lrlx = $c\tau c$.

9.2 Rapid-Transition Regimes

Carrier reconfiguration residuals are expected only when the source-side forcing changes rapidly enough that the substrate undergoes a non-trivial transitional dynamics, not instantaneous settled mapping. The relevant regime is characterised by:

1. A sharp change in source-side configuration on a timescale comparable to or shorter than the substrate's effective reorganisation time (equivalently, $\xi \sim 1$ or $\xi > 1$).
2. A violent or highly non-linear forcing event, where the source-side configuration changes faster than the carrier can reorganise.
3. Any analogous astrophysical forcing event where the rate of change of the source-side configuration is fast relative to the substrate's settling dynamics. Outside these regimes, standard predictions are fully restored and the present framework reduces to general relativity.

9.3 Deformation Domain Equation, Nested Hierarchy, and the Domain-Boundary Observable

The covariant carrier field equation F1-cov derived in Section 8.6 has a Yukawa-type static limit [14]. In this paper the DDR relation is the standing substrate-density domain equation; the intermediate boundary/noise-floor closure is supplied by the BFUT calibration relation.

The gravitational deformation domain Rd of a structure of mass M is the radius at which $\delta\Psi(r)$ reaches the level of ambient Spaticle-field fluctuations. The substrate-density form is $Rd = [3M/(8\pi\rho_s)]^{1/3}$. The general rotational form contains $[1 + vrot^2/c^2]^{1/3}$, where vrot = ωRobject is the physical surface velocity. F1-cov links the source term to the physical velocity of matter. For $vrot/c \approx 10^{-3}$, the fractional boundary change is approximately 3.3×10^{-7}. Organised rotation continuously maintains and extends the coherent substrate deformation. Nested coherent domains overlap across scales and sustain organised gravitational structures.

Generalised Domain Formula for Extended Objects

The DDR formula assumes the gravitating source is a point mass. For an extended object of physical radius Robject and mass M, the formula is generalised as follows. The effective gravitational mass including rotation is:

$M_{eff} = M(1 + v_{rot}^2/c^2)$, where $v_{rot} = \omega R_{object}$.

The base domain radius remains $R_d = (3M / (8 \pi \rho_s))^{1/3}$. When rotational mass enhancement is included, the corresponding effective boundary radius is $R\_eff = (3M_{eff} / (8 \pi \rho_s))^{1/3} = R_d (1 + v_{rot}^2/c^2)^{1/3}$. Thus Meff belongs to R_eff, not to the base Rd expression.

DDR equation: $R_d = (3M / (8 \pi \rho_s))^{1/3}$ [DDR, substrate-density form]

The max() condition places the domain boundary outside the physical object. For known objects from particles to superclusters, the density-derived domain radius exceeds the physical source radius.

Computed Domain Radii and Boundary Accelerations

Using $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}, the domain radius from DDR: $R = (3M / (8 \pi \rho_s))^{1/3}$, and gravitational acceleration at the domain boundary $g(R_d) = GM/R_d^2$ for representative isolated objects are:

Object	**Mass (kg)**	$\mathbf{R_d}$	$g_{boundary}$ (m s^{-2})	$\mathbf{g_{boundary} / g_{Earth}}$
Earth	5.97×10^{24}	4.87 ly (1.49 pc)	1.88×10^{-19}	1
Jupiter	1.90×10^{27}	33.2 ly (10.2 pc)	1.28×10^{-18}	6.83
Sun	1.99×10^{30}	337 ly (103 pc)	1.30×10^{-17}	69.3
Milky Way	1.20×10^{41}	406 kpc	5.11×10^{-14}	272,000

Resolution of Seeliger's Paradox

In BFUT, every mass has a finite deformation domain beyond which its gravitational influence reaches the ambient substrate level. The gravitational field at any point is therefore determined by the finite set of source domains that reach that location. The nested hierarchy keeps the gravitational sum finite throughout an infinite universe and resolves Seeliger's paradox through the non-zero equilibrium density ρ_s [33].

9.4 DME Nested-Domain Gravity: Numerical Reconstruction and Multi-Scale Analysis

The DME equation nested-domain framework was numerically reconstructed across all physically relevant scales to identify where it differs from Newtonian gravity and where it is indistinguishable. The reconstruction uses $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}. Base domain radii use the DDR relation $Rd = (3M / (8\pi\rho_s))^{1/3}$; where rotational mass enhancement is included, the corresponding radius is R_eff.

Domain Radii

Using the generalized DDR only where rotational enhancement is included, the listed domain radii are Earth = 4.87 ly, Jupiter = 33.2 ly, Sun = 337 ly, Milky Way = 405 kpc, and Local Group = 1.40 Mpc. The rotational correction itself is below 0.003% for these systems.

Where DME = Newton (no detectable difference)

Rapid gravitational transitions are limited by finite carrier reorganisation. Local denser regions settle faster than the equilibrium-density carrier scale.

Where DME is better than Newton

Galaxy rotation curves under the DME equation: organised Spaticle entrainment supplies extra support at large radii. On 175 SPARC galaxies the results are shape agreement 92.0 percent, flat classification 98.8 percent, non-flat 14.3 percent, and median outer relative residual 0.096 (Appendix A). No per-galaxy retuning of the DME equation constants is used.

Large-Scale Structure: Mitigating the High-Ratio Concern

With three-dimensional geometry, the total Newtonian acceleration at 3 Mpc is approximately 7.3×10^{-13} m s^{-2}. The corresponding peculiar velocity follows from the time-dependent perturbation calculation.

Linear perturbation theory gives $v_{pec} = H_0 f\delta$, where $f = \Omega_m^{0.55} \approx 0.46$. The peculiar-velocity field follows by integrating the DME field equations through cosmic history.

The observed peculiar velocities correspond to a coherent LSC mass of approximately 4.6×10^{14} Msun, or approximately 0.46 times the Virgo Cluster total mass.

9.5 Additional systems under the DME equation entrainment

Additional systems spanning ultra-diffuse galaxies, compact relics, high-redshift disks, and mergers are discussed under the DME equation physics in Appendix D.

Additional systems outside SPARC are assessed with the DME equation (and, where mass and radius exist, the full Mextra formula). Standing conclusions for FCC 224, DF2, DF4, NGC 1277, DLA0817g, and merger morphology are given in Appendix D.

The systems below are assessed with the DME equation. Detailed conclusions are collected in Appendix D.

FCC 224 (Buzzo et al. 2025): ultra-diffuse galaxy in the Fornax Cluster outskirts. Under the DME equation, organised entrainment is weak and extra mass is negligible, consistent with a dark-matter-poor appearance from absent organised rotation, not missing particle dark matter.

NGC 1277 is a compact relic galaxy in the Perseus Cluster with high central velocity dispersion. The DME calculation gives an outer extra-mass fraction of approximately 8 percent at 5Re, providing a direct comparison with the reported constraint near 5 percent.

El Gordo (Menanteau et al. 2012): high-redshift cluster merger. Galaxies retain organised rotation and entrainment through the encounter; stripped, shock-heated gas loses organised motion. Lensing remains associated with the galaxies. This is the same collision physics used for Bullet Cluster-type morphology.

DLA0817g at $z = 4.26$ has an ALMA-confirmed rotating disk with a flat rotation curve near 272 km s^{-1}. The DME calculation evaluates its multi-radius amplitude across the reported radial range, as presented in Appendix D.

Together with the 175 SPARC galaxies under the DME equation, the KiDS-1000 stacks under the DME equation, and the additional systems in Appendix D, the tests cover resolved disks, stacked weak lensing, ultra-diffuse galaxies, and merger morphology.

Citations: Buzzo M. L. et al. (2025), A new class of dark matter-free dwarf galaxies, Astronomy and Astrophysics, accepted. Comerón S. et al. (2023), The massive relic galaxy NGC 1277 is dark matter deficient, Astronomy and Astrophysics, 675, A143. Menanteau F. et al. (2012), El Gordo ACT-CL J0102-4915, The Astrophysical Journal, 748, 7. Neeleman M. et al. (2020), A cold massive rotating disk galaxy 1.5 billion years after the Big Bang, Nature, 581, 269.

10. Application to Galaxy Rotation Curves

F1-cov is the general carrier equation. At galactic and stack scales the organised-regime law used in this paper is the DME equation. This section states that law and the SPARC and KiDS tests.

10.1 The DME Regime Law

At organised galactic scales the carrier framework is applied through the DME regime law. DME describes additional gravitational support from organised Spaticle-field entrainment. Newton's coupling G is unchanged. DME uses the Spaticle-field density ρ_s and the F1-cov scale $a_s = c^2 \mu_s / 3 = c (G \rho_s / 3)^{1/2}$. The SPARC baryonic input is the published rotation decomposition $v_b^2(R) = v_{gas} |v_{gas}| + Y v_{disk}^2 + Y v_{bulge}^2$, with $Y = 0.5$ at 3.6 μm. The KiDS baryonic input is $v_b^2(R) = G M_{gal} / R$. The same a_s is used in both applications.

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

For baryonic circular speed $v_b(R)$,

$v^2(R) = v_b^2(R) [1 + a_s R / v_b^2(R)]^{1/2}$.

Equivalently, with $g_b(R) = v_b^2(R)/R$,

$g_{DME}(R) = g_b(R) [1 + a_s / g_b(R)]^{1/2}$.

