Beyond General Relativity:

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

Vijay Shankar Sharma

Independent Researcher, Gurugram, National Capital Region, India

vss@vijayshankarsharma.com

ORCID: 0009-0001-9622-6121

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Abstract

This paper presents a unified gravitational programme based on the Spaticle field as the local carrier of gravitation. A single covariant carrier equation, F1-cov, identifies substrate deformation as the immediate gravitational state at the observation point; Newtonian gravity and weak-field general relativity are recovered as settled-domain limits. The DDR equation defines a finite gravitational domain for every mass from the equilibrium substrate density ρ_s = 5.9 x 10^-27 kg m^-3. The linear carrier relaxation time at that equilibrium density is approximately 6.96 hours and is shorter in denser regions. In organised galactic and stack regimes, the effective support is given by density-driven entrainment laws DM1 and DM2: compressed, rotating Spaticle medium supplies the extra gravity usually attributed to particle dark matter. DM1 is tested on 175 SPARC galaxies (shape agreement 86.3 percent, flat classification 93.0 percent, non-flat 27.8 percent, median outer relative residual 0.25). DM2 is tested on KiDS-1000 stacked weak lensing (chi-square quality of order 2 to 3). Ultra-diffuse systems with negligible organised rotation show negligible extra mass. In merging clusters, galaxies retain organised rotation and entrainment while stripped gas loses organised motion, so lensing stays with the galaxies. Clock rates are described by a combined special- and gravitational-dilation factor with a finite-domain cutoff. DM1 and

DM2 are regime laws within the same Spaticle programme; they are not presented as closed-form integrals of F1-cov.

Keywords: Spaticle field; gravitation; dark matter; rotation curves; weak gravitational lensing; finite deformation domain; DDR; BFUT; carrier dynamics; KiDS-1000; SPARC; entrainment

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 instead of 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 of this paper is not merely that spacetime should be regarded as physically real. Rather, the claim is that the local gravitational carrier possesses finite transitional dynamics that may produce short-lived observational residuals not exhausted by the settled general-relativistic mapping.

The goal throughout is not to challenge the extraordinary track record of Newtonian gravity or general relativity, but to supply what those frameworks do not themselves provide: an explicit identification of the local physical substrate whose state is the gravitational condition at the observation point, and a concrete empirical programme for detecting the substrate's distinct transitional behaviour.

The present work focuses on the dynamical behaviour of an already-formed spacetime substrate. The origin of gravitation itself, including the emergence of the spacetime structure (the Spaticle field substrate) and its governing law in the absence of pre-existing structure, is developed separately in BFUT Paper P17 ("The Birth of Gravity"). Together, P17 and P18 form a layered framework in which P17 establishes the origin of gravity and P18 develops its dynamical and observational consequences.

2. Clarification Regarding Spaticle Field Density and Cosmological Interpretation

The Spaticle field density is not derived from the cosmological constant, dark energy, finite-universe assumptions, or LCDM cosmology. The framework treats the Spaticle field density as an intrinsic equilibrium property of the underlying substrate itself.

The existence of a continuous universal substrate, the Spaticle field, has been established independently in BFUT Papers 14, 16, and 17, particularly the main BFUT paper, Paper 14, and Paper 14M, where the universe is necessarily infinite within the BFUT framework, continuously connected, and permeated by a physically real substrate field responsible for matter emergence, organisation, propagation, and deformation persistence. Paper 16 further develops the condensation and organisational dynamics of this substrate and demonstrates how stable matter structures emerge from it. Papers 19 and 19A subsequently extend this framework into rotational organisation, half-spin emergence, finite-domain gravitational structure, galactic rotational persistence, and substrate-mediated large-scale coherence behaviour.

One conceptual distinction is essential throughout this paper: the equilibrium substrate density ρ_s is a global property of the undisturbed Spaticle field, not a local quantity. Local matter-induced deformation of the substrate represents a departure from this equilibrium baseline and is physically distinct from ρ_s itself. The equilibrium density sets the reference level against which deformations are defined; it provides the stable background against which gravitational curvature structure is organised and measured, and is not itself modified or displaced by local deformations.

2.1 Notation and Principal Symbols

Symbol	Definition	Value / Expression
Fundamental Spaticle Field Constants		
ρ_s	Intrinsic equilibrium density of the Spaticle field	5.9 x 10^-27 kg/m^3

$\Psi(r,t)$	Spaticle carrier field / gravitational potential	Carrier potential; exponential form optional, not required for DM1/DM2
$\delta\Psi$	Carrier perturbation	$\delta\Psi = \Psi - \Psi_{vac}$
Ψ_{vac}	Vacuum equilibrium configuration	$\lambda \times \Psi_{vac}^2 = \rho_s c^2$
λ	Quartic self-interaction coupling	$\lambda = \rho_s/4$
κ	Source-to-substrate coupling coefficient	$\kappa = 1/c^2$
m_{eff}	Effective mass of carrier perturbation	$m_{eff}^2 \propto \rho_s c^2$
Carrier Field Timescales and Lengths		
τ_{nat} (eq.)	Carrier response / relaxation time	tau_nat = 1/(c*sqrt(3*ρ_s)) ≈ 6.96 h at equilibrium (evaluated using ρ_s in SI units, taking the normalisation constant relating substrate density to the carrier response scale as unity); shorter if denser
L_{nat} (eq.)	Substrate relaxation length	L_nat = c*tau_nat ≈ 50 AU at equilibrium
L_{cosm}	Cosmological coherence length	$= c/\sqrt{(3\rho_s G)} \sim 5.82$ GlyLarge-scale coherence scale from ρ_s (programme context)
ξ	Dimensionless transition parameter	$\xi(t) = \tau_c\lvert dS_{GR}/S_{GR}(t)\rvert$
R_d	Deformation domain radius (DDR equation)	$R_d = (3M/(8 \pi \rho_s))^{(1/3)}$
R_{eff}	Domain radius with rotational mass enhancement	$R_{eff} = R_d (1 + v_{rot}^2/c^2)^{(1/3)}$; impact << 0.01% at galactic speeds; not used in DM1/DM2
DM1	Organised-disk entrainment force law (SPARC)	See Appendix A; A=2500, alpha=0.5, R_ref=15 kpc
DM2	Stack-scale entrainment force law (KiDS-1000)	See Appendix B; A=38, alpha=0.5, R_ref=300 kpc
Carrier Field Equations		
F1-cov	Fully covariant carrier field equation	$g^{\mu\nu}\nabla_\mu\nabla_\nu(\delta\Psi) - m_{eff}^2 \times \delta\Psi = \kappa \times \nabla^2 \Psi_{matter}$General covariant carrier equation (programme-level)

Observational Signals		
S_obs(t)	Actual measured gravitational signal	= S_GR(t) + δS_carrier(t)
δS_carrier(t)	Carrier reconfiguration residual	= -∫exp(-(t-t_0)/τ_c) x (dS_GR/dt_0) dt_0Finite response; local time density-dependent; eq. baseline ~6.96 h
Rotation Curves and Lensing		
ρ_∇	Gradient-sourced substrate density	= α_g|∇Ψ|^2
DM2 / lensing	Stack lensing described by DM2, not old ESD fit form	Chi-square quality ~2 to 3 (Appendix B)
Shared Physical Constants		
G	Gravitational constant	6.674 x 10^-11 m^3 kg^-1 s^-2
c	Speed of light	2.998 x 10^8 m/s

The Big Flare-Up Theory (BFUT) identifies the real physical substrate (medium) of space as the Spaticle field, with a specific equilibrium density of ρ_s = 5.9 x 10^-27 kg/m^3 (BFUT P14 (DOI: 10.5281/zenodo.19394064); BFUT L1 (DOI: 10.5281/zenodo.19149785)). From this single measured constant, the entire BFUT programme derives - covering over 30 papers on cosmology, the Hubble relationship, dark energy and cosmic acceleration, universe boundary and topology, cosmic rotation, the CMB temperature and acoustic peaks, nucleosynthesis, the Sunyaev-Zel'dovich effect, the Lyman-alpha forest, the integrated Sachs-Wolfe effect, weak gravitational lensing and the S8 tension, black holes and singularities, gravitation and gravitational waves, new general relativity field equations, unification of general and special relativity, the pre-Big-Bang state, origin of matter and fundamental forces, antimatter and annihilation, particle masses and coupling constants, quantum mechanics, dark matter, a new physical definition of time, and consciousness. The Spaticle field is not an abstract mathematical convenience. It is a physical medium with measurable properties.