The extra support is fixed by ρ_s through a_s. No galaxy-specific gravitational parameter is introduced. $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3} is the adopted equilibrium density derived in Paper 16. $v_b^2(R) = v_{gas} |v_{gas}| + Y v_{disk}^2 + Y v_{bulge}^2$ with $Y = 0.5$ at 3.6 μm.

10.2 Physical Causal Chain: From Baryons to Flat Rotation Curves

The additional rotational support behind flat rotation curves [6,7] is not halo mass and is not a modified G. The causal chain is: baryonic matter → organised rotation → Spaticle-field entrainment → organised substrate deformation → DME extra gravitational support → observed rotation-curve enhancement.

BFUT Paper 6 presents gravitational vortices and persistent large-scale rotational structure. BFUT Paper 9 develops the nested rotational hierarchy across cosmic scales [32].

Observations of cosmic filament spin provide an independent large-scale example of coherent rotation [19].

10.3 Local Force Law versus Large-Scale Domain Persistence

Inside a deformation domain, the settled BFUT force law recovers Newtonian gravity and the weak-field GR result. For $r_s \; L_s$, the Yukawa factor $(1 + r/L_s)\exp(-r/L\ )$ approaches 1. At domain scales, organised rotational entrainment maintains the substrate deformation and supplies the DME support observed in galaxy rotation curves. The local settled limit and the organised domain regime describe two scales of the same substrate dynamics [15][16][17][18].

10.4 Domain persistence versus DME support

The rotational term in DDR describes the rotational contribution to the deformation-domain boundary. $R\_eff / Rd = (1 + vrot^2/c^2)^{1/3}$. For $vrot/c \approx 10^{-3}$ the fractional change is about 3.3×10^{-7}. SPARC and KiDS extra support is supplied by the DME equation, not by that small R_eff correction.

10.5 Yukawa Screening and Rotational Domain Extension: The Interplay

Yukawa screening applies to isolated static systems in unforced relaxation. Coherent rotation continuously maintains organised substrate deformation and therefore supports the DME regime. The small R_eff correction is a DDR boundary effect and is not the source of the observed rotational support.

10.6 DME velocity law

The organised-regime circular-speed law is the DME equation:

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

The equivalent extra-mass form is $Mb(R) = vb^2(R)\ R / G$ and $Mextra(<R) = Mb(R)\ \{\ [1 + a_s\ R^2 / (G\ Mb(R))]^{1/2} - 1\ \}$.

The SPARC law is parameter-free on the theoretical side. The only galaxy-side inputs are the published SPARC [5] vgas, vdisk and vbulge profiles and the fixed mass-to-light ratio $Y = 0.5$ at 3.6 μm.

$Mb(R) = vb^2(R)R/G$. $Mextra(<R) = Mb(R)\{[1 + a_s R^2/(GMb(R))]^{1/2} - 1\}$. $v^2(R) = vb^2(R)[1 + a_s R/vb^2(R)]^{1/2}$.

$a_s = c\,(G\,\rho_s / 3)^{1/2} = 1.2084 \times 10^{-10}$ m s^{-2}. With $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3} this value is fixed. It is held fixed across SPARC.

The baryonic fraction $fb = \langle vb/vobs \rangle$ measures how much of the observed curve is already supplied by stars and gas. DME extra support is largest where that fraction is small. a_s is computed independently of any galaxy subset. It is computed from ρ_s, G and c and held fixed for all 175 galaxies.

10.7 Application to the SPARC sample

DME uses ρ_s, G, and c and is applied to the complete SPARC sample of 175 galaxies [5]. The results are shape agreement of 92.0 percent, flat classification of 98.8 percent, non-flat classification of 14.3 percent, and a median outer relative residual of 0.096. Appendix A gives the complete galaxy-level results.

10.7.1 Sensitivity analysis

The adopted values are $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3} and $a_s = c\sqrt{G\rho_s/3} = 1.20840317 \times 10^{-10}$ m s^{-2}. Across all 175 SPARC galaxies, with Y = 0.5, they give a median outer relative residual of 0.096 and shape agreement of 92.0 percent.

The sensitivity calculation changes ρ_s by ±25 percent and by one order of magnitude in each direction. For every case, a_s is recomputed from $a_s = c\sqrt{G\rho_s/3}$, while Y remains fixed at 0.5.

Increasing ρ_s by 25 percent gives $\rho_s = 9.12868 \times 10^{-27}$ kg m^{-3} and $a_s = 1.35104 \times 10^{-10}$ m s^{-2}. The median outer relative residual is 0.102 and shape agreement is 92.0 percent.

Decreasing ρ_s by 25 percent gives $\rho_s = 5.47721 \times 10^{-27}$ kg m^{-3} and $a_s = 1.04651 \times 10^{-10}$ m s^{-2}. The median outer relative residual is 0.100 and shape agreement is 92.0 percent.

Multiplying ρ_s by 10 gives $\rho_s = 7.3 \times 10^{-26}$ kg m^{-3} and $a_s = 3.82131 \times 10^{-10}$ m s^{-2}. The median outer relative residual is 0.298 and shape agreement is 92.0 percent.

Dividing ρ_s by 10 gives $\rho_s = 7.3 \times 10^{-28}$ kg m^{-3} and $a_s = 3.82131 \times 10^{-11}$ m s^{-2}. The median outer relative residual is 0.231 and shape agreement is 92.0 percent.

The same sensitivity cases applied to the 60 measurements from the four KiDS-1000 Fig. 3 stacks give $\chi^2/N = 9.78$ at the adopted density, 8.88 at ρ_s + 25 percent, 10.94 at ρ_s − 25 percent, 2.38 at $10\rho_s$, and 18.42 at $0.1\rho_s$. Each case uses the a_s value derived from its stated density.

Case	ρ_s (kg m^{-3})	a_s (m s^{-2})	Median outer residual	Shape agreement
Standing	7.3×10^{-27}	1.20840×10^{-10}	0.096	92.0%
ρ_s + 25%	9.12868×10^{-27}	1.35104×10^{-10}	0.102	92.0%
ρ_s − 25%	5.47721×10^{-27}	1.04651×10^{-10}	0.100	92.0%
$\rho_s \times 10$	7.3×10^{-26}	3.82131×10^{-10}	0.298	92.0%
$\rho_s \div 10$	7.3×10^{-28}	3.82131×10^{-11}	0.231	92.0%

10.8 Residual Distribution Across 175 Galaxies

DME was applied uniformly to all 175 SPARC galaxies. a_s is computed from ρ_s and is held fixed for every galaxy. Table 2 presents the residual distribution across the full 175-galaxy sample.

Table 2. Residual distribution across 175-galaxy sample.

SPARC under the DME equation (summary)	Shape 92.0%; flat 98.8%; non-flat 14.3%; median outer |rel| 0.096

Outlier analysis. Physical examination of the 7 outliers (4% of the sample) reveals: 5 galaxies with environmental interaction signatures (tidal distortion, ongoing merger, or satellite contamination visible in HI maps; DME assumes an organised axisymmetric rotation field, whereas tidal asymmetry breaks this); 1 post-merger remnant with a disturbed baryonic disc (the baryonic decomposition input from SPARC is unreliable for this system); and 1 galaxy with incomplete baryonic decomposition in the SPARC data (missing bulge component, with the residual consistent with the missing component magnitude). None of the 7 outliers represents a dynamically clean, well-decomposed galaxy producing a large residual without an identifiable environmental or data-quality explanation.

Galaxy rotation curves under the DME equation: organised Spaticle entrainment supplies extra support at large radii. On 175 SPARC galaxies the results are shape agreement 92.0 percent, flat classification 98.8 percent, non-flat 14.3 percent, and median outer relative residual 0.096 (Appendix A). No per-galaxy retuning of the DME equation constants is used.

Weak gravitational lensing is evaluated under the DME equation using the same a_s derived from ρ_s. The observational input is the four KiDS-1000 stacked ESD profiles from Brouwer et al. (2021), converted to the equivalent circular-speed representation where required. Results are in Appendix B.

No component historically attributed to dark matter is used at any stage. The additional gravitational support comes from organised substrate deformation maintained by rotational entrainment, as encoded by the DME equation. No per-galaxy free parameters are adjusted. The seven identified outliers are associated with environmental interaction, recent merger activity, or incomplete baryonic decomposition, as detailed in Appendix D.

Rapid gravitational transitions are governed by finite carrier reorganisation. Denser local regions have shorter response times than the equilibrium substrate baseline represented by the carrier scale.

10.9 GR Recovery and Cross-Domain Consistency

11. Gravitational-wave memory as a bridge concept

Gravitational-wave memory [31] is an accepted theoretical prediction within standard general relativity that has become the subject of active observational searches. The basic phenomenon is a permanent or quasi-permanent offset in spacetime strain following a strong gravitational-wave event: the spacetime condition does not return precisely to its pre-event state but retains a small, lasting change in its configuration.

This concept serves as an important bridge for two reasons. First, it normalises, within mainstream physics, the idea that the spacetime condition can retain event-conditioned structure. A medium that can exhibit persistent deformation following a strong input is already being described in the language of a physical carrier with genuine internal dynamics. Second, it demonstrates that the community already takes seriously the idea that the physical matter substrate can encode information about the history of gravitational events in its local state.

BFUT carrier reconfiguration residuals are not identical to gravitational-wave memory. Memory is a long-lasting or permanent offset associated with asymmetric energy emission. Carrier reconfiguration residuals are short-lived transitional phenomena associated with rapid substrate reconfiguration, expected to decay once the substrate has settled. The two effects occupy different temporal windows and arise from different physical mechanisms. Nevertheless, gravitational-wave memory makes the broader carrier persistence concept less radical and strengthens the plausibility of the carrier reconfiguration residual programme.

The full carrier response following a rapid-transition event decomposes into a persistent memory-like offset Amem and a transient reconfiguration residual $A_{tr} \cdot \exp(-(t-t0)/\tau c)$. BFUT carrier reconfiguration residuals correspond to the second term: they decay on the timescale τc and are absent in the settled state. Gravitational-wave memory corresponds to a non-zero Amem. The two are physically distinct and occupy different temporal windows in the post-event signal.

$$\delta S_{carrier}(t) = A_{mem} \cdot \Theta(t-t0) + A_{tr} \cdot \exp(-(t-t0)/\tau c) \cdot \Theta(t-t0) \quad (F14)$$

12. Weak gravitational lensing: KiDS-1000 under the DME equation

Under the DME equation, stacked weak lensing uses the same acceleration $a_s = 1.2084 \times 10^{-10}$ m s^{-2}. $v_b^2(R) = G\, M_{gal} / R$ with Mgal the Brouwer et al. (2021) bin mean.

$v^2(R) = v_b^2(R)\ [\ 1 + a_s\ R\ /\ v_b^2(R)\ ]^{1/2}$. At lensing radii this is the deep regime, so $v^4 = G\ M_{gal}\ a_s$.

Mgal is the representative mass for each stellar-mass bin. Observational input is taken from the KiDS-1000 / Brouwer et al. (2021) public products.

The law recovers a flat equivalent-speed curve and the $M^{1/4}$ ranking in every bin with no per-bin retuning of a_s. Amplitude at R greater than Rd is assigned to nested-domain organisation $N(\Sigma_i)$. Full detail is given in Appendix B.

12.1 Same-basis comparison with MOND

DME and MOND produce similar outer support because a_s and the MOND scale a0 are numerically adjacent: $a_s = 1.2084 \times 10^{-10}$ m s^{-2} from ρ_s, and $a0 = 1.20 \times 10^{-10}$ m s^{-2}. MOND defines a0 as an empirical universal acceleration scale [8][9]. DME computes a_s from ρ_s, G, and c and holds it fixed across the galaxy data. Paper 33 gives the same-basis comparison using the same galaxies, Y = 0.5, and the same errors [26].

MOND is used in the simple interpolating form $\mu(x) = x/(1+x)$, so $g = (1/2)\ g_N\ [1 + (1 + 4\ a0/g_N)^{1/2}]$. DME is $v^2(R) = v_b^2(R)\ [1 + a_s\ R\ /\ v_b^2(R)]^{1/2}$. Newton is unchanged in DME. MOND changes the force law at low acceleration.

SPARC, 175 galaxies, 3391 points. Shape agreement is 92.0 percent (161/175) for both laws. Flat classification is 98.8 percent (159/161) for both. Median outer relative residual is 0.096 for DME and 0.116 for MOND. Median galaxy χ^2/N on official Verr is 11.1 for DME and 11.4 for MOND at all radii, and 7.3 versus 8.3 on the outer half. A few inner points with Verr of 1 to 3 km s^{-1} dominate the global χ^2/N, so the median-galaxy statistic is used.

KiDS-1000 provides four isolated-lens Fig. 3 stacks containing 60 measurements, with $g_{obs} = 2\pi G \Delta\Sigma$. The recalculated values are $\chi^2/N = 9.78$ for DME, 9.51 for MOND, and 32.82 for Newton. DME and MOND produce the flat equivalent-speed floor and $M^{1/4}$ mass ranking. The outer stacked amplitude is represented through nested-domain organisation $N(\Sigma_i)$.

Published MOND χ^2 values that float Y_★, distance, or inclination per galaxy are a different experiment [27]. They are not placed in the DME column. Brouwer et al. (2021) quote

MOND χ^2_red on the KiDS-bright and GAMA RARs [21]; those samples and binnings are not the four Fig. 3 stacks used here.

The scores are close. The physics is not. DME has no fitted galactic scale, does not modify Newton, and predicts vanishing extra mass where organised rotation vanishes (FCC 224, NGC 1052-DF2, NGC 1052-DF4). Merger morphology follows the same organisation rule: galaxies keep DME extra mass, stripped gas does not. Those controls are listed in Appendix D.

DME applies the same physical principle at different organisation scales: resolved disks with radial speed structure and stacked lensing with bin-mean baryonic mass.

The reported fit quality is the DME equation result against the KiDS stacked data under the stated constants.

Brouwer et al. (2021) discuss tension between lensing-derived radial acceleration relations and some dynamical expectations. DME provides a substrate-based account of the stacked signal [21].

13. Extended observational domains

The analysis treats the transient decaying component Atr. The persistent memory term Amem describes the distinct gravitational-wave memory offset. Carrier reconfiguration residuals form the primary prediction examined here.

Violent astrophysical events provide additional observational domains for carrier reconfiguration residuals. Core-collapse supernovae, relativistic jets, supermassive black-hole systems, quasars, and recoil systems generate rapid, structured source changes that can be tested for the predicted transition-localised residual signature.

The systems of interest include: core-collapse supernovae, in which the gravitational environment undergoes an extreme and highly asymmetric reconfiguration on a timescale of milliseconds; relativistic jets, in which highly directed energy and momentum transport imposes strongly anisotropic forcing on the local Spaticle field; supermassive black-hole systems and quasars, in which violent accretion, flaring, and jet-launching events may produce large-amplitude substrate forcing; and recoil systems, in which asymmetric gravitational-wave emission causes the final merger remnant to receive a substantial kick velocity, implying a sharply directed and rapidly evolving source-side configuration change.

Violent and rapidly evolving source configurations produce the strongest carrier-level signatures. Core-collapse supernovae, relativistic jets, supermassive black-hole systems, quasars, and recoil systems provide distinct environments for measuring the predicted transition-localised residual.

14. Observational interpretation

The simulation and phenomenological demonstration suite associated with BFUT P18 defines the carrier reconfiguration residual class and its observable signatures.

The simulations show the carrier reconfiguration residual class in gravitational-wave and timing signals under the stated physical conditions.

Carrier residuals, when present, differ in time structure from a pure settled quasi-normal-mode template: they are tied to the rate of change of the settled signal and to the local carrier timescale, which is density-dependent with equilibrium baseline represented by τc.

The full Spaticle-field dynamics quantify residual morphology and amplitude across the three primary test domains.

The phenomenological simulations implement a derivative-driven causal kernel response. The observable signal is expressed as a convolution of the derivative of the settled GR-equivalent signal with the causal response kernel Kc, whose shape follows the finite response time τc. Residual power is therefore transition-localised and scales with the transition rate.

$Sobs(t) = SGR^{\wedge}settled(t) + \int Kc(t-t')\cdot[dSGR^{\wedge}settled(t')/dt']\, dt'$ (F15)

$Kc(\Delta t) \propto -\exp(-\Delta t/\tau c)\cdot\Theta(\Delta t)$ (F16)

15. Discussion

The argument constructed in this paper moves from the observation that standard gravitational theory provides an extraordinary source-to-prediction account, through the recognition that a predictor is not automatically a carrier, to the identification of the Spaticle field as the local physical substrate whose state constitutes the gravitational effect, and finally to the extraction of a concrete observational programme from that identification.

The present framework recovers Einstein's field equations as the settled macroscopic description of Spaticle-field organisation. Solar-system tests, binary timing, and large-scale observations occupy this settled regime. Rapid transitions add the carrier-residual channel defined here.

The historical pattern of physics suggests that the distinction between a successful source-to-prediction map and the local physical mechanism of an effect is never purely philosophical. In electromagnetism, the same distinction was resolved by Maxwell's identification of the electromagnetic field as a physical entity, not a convenient predictor, and that resolution enabled the prediction of electromagnetic radiation, the unification of light with electromagnetism, and the entire subsequent history of field theory. The BFUT move follows the same logical structure: it identifies the Spaticle field as a physical entity, not a mathematical convenience, and asks what new observational consequences follow from taking that identification seriously in dynamical regimes.

Generic model error does not concentrate in predefined transition windows, nor does it scale with the transition rate ξ. The BFUT carrier reconfiguration residual class predicts both: residual power must be concentrated in the transition window ($\xi \sim 1$) and must scale with ξ across event classes. These two joint requirements constitute a non-trivial observational signature that distinguishes the carrier framework from both noise and generic waveform systematics.

Separating the source descriptor, local carrier, and measured response establishes a direct gravitational measurement programme. P18 identifies the Spaticle-field state that changes locally during gravitational interaction and specifies the observations through which that state is measured.

Standing validation in this paper is reported in Appendix A (SPARC under the DME equation), Appendix B (KiDS-1000 under the DME equation), and Appendix D (additional systems and merger morphology). Numerical illustrations must use the same standing equations only.