The Spaticle field is not the luminiferous ether. The Michelson-Morley experiment excluded a preferred-drift background through which light propagates and matter moves as separate entities. In BFUT, both light and matter are excitations of the same Spaticle field. Light is a propagating disturbance of the substrate; c is the substrate's own maximum reorganisation rate, not the speed of a separate entity measured against a background. No embedded observer can detect substrate-wide drift because all measuring instruments and all measured signals are excitations of the same medium - no more than a person on a ship can detect the ship's uniform motion by measuring distances between objects fixed to the same ship. The Michelson-Morley null result is therefore the only possible result in a BFUT universe. The experiment is constitutionally incapable of distinguishing between no substrate and a substrate in which light and matter are both substrate excitations. The latter is the BFUT position. Full derivation in BFUT P16; light as substrate excitation derived in P17 Section 6.6 and P19 Section 13.

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 what is observed when massive bodies accelerate

toward one another, when planetary orbits remain stably curved, when clocks run slower in deeper gravitational wells, when light bends near massive objects, when free-fall trajectories converge, when tidal forces stretch and compress extended bodies, and when precision interferometers record the oscillatory strain of passing gravitational waves. These are phenomena, not yet ontology. This question is empirical and descriptive. Gravity is what is observed when massive bodies accelerate toward one another, when planetary orbits remain stably curved, when clocks run slower in deeper gravitational wells, when light bends near massive objects, when free-fall trajectories converge, when tidal forces stretch and compress extended bodies, and when precision interferometers record the oscillatory strain of passing gravitational waves. These are phenomena, not yet ontology.

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 is the immediate local physical entity that is in a changed state when gravitation is measured at a specific point? When a test mass accelerates, when a clock rate shifts, when an interferometer arm changes its effective length under a passing gravitational wave, something local has changed. A distant mass label has not literally arrived at the detector. A symbolic tensor has not physically relocated to the observation point. BFUT identifies that changed local entity as the state of the physically real spacetime substrate (the Spaticle field). After this first introduction, the substrate is referred to simply as the Spaticle field.

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 developed across Papers 14, 16, 17, 18, 19, and 19A establishes that gravitation is not fundamentally an infinite-range spacetime curvature, but rather the persistence, propagation, organisation, and relaxation of deformation within a physically real continuous substrate: the Spaticle field. In standard Newtonian gravity and general relativity, gravity extends mathematically to infinity. BFUT rejects this as physically unrealistic. In an infinite universe containing finite-density matter and finite organisational coherence, deformation persistence itself must be finite. Infinite gravitational influence is therefore not fundamental physics, but only a local approximation valid inside sufficiently large deformation domains.

The unified BFUT gravitational equation is:

Psi(r,t) = -(GM/r) exp(-r/R_eff) R(τ_c, ∂_t) N(Sigma_i)

where:

The DDR equation fixes the domain radius R_d from mass and ρ_s. Organised rotation is handled by the DM1 and DM2 entrainment laws.

and:

DDR equation: R_d = (3M / (8 π ρ_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: R_d = (3M/(8 pi ρ_s))^(1/3). If the same mass is assigned an effective inertial factor from organised rotation, M_eff = M(1 + v_rot^2/c^2), and this M_eff is inserted into the DDR expression, the algebra gives R_eff = (3 M_eff/(8 pi ρ_s))^(1/3) = R_d (1 + v_rot^2/c^2)^(1/3). That identity is exact: the factor (1 + v_rot^2/c^2) comes out of the cube root with no further approximation.

For ordinary galactic rotation speeds, v_rot/c is of order 10^-3, so (1 + v_rot^2/c^2)^(1/3) - 1 is of order a few parts in 10^6 (well below 0.01 percent). The shift in domain boundary is therefore real but negligible for galactic applications.

Relation to DM1 and DM2. R_eff is a domain-boundary quantity. It is not the mechanism used in the SPARC or KiDS tests. Those tests use the density-driven entrainment laws DM1 and DM2 (extra mass from organised, compressed Spaticle medium). R_eff is recorded here for completeness as a consistent consequence of the DDR equation plus rotational mass enhancement; it is not fitted to rotation curves or lensing stacks and is not required for the results in Appendices A and B.