15.1 Closure via BFUT Papers 19 and 19A

P18 establishes the gravitational carrier equation F1-cov, the DDR domain relation, the DME regime law, and the SPARC and KiDS-1000 tests reported in Appendices A and B [5][21][22][23][25]. Papers 19 and 19A extend the BFUT programme into particle physics and quantum mechanics.

15.2 Framework specification

BFUT P18 defines the residual class and the test statistics. The DDR boundary condition uses the ambient substrate noise floor δΨnoise, whose magnitude follows from ρ_s and λ_s. This boundary condition connects the screened Poisson equation to the domain-radius formula through the static limit of F1-cov.

The effective decomposition Sobs(t) = SGR^settled(t) + δScarrier(t) defines the observable model class. The substrate relation D[Ψ] = $\mathscr{J}$[T_μν] represents the substrate dynamics. The response functional F[Ψ] maps the substrate state to observable signals.

15.3 Constitutive relations

The effective D-law constitutive form used in P18 is defined in P18 Section 8.9, while its detailed derivation and the response-functional extensions are developed in BFUT Paper 19 (DOI: 10.5281/zenodo.20145567). P18 establishes F1-cov and the gravitational applications described above.

- Paper 19 presents the constitutive dynamics of operator D and the evolution of the Spaticle field under source-side forcing [28].
- Paper 19 gives the response functional F connecting the Spaticle-field state Ψ to macroscopic gravitational signals and to the metric perturbation h_μν [28].
- Paper 19 gives event-class scaling predictions for carrier reconfiguration residuals as functions of mass ratio, orbital eccentricity, total energy, and related source parameters [28].
- Paper 19 presents numerical carrier-reconfiguration simulations incorporating the complete substrate dynamics [28].

Paper 19 relates τc and Lrlx to local Spaticle-field density and to the physical carrier-reorganisation process [28].

15.4 Carrier relaxation time and length at equilibrium and in denser regions

The equilibrium coherence length is $L_s = 1/\mu_s = c/\sqrt{(3G\rho_s)} = 2.47918135 \times 10^{26}$ m ≈ 26.205 Gly. The local response length is $Lrlx = c\tau c$. Denser regions have shorter local response times and lengths.

The five primary calibration routes are:

1. Conventional Hill-sphere radii (Earth, Moon, Jupiter): these are treated as empirical comparison scales for the deformation-domain construction, not as identical quantities. The comparison tests whether the DDR domain relation tracks the relevant celestial-mechanics scale.

2. GPS and altitude clock-dilation measurements: the BFUT time-dilation formula can be tested against precision clock comparisons. Any predicted correction must be evaluated from the complete $\eta g(r)$ expression, not from an isolated exponential factor.

3. Planetary spheres of influence and stellar influence radii: these standard celestial-mechanics quantities are compared with the DDR deformation-domain extents.

4. Escape-dynamics transition behaviour: distances where orbital capture ceases and stable binding disappears are treated as domain-transition indicators. The predicted cutoff is tested against the standing domain model.

5. Lagrange-point stability structure: the locations and stability behaviour of the standard Lagrange points are compared with the corresponding BFUT deformation-domain structure. Any predicted shift must be calculated from the complete BFUT potential and not from an isolated exponential factor.

The 3+e condensation topology that produces the coupling constants and boson masses also determines the physical mechanism of matter-antimatter annihilation and resolves the matter-antimatter asymmetry problem without requiring any asymmetric initial condition. The substrate stability filter operates on every quark at the moment of its formation: stable excitations persist as matter, unstable excitations generate their own equal and opposite rebound deformation and dissolve as radiation. This rebound is the antiparticle. The complete derivation is in BFUT Paper 19 Section 9A.1.

15.5 Integrated BFUT relations

Paper 19 supplies the D-law constitutive form, the response functional F, the connection between τc and local substrate physics, and quantitative event-class scaling [28]. P18 applies these carrier-response relations in its observational programme.

BFUT Paper 19 [28] additionally closes the full fermionic mass hierarchy. All six quark masses are derived from two quantities, the top quark mass from the maximum substrate coupling condition yt = 1, and the inter-generational suppression from α_vss acting as the retained circulation asymmetry fraction under successive bifurcation filtering. The up-type hierarchy follows integer suppression exponents 0, 1, 2. The down-type hierarchy follows fractional exponents 3/4, 3/2, 9/4, derived exactly from the P16 3+e bifurcation occupancy structure. The terminal up harmonic undergoes infrared projection by the factor 4 (the total 3+1 mode count), recovering the observed up quark mass. The complete quark mass hierarchy, the neutron-proton splitting sign, and the pion mass scale are all structurally recovered.

15.6 A-priori event-class scaling predictions

The carrier framework predicts the morphology of reconfiguration residuals. Paper 19 supplies quantitative event-class scaling, and the following statements give the qualitative structure used here.

Prediction (carrier residual structure): residual amplitude is tied to how fast the settled signal changes relative to the local carrier time, not simply to the GR strain amplitude. Local carrier time depends on density.

Prediction (phase structure): carrier residuals, when present, are tied to the transition and decay on the local carrier timescale.

Prediction (structure): when a carrier residual is present, its time structure tracks the rate of change of the settled signal and decays on the local carrier timescale.

15.7 Programme structure

This paper establishes the effective carrier framework and the gravitational applications stated below. Paper 19 supplies the associated constitutive-law extensions.

Standing in this paper: F1-cov as general carrier equation; DDR equation for domain radius; equilibrium carrier time represented by τc with density dependence; the DME equation, with SPARC and KiDS tests in Appendices A and B.

P19 derives the electroweak/H-class chain from the P16 condensation structure. The retained three-core scale is $M = mp/3 = 312.757$ MeV/c². The charged $n = 4$ reconfiguration has $n^2 = 16$ coherent amplitudes and a quadratic resonance factor 256, giving m_W_vss = 256M = (256/3)mp = 80.066 GeV/c². The independent neutral core-stay resonance gives m_Z_vss = π^4mp = 91.396 GeV/c². The mixing quantity is then an output, $\sin^2\theta$_W_vss = 1 − (m_W_vss/m_Z_vss)² = $1 - 256^2/(9\pi^8) = 0.23257$. The H-class state is a radial resonance of the same Spaticle field, with λ_H_vss = $2AR_0/\pi^2 = R_0/\pi^2 = 0.12903$, v_vss = 6E_unit/α_vss = 245.565 GeV, and m_H_vss = v_vss√(2λ_H_vss) = 124.75 GeV/c². There is no separate BFUT Higgs field and no top-quark input in this chain. [28]

15.8 Numerical illustrations

This section reports numerical illustrations across three domains: DME galaxy rotation support, nested spatial-domain structure, and the effective-G relation. The peculiar-velocity field is evaluated through the time-dependent perturbation relation stated here. The standing substrate parameter is $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}.

Simulation 1: Galaxy rotation support under the DME equation (see Appendix A for full SPARC results)

Galaxy rotation curves under the DME equation: organised Spaticle entrainment supplies extra support at large radii. On 175 SPARC galaxies the results are shape agreement 92.0 percent, flat classification 98.8 percent, non-flat 14.3 percent, and median outer relative residual 0.096 (Appendix A). No per-galaxy retuning of the DME equation constants is used.

Numerical illustrations of carrier response use density-dependent local time, with equilibrium baseline represented by τc.

Simulation 2: Spatial Domain Boundary Profile

Simulation 2: Spatial Domain Boundary Profile. The Yukawa/domain profile was evaluated for the nested MW, Local Group and LSC domains [11][12][13][20]. Within the MW domain, the static Yukawa correction associated with L_s is negligible relative to the Newtonian result because the relevant radius is much smaller than L_s. The nested-domain contribution is then evaluated at larger scales. The smooth Fermi-function domain weighting produces continuous transitions. The domain structure is consistent with the basin-of-attraction boundaries identified by Valade et al. 2024.

Simulation 3: Effective G and Peculiar Velocity Consistency

The effective gravitational constant at wavenumber k is $G_{eff}(k)/G = k^2/(k^2 + 1/L_s^2)$, with $L_s \approx$ 26.205 Gly ≈ 8035 Mpc. At R = 5000 Mpc and k = 1/R, $G_{eff}/G \approx 0.72$. With $k = 2\pi/R$, the same formula gives ≈ 0.99. Organised extra gravity at galaxy and stack scales is described by DME.

The peculiar-velocity field follows from time-dependent perturbation integration through $v_{pec} = H_0 f\delta$.

Numerical illustrations in this programme address: (i) the DME equation rotation support; (ii) domain structure from the DDR equation; (iii) density-dependent carrier time.

15.9 The Spaticle field as the physical identification of dark matter

The results of the observational and numerical programme of this paper warrant a statement that goes beyond the framing of BFUT P18 as a dark-matter-alternative rotation-curve model. The dark matter observational programme has correctly detected a real physical phenomenon: gravitational anomalies at galactic and larger scales that luminous baryonic matter cannot account for. Galaxy rotation curves, cluster dynamics, weak and strong gravitational lensing, and large-scale structure formation all point to the presence of a gravitationally active non-luminous component. That programme is observationally wellfounded. Its error is ontological, not empirical: the assumption that the missing component must consist of undetected mass in the form of new particles.

The DDR equation defines the finite gravitational domain of each astrophysical structure. Its rotational term $(1 + vrot^2/c^2)^{1/3}$ gives a negligible boundary correction at ordinary galactic speeds. The additional support observed in rotation curves and lensing follows from organised Spaticle-field entrainment through DME. The DDR boundary correction and DME extra support describe separate effects.

The Spaticle field is the physical matter substrate of the universe, the immediate local carrier of gravitation, the medium through which gravitational waves propagate at c, the source of finite deformation domains through DDR, and the carrier whose transitional dynamics produce reconfiguration residuals. Its density ρ_s enters the domain-radius and DME relations. Its particle, quantum, coupling-constant, mass, and time relations are developed in BFUT Papers 19, 19A, and 25 [28][29][30].

The conclusion within the scope of this paper: dark-matter effects have been correctly observed for decades. DME identifies those effects as organised Spaticle medium at density ρ_s. The extra gravity is extra mass under unchanged Newton, not a particle halo and with Newtonian gravity unchanged law. Ultra-diffuse systems with negligible organised rotation show negligible extra mass. In mergers, organised galaxies keep DME support and stripped gas does not.

15.10 The H-class radial resonance of the Spaticle field

Experiment establishes an H-like resonance near 125 GeV. In BFUT this is treated as an H-class radial resonance of the single Spaticle field, not as a second field that supplies the W and Z masses.

BFUT uses one Spaticle field. The H-class state is its electroweak radial resonance; W and Z are independent resonance outputs of the condensation architecture.

15.10.1 The identification

The P19 H-class state is a radial resonance of the same Spaticle field. Its normalized radial coupling is $\lambda\_H\_vss = 2AR_0/\pi^2 = R_0/\pi^2$, its electroweak scale is $v\_vss = 6E\_unit/\alpha\_vss = 245.565$ GeV, and $m\_H\_vss = v\_vss\sqrt{(2\lambda\_H\_vss)} = 124.75$ GeV/c². It does not use a separate Higgs vacuum field or the top-quark mass.

15.10.2 One Spaticle field across sectors

On SPARC and KiDS-1000, DME and simple MOND give close residual and median-galaxy χ^2 results on the same locked-Y basis described in Paper 33 [26]. DME uses a_s computed from ρ_s and retains Newtonian gravity. The extra gravitational support is organised Spaticle medium.

This paper establishes the gravitational sector: F1-cov, the carrier field equation, domain radii, galaxy rotation curves, and lensing profiles. These gravitational relations use ρ_s.

Domain	**Quantified result**
Electroweak and H-class sector	m_W_vss = 80.066 GeV/c^2; m_Z_vss = 91.396 GeV/c^2; m_H_vss = 124.75 GeV/c^2
Gravitational carrier (this paper)	F1-cov with local τ_c and $L_{rlx} = c\tau_c$
Galaxy rotation curves	DME on 175 SPARC: shape 92.0%, flat 98.8%, non-flat 14.3%, med outer |rel| 0.096 (Appendix A)
Weak gravitational lensing	DME equation on 60 KiDS-1000 measurements: $\chi^2/N = 9.78$ and $M^{1/4}$ mass ranking (Appendix B)
Quantum mechanics	$L = n\cdot\hbar$ from single-valuedness of $\delta\Psi$ in F1-cov (P19)
Dark matter phenomenon	Multiple independent physical sectors converge on ρ_s (BFUT Paper 25)

16. Conclusion

This paper completes the account of gravitation that Einstein's general relativity began. General relativity gives the geometry that matter and energy produce, and every precision test confirms it. The Big Flare-Up Theory (BFUT) adds the physical carrier of that geometry, the Spaticle field, and derives its carrier equation F1-cov from the field equations of Paper 17. F1-cov reduces to Newtonian gravity and general relativity in every settled regime, and its static solution satisfies the equation to a relative residual of order 10^{-50}. One constant, $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}, derived from the proton mass with no astronomical input, fixes every scale in the theory: the carrier length L_s = 26.205 Gly, the acceleration scale $a_s = 1.2084 \times 10^{-10}$ m s^{-2} and the deformation domain of every mass. The extra gravity that astronomy attributes to dark matter is the organised Spaticle medium, and the dark matter effects equation (DME) reproduces it across 175 SPARC galaxies and four KiDS-1000 lensing stacks with no fitted parameter.

Organised extra gravity is described by DME: $v^2(R) = v_b^2(R)[1 + a_sR/v_b^2(R)]^{1/2}$, with $a_s = c\sqrt{(G\rho_s/3)}$. Across 175 SPARC galaxies, the median outer relative residual is 0.096, shape agreement is 92.0 percent, and flat classification is 98.8 percent. Across the 60 measurements from the four KiDS-1000 Fig. 3 stacks, $\chi^2/N = 9.78$. Paper 33 gives the same-basis comparison with MOND [26]. DME retains Newtonian gravity and uses the density-derived acceleration scale.

Standard gravitational theory provides the most precise and comprehensive predictive framework in the history of science for the description of gravitational phenomena. The present paper has argued that this predictive success, remarkable as it is, does not by itself resolve the question of the immediate local physical carrier of gravitation: the physical entity whose local state is in a changed condition when gravitation is measured at a specific detector or observation point.

Gravitational waves establish, within mainstream physics, that the local gravitational condition can propagate, oscillate, and evolve in time as structured spacetime strain. BFUT interprets this as consistent with a physically real carrier medium, identified as the Spaticle field, of which the spacetime geometry of general relativity is the macroscopic mathematical description.

The framework is characterised by three joint properties: finite carrier response time τ_c governing reconfiguration dynamics, derivative-driven residuals whose amplitude scales with the dimensionless transition parameter ξ, and transition-localised observables concentrated in physically motivated windows.

In quasi-static and slowly evolving regimes, the Spaticle field tracks source-side descriptors with such fidelity that the settled GR-equivalent prediction is recovered to the precision of all existing tests. It is a targeted prediction about the Spaticle field's transitional behaviour during rapid reconfiguration events: carrier reconfiguration residuals, short-lived deviations from the settled GR-equivalent signal arising when the substrate is being sharply reorganised by a violent source-side configuration change.

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
LEVEL 1 ; ρ_s appears directly in the formula				
1	**Substrate density** [Foundation]	GR models the vacuum as geometric spacetime with no physical medium. Gravity is curvature of geometry, acting through the structure of spacetime itself without a material carrier.	The vacuum is a physically real continuous substrate with an intrinsic equilibrium density. This single number anchors every result in P18 and across the BFUT programme.	$\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}
2	**Carrier response time** [Foundation]	In GR the gravitational field adjusts to changes in the source mass distribution without a characteristic settling timescale. The theory describes settled	A local Spaticle-field perturbation relaxes with response time τ_c.	$L_{rlx} = c\tau_c$

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		configurations to extraordinary precision.		
3	**Substrate relaxation length** [Foundation]	GR and Newtonian gravity have infinite range with no characteristic decay length. The gravitational field extends throughout space with no intrinsic attenuation scale.	The substrate has an intrinsic e-folding length for unsustained disturbances. Organised rotating structures continuously re-pump their domains well beyond this scale; L_{rlx} governs only transient single-event disturbances.	$L_s = 1/\mu_s = c/\sqrt{3G\rho_s}$; $L_{rlx} = c\tau_c$
4	Gravitational domain radius [DDR]	Both Newtonian gravity and GR give every mass infinite gravitational range, with influence falling as $1/r^2$. This is one of the most precisely tested predictions of both frameworks.	Every mass creates a finite deformation domain beyond which its influence merges into the ambient substrate. Resolves Seeliger's paradox naturally. Inside the domain, Newtonian gravity and GR are recovered exactly.	$R_d = (3M/(8\pi\rho_s))^{1/3}$; Sun: 337 ly; Milky Way: 405 kpc
5	**Carrier field effective mass** [F1-cov]	In GR the gravitational field is described by a massless spin-2 field (the graviton in linearised theory), which gives it infinite range. This is required by the	The substrate perturbation acquires an effective mass term set by ρ_s. The	$\mu_s^2 = 3G\rho_s/c^2 = 1/L_s^2$

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		long-range nature of gravity as observed.	implied range is approximately 26.205 billion light-years, far exceeding any astrophysical structure; so all local GR tests are unaffected.	
LEVEL 2 ; one step from ρ_s: quantities derived from τc, Lrlx, or R_d				
6	**Covariant carrier field equation** [F1-cov]	Einstein's field equations G_μν = (8πG/c⁴)*T_μν describe how mass-energy curves spacetime. They are exact in the classical regime and have been validated to extraordinary precision across many experimental domains.	F1-cov reproduces GR exactly in settled regimes. In rapid transitions the effective mass term produces short-lived observable deviations. All from ρ_s alone, with no additional free parameters.	g^{μν}∇_μ∇_ν(δΨ) - μ_s^2δΨ = κ_s g^{μν}∇_μ∇_νΨmatter
7	**Transition parameter ξ**	GR is a complete self-consistent theory. Its predictions are tested	ξ specifies exactly when BFUT	$\xi(t) = \tau c \times \lvert dS_{GR}/dt \rvert / \lvert S_{GR}(t) \rvert$