This equation unifies Newtonian gravity, GR weak-field behaviour, finite gravitational domains, galactic rotational persistence, weak gravitational lensing, and nested-domain organisation. Quick reference: $R_d = (3M / (8 \pi \rho_s))^{(1/3)}$ [domain radius, substrate-density form, DDR]; $R_{eff} = R_d (1 + v_{rot}^2/c^2)^{(1/3)}$ [effective domain radius with rotational entrainment]; $R(\tau_c, \partial_t) = 1/(1 + \tau_c \partial_t)$ [relaxation operator, equals 1 in static limit]; ρ_s approximately 5.9×10^{-27} kg/m^3 [intrinsic substrate equilibrium density, see Section 2]. For comparison only: $Lambda_{eff} = 8 \pi G \rho_s / c^2$ [derived effective mapping, not an ontological identity].

Rapid gravitational transitions are limited by finite carrier reorganisation. The equilibrium baseline is approximately 6.96 hours; denser local regions settle faster.

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 $Psi(r)$ approximately $-(GM/r)$. Thus Newtonian gravity and GR are not 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 relaxation operator $R(\tau_c, \partial_t) = 1/(1 + \tau_c \partial_t)$ becomes important during rapid-transition regimes and violent domain reconfiguration events, where finite deformation-settling times become observable. In static systems ∂_t approaches 0 and therefore $R(\tau_c, \partial_t)$ approaches 1, recovering ordinary settled-domain gravity exactly. The nested-domain interaction structure $N(Sigma_i)$ encodes the cumulative contribution of nested larger-scale domains: the overlapping coherence interactions between neighbouring deformation domains that allow hierarchical gravitational organisation across planetary, stellar, galactic, and cluster scales.

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 rho 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_{μν} is the Einstein tensor encoding spacetime curvature, Λ corresponds effectively to the cosmological constant, g_{μν} is the metric tensor, and T_{μν} 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.

8. 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, DOI: 10.5281/zenodo.19394064). P14 establishes the Spaticle field as the physically real spacetime 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 does not challenge the empirical validity of Einstein's field equation. Rather, it reinterprets the Einstein field equations as an equilibrium-level description of the spacetime substrate in settled regimes, while the deeper dynamical formulation of Sections 9.3 and 9.4 introduces the substrate-level carrier dynamics that become separately observable only 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.

8.1 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.

9. Effective First-Stage Formalism for the Carrier Interpretation

A rigorous final microscopic constitutive law for the Spaticle field is a goal of later BFUT development and is not claimed here. What is claimed is a first-stage effective framework sufficient to identify the carrier question, define the residual class, and specify where observations should be directed.

9.1 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.

9.2 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,

$D[\Psi] = J[T\mu\nu],$

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

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

Here D[·] is an effective dynamics operator governing the coarse-grained substrate evolution, J[·] is the source-to-substrate forcing or organisation map from source-side stress-energy content into substrate-state dynamics, and F[·] 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.

9.3 Minimal Effective Carrier Dynamics

An effective carrier state variable Ψ(x,t) describes the local Spaticle-field configuration at the coarse-grained scale relevant to gravitational observables. Its effective dynamics are governed by:

Here τ_nat is the equilibrium carrier response time (approximately 6.96 hours at ρ_s; shorter when denser), L_rlx is the substrate relaxation length, K is the source-to-substrate coupling coefficient, J[T_μν] is the source-to-substrate forcing functional, and α is the substrate-to-observable response coefficient. Together, τ_c and L_rlx define the regime in which the carrier can track the source faithfully (τ_c → 0 recovers standard GR) and the regime in which reconfiguration residuals become detectable (τ_c comparable to the source-change timescale).

The equilibrium carrier response time is fixed by the equilibrium substrate density: tau_nat = 1/(c*sqrt(3*ρ_s)) approximately 6.96 hours. Local relaxation times are shorter in denser regions, including near mass concentrations, inside entrained galaxies, and inside deformation domains.

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

$$S\_obs(t) \approx \alpha \cdot \Psi(x\_det, t) \quad (F2)$$

The equilibrium value tau_nat is fixed by ρ_s (approximately 6.96 hours). Local values depend on local density and are not a free per-event fit parameter of the old millisecond type.

The evolution equation is written in the local observer frame as an effective description. The fully covariant formulation F1-cov is derived in Section 9.6 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 $\Psi = 0$; instead, the spacetime substrate can exist in a stable baseline configuration Ψ_vac. 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.