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
	[Observability]	and confirmed across an enormous range of regimes. A departure from GR would require a physical mechanism operating at specific conditions.	deviations become observable: only when the event timescale is comparable to τ_c. GR is recovered when $\xi \ll 1$, that is when the source changes on a timescale much longer than τ_c. No separate solar-system ξ number is quoted here.	
8	**Carrier residual signal** [Observable]	GR waveform templates describe the gravitational signal of compact object mergers with high fidelity. Post-merger residuals after template subtraction are attributed to noise or waveform modelling uncertainties.	The total observed signal equals GR plus a short-lived substrate carrier term. The carrier term is derivative-driven and exponentially decays at τ_c. Zero during steady periods; maximum at violent transitions.	$S_{obs}(t) = S_{GR}(t) + \delta S_{carrier}(t)$; $\delta S_{carrier} = -\int \exp[-(t-t')/\tau c]\, dS_{GR}/dt'\, dt'$
LEVEL 3 ; two or more steps from ρ_S: observational predictions and validations				
9	**Unified gravitational**	Newtonian gravity and GR provide the	One unified framework	R_eff = $R_d[1 + v_{rot}^2/c^2]^{1/3}$; the

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
	equation [Grand equation]	settled local gravitational description.	combines the local carrier state, finite-domain structure, carrier response, and nested-domain organisation. Organised galactic support is represented by DME.	fractional DDR boundary change is approximately 3.3×10^{-7} at galactic speeds
10	Rotational domain enlargement [DDR rotational]	Galactic rotation curves require additional gravitational mass beyond visible baryons. The Λ-CDM framework introduces dark matter halos whose profiles are fitted to the observed rotation data of each galaxy.	Organised rotation sustains the DME regime through continuous Spaticle-field entrainment. The DDR rotational boundary correction itself is negligible at galactic speeds.	$R\_eff / R_d = (1 + vrot^2/c^2)^{1/3}$. For $vrot/c \sim 10^{-3}$ the fractional change is $\sim 3.3 \times 10^{-7}$.
11	**Galaxy rotation velocity** [Validation]	Λ-CDM models rotation curves as $v^2(r) = vb^2(r) +$	The DME equation supplies organised extra mass;	$v^2(R) = vb^2(R) [1 + a_s R / vb^2(R)]^{1/2}$ $a_s = c(G\ \rho_s / 3)^{1/2} =$

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		$v_{DM}^2(r)$, where the dark matter halo contribution is determined by fitting the NFW profile parameters to each galaxy's observed rotation data.	SPARC results in Appendix A.	1.2084×10^{-10} m s^{-2}
12	**Weak gravitational lensing profile** [Validation]		DME equation describes stack lensing; results in Appendix B.	Same a_s as SPARC. $v_b^2(R) = G\,M_{gal} / R$. Deep-regime $v^4 = G\,M_{gal}\,a_s$.
LEVEL 4 ; grand implications: what all of the above means together				
13	**Recovery of General Relativity** [Limit]	GR has passed every experimental test to extraordinary precision, from the perihelion of Mercury to gravitational wave detection. It is one of the most successful theories in the history of physics.	The settled limit recovers the standard GR field equations used for local precision tests.	$\delta\Psi \rightarrow 0$: standard GR settled limit
14	**Resolution of Seeliger's paradox** [Implication]	In an infinite static universe with Newtonian gravity, the gravitational potential diverges. GR resolves this through	Under the finite nested-domain construction, only sources whose	$g_{total}(r) = \Sigma_i\, g_i(r)\, N_i(r)$, with $N_i(r)=0$ outside the active domain

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		the cosmological constant and the dynamic nature of spacetime, which allows consistent infinite-universe solutions.	active domains reach the observation point contribute to the local sum.	
15	**Dark matter identification** [Grand result]	Λ-CDM predicts that approximately 27% of the energy content of the universe is cold dark matter. Extensive direct detection programmes are ongoing and represent one of the most active areas of experimental particle physics.	The observed extra gravitational support is identified with organised Spaticle-field deformation represented by DME, not with a new particle halo.	

Appendix A. SPARC validation under DME

This appendix reports DME on all 175 galaxies in the SPARC database (Lelli, McGaugh and Schombert 2016). Y = 0.5 at 3.6 μm. No per-galaxy gravity parameter.

A1. Formula

Constants: $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}; $a_s = c\,(G\,\rho_s / 3)^{1/2} = 1.2084 \times 10^{-10}$ m s^{-2}; Y = 0.5 (SPARC 3.6 μm convention).

Outer-half points are those with R greater than or equal to half the last measured radius. A curve is flat when the outer-half standard deviation divided by the outer-half mean is less than 0.12.

Residuals are |Vpred − Vobs|/Vobs on the outer half. Complete galaxy-level results follow.

$v^2(R) = v_b^2(R)\,[\,1 + a_s\,R / v_b^2(R)\,]^{1/2}$, with $v_b^2(R) = v_{gas}\,|v_{gas}| + Y\,v_{disk}^2 + Y\,v_{bulge}^2$.

Predicted speed: $V_{pred}^2(R) = V_{bar}^2(R) + G^*M_{extra}(<R)/R$.

Flat classification: outer-half scatter (std/mean) < 0.12.

A2. Summary results

N = 175 galaxies.

- Shape agreement (flat versus non-flat): 92.0% (161/175)
- Flat correct: 98.8% (159/161)
- Non-flat correct: 14.3% (2/14)
- Median outer relative residual: 0.096
- Fraction with outer relative residual < 0.20: 76.0% (133/175)
- Fraction with outer relative residual < 0.25: 84.6% (148/175)

A3. Second-level note on non-flat failures

Of galaxies observed non-flat but predicted flat, the large majority have a baryonic curve Vbar that is already flat under the same outer-scatter rule. The non-flat recovery ceiling is therefore largely structural: non-negative extra mass cannot force a declining shape when Vbar itself is flat.

A4. Full galaxy table

Columns: Galaxy; N points; Mb (solar masses); Vchar (km s⁻¹); observed flat; predicted flat; shape correct; median outer relative residual.

Galaxy	N points	Mb (M_{sun})	V_{char} (km s⁻¹)	Observed flat	Predicted flat	Shape correct	Median outer |rel|
CamB	9	6.613e+07	20.1	N	Y	N	1.092
D512-2	4	2.378e+08	35.9	Y	Y	Y	0.116
D564-8	6	5.626e+07	25.0	Y	Y	Y	0.246
D631-7	16	5.561e+08	57.3	Y	Y	Y	0.047
DDO064	14	4.432e+08	46.9	Y	Y	Y	0.044
DDO154	12	3.637e+08	45.5	Y	Y	Y	0.036
DDO161	31	2.691e+09	66.1	Y	Y	Y	0.250
DDO168	10	6.237e+08	52.0	Y	Y	Y	0.022
DDO170	8	2.100e+09	62.2	Y	Y	Y	0.232
ESO079-G014	15	3.626e+10	178.0	Y	Y	Y	0.106
ESO116-G012	15	5.071e+09	112.0	Y	Y	Y	0.153
ESO444-G084	7	2.531e+08	62.7	Y	Y	Y	0.267
ESO563-G021	30	2.104e+11	312.0	Y	Y	Y	0.182
F561-1	6	4.668e+09	50.4	Y	N	N	0.656
F563-1	17	6.975e+09	106.0	Y	Y	Y	0.160
F563-V1	6	1.242e+09	27.3	Y	Y	Y	1.196
F563-V2	10	5.549e+09	118.0	Y	Y	Y	0.177
F565-V2	7	1.861e+09	83.1	Y	Y	Y	0.124
F567-2	5	2.526e+09	52.2	Y	N	N	0.470
F568-1	12	1.075e+10	142.0	Y	Y	Y	0.245
F568-3	18	1.137e+10	120.0	Y	Y	Y	0.024
F568-V1	15	7.569e+09	118.0	Y	Y	Y	0.167
F571-8	13	6.014e+09	144.0	Y	Y	Y	0.293

Galaxy	N points	Mb (M_{sun})	V_{char} (km s⁻¹)	Observed flat	Predicted flat	Shape correct	Median outer |rel|
F571-V1	7	3.737e+09	83.9	Y	Y	Y	0.040
F574-1	14	6.330e+09	99.7	Y	Y	Y	0.077
F574-2	5	3.659e+09	40.0	Y	Y	Y	1.208
F579-V1	14	1.097e+10	114.0	Y	Y	Y	0.032
F583-1	25	6.466e+09	85.8	Y	Y	Y	0.155
F583-4	12	1.556e+09	69.9	Y	Y	Y	0.063
IC2574	34	2.439e+09	67.5	N	Y	N	0.229
IC4202	32	1.245e+11	247.0	Y	Y	Y	0.089
KK98-251	15	2.770e+08	34.2	Y	Y	Y	0.330
NGC0024	29	3.205e+09	110.0	Y	Y	Y	0.193
NGC0055	21	7.162e+09	86.5	Y	Y	Y	0.161
NGC0100	21	2.847e+09	91.2	Y	Y	Y	0.069
NGC0247	26	7.860e+09	107.0	Y	Y	Y	0.010
NGC0289	28	8.326e+10	165.0	Y	Y	Y	0.132
NGC0300	25	2.995e+09	93.5	Y	Y	Y	0.088
NGC0801	13	2.363e+11	216.0	Y	Y	Y	0.155
NGC0891	18	8.382e+10	208.0	Y	Y	Y	0.025
NGC1003	36	1.331e+10	115.0	Y	Y	Y	0.032
NGC1090	24	5.868e+10	160.0	Y	Y	Y	0.062
NGC1705	14	5.493e+08	71.5	Y	Y	Y	0.267
NGC2366	26	1.092e+09	49.4	Y	Y	Y	0.188
NGC2403	73	1.284e+10	134.0	Y	Y	Y	0.098
NGC2683	11	4.293e+10	151.0	Y	Y	Y	0.071
NGC2841	50	1.651e+11	294.0	Y	Y	Y	0.212
NGC2903	34	4.701e+10	180.0	Y	Y	Y	0.071
NGC2915	30	1.250e+09	86.5	Y	Y	Y	0.232
NGC2955	24	2.137e+11	227.0	Y	Y	Y	0.028
NGC2976	27	1.902e+09	85.3	N	Y	N	0.026
NGC2998	13	1.240e+11	203.0	Y	Y	Y	0.014

Galaxy	N points	Mb (M_{sun})	V_{char} (km s^{-1})	Observed flat	Predicted flat	Shape correct	Median outer |rel|
NGC3109	25	6.844e+08	67.3	Y	Y	Y	0.132
NGC3198	43	4.292e+10	149.0	Y	Y	Y	0.059
NGC3521	41	5.215e+10	206.0	Y	Y	Y	0.119
NGC3726	12	4.896e+10	167.0	Y	Y	Y	0.018
NGC3741	21	3.036e+08	51.6	Y	Y	Y	0.079
NGC3769	12	1.805e+10	113.0	Y	Y	Y	0.109
NGC3877	13	4.993e+10	169.0	Y	Y	Y	0.070
NGC3893	10	4.029e+10	167.0	Y	Y	Y	0.076
NGC3917	17	1.699e+10	137.0	Y	Y	Y	0.041
NGC3949	7	2.337e+10	169.0	Y	Y	Y	0.037
NGC3953	8	9.236e+10	215.0	Y	Y	Y	0.023
NGC3972	10	1.049e+10	134.0	Y	Y	Y	0.103
NGC3992	9	1.438e+11	237.0	Y	Y	Y	0.068
NGC4010	12	1.268e+10	122.0	Y	Y	Y	0.029
NGC4013	36	4.530e+10	170.0	Y	Y	Y	0.034
NGC4051	7	4.482e+10	153.0	Y	Y	Y	0.135
NGC4068	6	3.521e+08	41.9	N	Y	N	0.279
NGC4085	7	1.486e+10	136.0	Y	Y	Y	0.034
NGC4088	12	7.062e+10	174.0	Y	Y	Y	0.186
NGC4100	24	3.734e+10	159.0	Y	Y	Y	0.065
NGC4138	7	2.502e+10	150.0	Y	Y	Y	0.025
NGC4157	17	6.732e+10	185.0	Y	Y	Y	0.029
NGC4183	23	1.218e+10	113.0	Y	Y	Y	0.073
NGC4214	14	8.517e+08	80.6	Y	Y	Y	0.247
NGC4217	19	4.807e+10	178.0	Y	Y	Y	0.023
NGC4389	6	1.276e+10	110.0	N	Y	N	0.464
NGC4559	32	2.340e+10	119.0	Y	Y	Y	0.090
NGC5005	18	1.041e+11	265.0	Y	Y	Y	0.066

Galaxy	N points	Mb (M_{sun})	V_{char} (km s⁻¹)	Observed flat	Predicted flat	Shape correct	Median outer |rel|
NGC5033	22	7.625e+10	196.0	Y	Y	Y	0.034
NGC5055	28	9.795e+10	172.0	Y	Y	Y	0.117
NGC5371	19	2.004e+11	213.0	Y	Y	Y	0.188
NGC5585	24	4.238e+09	89.4	Y	Y	Y	0.034
NGC5907	19	1.391e+11	214.0	Y	Y	Y	0.024
NGC5985	33	1.546e+11	285.0	Y	Y	Y	0.229
NGC6015	44	2.654e+10	152.0	Y	Y	Y	0.070
NGC6195	23	2.350e+11	246.0	Y	Y	Y	0.052
NGC6503	31	1.004e+10	115.0	Y	Y	Y	0.021
NGC6674	15	1.447e+11	242.0	Y	Y	Y	0.077
NGC6789	4	6.095e+07	60.4	N	Y	N	0.417
NGC6946	58	4.136e+10	154.0	Y	Y	Y	0.039
NGC7331	36	1.527e+11	238.0	Y	Y	Y	0.017
NGC7793	46	5.852e+09	90.8	Y	Y	Y	0.094
NGC7814	18	4.118e+10	214.0	Y	Y	Y	0.217
PGC51017	6	2.589e+08	18.3	Y	Y	Y	1.378
UGC00128	22	2.150e+10	125.0	Y	Y	Y	0.055
UGC00191	9	3.822e+09	83.8	Y	Y	Y	0.059
UGC00634	4	7.183e+09	107.5	Y	Y	Y	0.051
UGC00731	12	3.451e+09	73.9	Y	Y	Y	0.096
UGC00891	5	9.939e+08	63.8	Y	Y	Y	0.028
UGC01230	11	1.746e+10	103.0	Y	Y	Y	0.261

Galaxy	N points	Mb (M_{sun})	V_{char} (km s^{-1})	Observed flat	Predicted flat	Shape correct	Median outer |rel|
UGC01281	25	6.784e+08	56.9	Y	Y	Y	0.041
UGC02023	5	9.205e+08	58.8	N	Y	N	0.202
UGC02259	8	2.316e+09	90.0	Y	Y	Y	0.126
UGC02455	8	2.824e+09	61.0	N	Y	N	0.745
UGC02487	17	2.900e+11	333.0	Y	Y	Y	0.200
UGC02885	19	3.540e+11	298.0	Y	Y	Y	0.073
UGC02916	43	1.119e+11	181.0	Y	Y	Y	0.079
UGC02953	115	1.454e+11	272.0	Y	Y	Y	0.147
UGC03205	48	7.573e+10	220.0	Y	Y	Y	0.087
UGC03546	30	5.718e+10	193.0	Y	Y	Y	0.047
UGC03580	47	1.446e+10	124.0	Y	Y	Y	0.022
UGC04278	25	3.222e+09	92.8	N	N	Y	0.152
UGC04305	22	1.417e+09	33.0	Y	Y	Y	0.942
UGC04325	8	2.456e+09	91.5	Y	Y	Y	0.157
UGC04483	8	5.031e+07	24.2	Y	Y	Y	0.221
UGC04499	9	3.024e+09	74.3	Y	Y	Y	0.060
UGC05005	11	1.235e+10	99.1	Y	Y	Y	0.113

Galaxy	N points	Mb (M_{sun})	V_{char} (km s^{-1})	Observed flat	Predicted flat	Shape correct	Median outer |rel|
UGC05253	73	1.186e+11	218.0	Y	Y	Y	0.031
UGC05414	6	1.084e+09	61.4	Y	Y	Y	0.087
UGC05716	12	2.534e+09	74.7	Y	Y	Y	0.059
UGC05721	23	1.217e+09	79.5	Y	Y	Y	0.191
UGC05750	11	9.131e+09	78.9	Y	Y	Y	0.263
UGC05764	10	3.768e+08	49.9	Y	Y	Y	0.139
UGC05829	11	2.251e+09	68.6	N	N	Y	0.137
UGC05918	8	4.031e+08	44.5	Y	Y	Y	0.064
UGC05986	15	4.268e+09	107.0	Y	Y	Y	0.205
UGC05999	5	1.043e+10	100.0	Y	Y	Y	0.029
UGC06399	9	2.726e+09	87.6	Y	Y	Y	0.077
UGC06446	17	3.156e+09	80.1	Y	Y	Y	0.052
UGC06614	13	1.198e+11	204.0	Y	Y	Y	0.041
UGC06628	7	3.715e+09	42.3	Y	Y	Y	0.872
UGC06667	9	1.618e+09	85.7	Y	Y	Y	0.221
UGC06786	45	4.501e+10	211.0	Y	Y	Y	0.242
UGC06787	71	6.101e+10	255.0	Y	Y	Y	0.269

Galaxy	N points	Mb (M_{sun})	V_{char} (km s^{-1})	Observed flat	Predicted flat	Shape correct	Median outer |rel|
UGC06818	8	1.689e+09	74.4	N	Y	N	0.037
UGC06917	11	7.717e+09	111.0	Y	Y	Y	0.063
UGC06923	6	2.754e+09	81.1	Y	Y	Y	0.019
UGC06930	10	1.133e+10	108.0	Y	Y	Y	0.075
UGC06973	9	3.005e+10	180.0	Y	Y	Y	0.058
UGC06983	17	8.774e+09	109.0	Y	Y	Y	0.031
UGC07089	12	3.689e+09	79.1	Y	Y	Y	0.168
UGC07125	13	6.642e+09	64.9	Y	Y	Y	0.568
UGC07151	11	2.487e+09	76.2	Y	Y	Y	0.029
UGC07232	4	8.738e+07	44.0	N	Y	N	0.098
UGC07261	7	2.319e+09	76.1	Y	Y	Y	0.029
UGC07323	10	3.623e+09	85.6	N	Y	N	0.055
UGC07399	10	1.617e+09	106.0	Y	Y	Y	0.328
UGC07524	31	4.793e+09	79.0	Y	Y	Y	0.067
UGC07559	7	2.296e+08	32.1	Y	Y	Y	0.310
UGC07577	9	6.036e+07	17.8	N	Y	N	1.091
UGC07603	12	4.905e+08	64.0	Y	Y	Y	0.162

Galaxy	N points	Mb (M_{sun})	V_{char} (km s^{-1})	Observed flat	Predicted flat	Shape correct	Median outer |rel|
UGC07608	8	7.935e+08	69.3	Y	Y	Y	0.170
UGC07690	7	9.475e+08	55.9	Y	Y	Y	0.081
UGC07866	7	1.830e+08	33.1	Y	Y	Y	0.282
UGC08286	17	1.997e+09	84.3	Y	Y	Y	0.143
UGC08490	30	1.715e+09	77.6	Y	Y	Y	0.112
UGC08550	11	7.564e+08	57.5	Y	Y	Y	0.089
UGC08699	41	3.368e+10	183.0	Y	Y	Y	0.131
UGC08837	8	8.396e+08	48.0	Y	Y	Y	0.266
UGC09037	22	6.316e+10	152.0	Y	Y	Y	0.144
UGC09133	68	2.097e+11	229.0	Y	Y	Y	0.050
UGC09992	5	4.984e+08	34.3	Y	Y	Y	0.532
UGC10310	7	2.849e+09	73.2	Y	Y	Y	0.096
UGC11455	36	2.293e+11	266.0	Y	Y	Y	0.033
UGC11557	12	1.041e+10	84.5	Y	Y	Y	0.380
UGC11820	10	5.134e+09	84.5	Y	Y	Y	0.135
UGC11914	65	7.692e+10	305.0	Y	Y	Y	0.175
UGC12506	31	1.580e+11	225.0	Y	Y	Y	0.118

Galaxy	N points	Mb (M_{sun})	V_{char} (km s^{-1})	Observed flat	Predicted flat	Shape correct	Median outer |rel|
UGC12632	15	3.331e+09	73.1	Y	Y	Y	0.095
UGC12732	16	7.672e+09	98.0	Y	Y	Y	0.054
UGCA281	7	6.001e+07	29.5	Y	Y	Y	0.061
UGCA442	8	4.959e+08	56.5	Y	Y	Y	0.036
UGCA444	36	1.246e+08	38.3	Y	Y	Y	0.134

End of Appendix A. Data source: SPARC (Lelli et al. 2016). Computations: DME equation with $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}.

Appendix B. KiDS-1000 under the DME equation

This appendix reports the application of the DME equation to the KiDS-1000 stacked weak-lensing products of Brouwer et al. (2021), four stellar-mass bins, using the public Fig. 3 ESD files [21].

B1. Formula

Global constants:

- $a_s = 1.2084 \times 10^{-10}$ m s^{-2} from ρ_s
- $v_b^2(R) = G\ M_{gal} / R$
- log10 <Mgal / Msun> = {10.14, 10.57, 10.78, 10.96} from Brouwer et al. 2021
- $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}
- Point-mass baryons $v_b^2 = G\ M_{gal} / R$ at stack radii

Extra mass:

$$v_{pred}^2(R) = v_b^2 \left[1 + a_s R / v_b^2 \right]^{1/2}$$

Predicted equivalent circular speed:

$$V_{pred}^2(R) = G \times M_{gal} / R + G \times M_{extra}(<R) / R$$

Mgal is the representative galaxy mass for each stellar-mass bin from the survey mass bins. ESD profiles are converted to equivalent circular velocity using the standard relation from the public data release documentation where required.

B2. Data

Source: KiDS-1000 / Brouwer et al. (2021) public lensing products (four stellar-mass bins). Official survey data products are the observational input; a_s is computed from ρ_s and is not retuned per bin.

B3. Results

KiDS-1000, four isolated-lens stacks and 60 measurements: $\chi^2/N = 9.78$ for DME, 9.51 for MOND, and 32.82 for Newton.

- The same a_s serves all four bins. There is no per-bin retuning.

The median absolute relative ESD residuals for the four bins are 0.481, 0.471, 0.502, and 0.509.

These results are the KiDS test under the DME equation.

B4. Relation of the two tests

SPARC and KiDS use the same DME equation and the same derived a_s, with the difference confined to the observational baryonic input: resolved vb(R) for SPARC and point-mass G Mgal / R for the KiDS stack bins. Radii beyond Rd still require nested-domain organisation $N(\Sigma_i)$.

Appendix C. Formula reference for this paper

Central anchor: one equilibrium substrate density $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}. Only standing equations are listed.

C1. Equilibrium density

$$\rho_s = 7.3 \times 10^{-27} \text{ kg m}^{-3}$$

C2. F1-cov (general carrier equation)

F1-cov is the general covariant carrier-field equation. It identifies Spaticle-substrate deformation as the local gravitational carrier. Settled limits recover Newtonian and weak-field behaviour. Rapid changes follow a finite density-dependent relaxation time. The DME scale is $a_s = c^2\mu_s/3 = c\sqrt{(G\rho_s/3)}$, derived from the F1-cov mass term and ρ_s. SPARC and KiDS-1000 use this scale.

C3. DDR equation (Deformation Domain Radius)

$$Rd = [3M/(8\pi\rho_s)]^{1/3}$$

Finite gravitational domain of mass M. For r much less than Rd and weak organisation, standard inverse-square / weak-field behaviour applies.

C4. Carrier relaxation time

$L_s = 1/\mu_s = c/\sqrt{(3G\rho_s)} = 2.47918135 \times 10^{26}$ m ≈ 26.205 Gly. The local response length is

$$Lrlx = c\tau c.$$

$$\mu_s^2 = 3G\rho_s/c^2; \; Lrlx = c\tau c.$$

The local response time follows the local Spaticle-field density. Denser regions, including mass concentrations, organised galaxies, and deformation domains, have shorter response times and response lengths.

C5. Combined time dilation

$$\eta g = \sqrt{[1 - v^2/c^2 - (2GM/(rc^2))f(r,Rd)]}$$

$$d\tau = \eta g dt$$

$f(r,R_d)$ is approximately 1 inside the domain and 0 outside. The factor η_g determines clock rates.

C6. DME on organised disks (SPARC)

Constants: $\rho_s = 7.3 \times 10^{-27}$ kg m^{-3}; $a_s = c\sqrt{G\rho_s/3} = 1.2084 \times 10^{-10}$ m s^{-2}; $Y = 0.5$ under the SPARC 3.6 µm convention.

$a_s = c\,(G\,\rho_s / 3)^{1/2} = 1.2084 \times 10^{-10}$ m s^{-2}.

$v_b^2(R) = v_{gas}\,|v_{gas}| + Y\,v_{disk}^2 + Y\,v_{bulge}^2$.

$$v^2(R) = v_b^2(R)\,[\,1 + a_s\,R / v_b^2(R)\,]^{1/2}.$$

$$M_{extra}(<R) = M_b(R)\{[1 + a_sR^2/(GM_b(R))]^{1/2} - 1\},\ \text{with}\ M_b(R) = v_b^2(R)R/G.$$

Full galaxy-by-galaxy results: Appendix A.

C7. DME on stack lensing (KiDS-1000)

Same a_s. $v_b^2(R) = G\,M_{gal} / R$, with M_{gal} the Brouwer 2021 bin mean (stars + cold gas).

$$v^2(R) = v_b^2(R)\,[\,1 + a_s\,R / v_b^2(R)\,]^{1/2}.$$

Valid as a single-domain law for R of order R_d or less. Beyond R_d the nested-domain term is required. Four-bin comparison: Appendix B.

Stack results: Appendix B.

C8. Framing

- F1-cov: general carrier layer.
- DDR: domain size.
- DME: organised disks and stacks. Uses ρ_s and $a_s = c^2\,\mu_s / 3$ from F1-cov. SPARC and KiDS applications. Same-basis MOND comparison: Paper 33.

η_g: combined motion and gravitational clock-rate factor.

- Entrainment in mergers: organised rotation retained by galaxies; collision destroys organised motion in stripped gas (carpet / air-curtain physics).

Appendix D. Additional systems and merger morphology under DME

This appendix records extra-system tests of the DME equation outside the SPARC table, and the merger morphology argument. Only standing conclusions are listed.

D1. Confirmed

- FCC 224 (ultra-diffuse): negligible extra mass; dark-matter-poor appearance from absent organised entrainment.

- NGC 1052-DF2: velocity dispersion and distance are disputed in the literature; the formula was run across the full published dispersion range about 3.2 to 9.5 km s^{-1}; extra mass remains negligible (about 0.00 to 0.09 percent) across that range.

- NGC 1052-DF4: negligible extra mass.

D2. Additional quantitative cases

- DLA0817g: the observed rotation speed is approximately 272 km s^{-1}. The trial dynamical mass gives the corresponding multi-radius DME amplitude across the reported radial range.

- NGC 1277: the calculated outer extra-mass fraction at 5Re is approximately 8 percent, providing a direct comparison with the reported constraint near 5 percent.

D3. Bullet Cluster and El Gordo-type morphology

Before collision, gas shares organised motion with galaxies. In the collision, galaxies keep organised rotation and entrainment; gas is stripped and shock-heated so its organised motion is destroyed. High thermal speed is the signature of lost organisation, not an organised Vchar. Lensing stays with the galaxies. This is ordinary collision physics applied to the entrainment rule (carpet / air-curtain picture).

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