9.4 Carrier equation used in this paper

The governing dynamics may alternatively be expressed directly in terms of the intrinsic evolution of the spacetime substrate without explicit reference to source-side descriptors. In this formulation, all source effects are encoded in the configuration of the substrate itself, and the vacuum evolution law takes the form:

The general carrier equation retained in this paper is 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 term τ_c u^μ ∇_μ Ψ generates the carrier reconfiguration residuals defined in Section 9.1. 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 spacetime structure (the Spaticle field substrate), independent of any source-side descriptor.

The general carrier equation is F1-cov. Organised galactic and stack regimes are described by DM1 and DM2.

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.

9.5 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. DM1 and DM2 are the organised-regime force laws tested on SPARC and KiDS.

9.5.1 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 9.5. Gravitation is governed by the substrate field equation

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

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 9.5.

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, not 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 Sections 10 to 12.

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.

9.6 The Fully Covariant Carrier Field Equation

Section 9.6 therefore derives the fully covariant carrier field equation governing departures from that equilibrium during rapid gravitational reconfiguration.

The fully covariant carrier field equation F1-cov is the general carrier equation of this paper. Organised galactic and stack results use the regime laws DM1 and DM2; they are not obtained by integrating F1-cov on those datasets.

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 Psi; the substrate field equation of Paper 17 governs how the resulting Psi configuration sources spacetime curvature. Together they form a closed covariant system. In settled regimes (delta_Psi approximately 0, Psi approximately 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 non-trivial dynamics of delta_Psi governed by F1-cov produce the carrier reconfiguration residuals defined in Sections 9.1 and 11.

$G_{\mu\nu} = (8\pi G/c^4)\,[T^{matter}_{\mu\nu} + \partial_\mu\Psi\,\partial_\nu\Psi - g_{\mu\nu}\,((1/2)(\partial\Psi)^2 - (\lambda/4)\Psi^4)]$ *(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 free covariant equation for a massive carrier perturbation in curved spacetime, with effective mass $m_{eff}^2 \propto \rho_s c^2$ (proportional to the substrate vacuum density, up to a normalisation constant relating substrate density to the carrier mass scale). The vacuum solution $\delta\Psi = 0$ (i.e. $\Psi = \Psi\_vac$) is stable, recovering settled GR. Non-trivial solutions represent propagating carrier disturbances; gravitational waves correspond to the massless limit of these disturbances when the relaxation length L_rlx greatly exceeds the wavelength.

The covariant analogue of F1-cov, in which all source effects are encoded in the boundary conditions of $\delta\Psi$ instead of as explicit forcing, is:

Light-crossing times of compact objects are ordinary GR dynamical scales. They are distinct from the equilibrium Spaticle carrier time tau_nat (approximately 6.96 hours). Local carrier response in dense regions is shorter than the cosmic baseline.

(3) Quark confinement (proton radius ~ 0.87 fm): $\tau\_c = r\_conf/c \approx 3 \times 10^{-24}$ s, hadronic scale.

(1) Spaticle vacuum relaxation (cosmological scale): $\tau\_c \sim 10^5$ s, relevant to large-scale structure formation.

The carrier response time τ_c is not a single fixed number, it is scale-dependent, emerging from F1-cov with boundary conditions set by the physical system under consideration. Three physically distinct scales all emerge from the same equation:

Scale hierarchy of τ_c.

the slow-variation limit (∂_t << τ_c^{-1}) recovers F1 exactly, with K = κ τ_c / L_rlx^2 = 1/(c^2 · 3ρ_s). This is consistent with F1 not being an independently postulated equation but a systematic reduction of F1-cov in the appropriate limit.

tau_nat = 1 / (c * sqrt(3*ρ_s)) approximately 6.96 hours at equilibrium; L_nat = c * tau_nat approximately 50 AU. Local values are shorter when density exceeds ρ_s.

In the local observer frame and in the non-relativistic, slow-variation limit, $\square \approx -\partial_t^2/c^2 + \nabla^2$. The dominant spatial term gives $\nabla^2(\delta\Psi) - m_{eff}^2\, \delta\Psi \approx \kappa\, J(T)$. Identifying the carrier response time and coherence length as:

Recovery of F1 in the non-relativistic limit.

Every coefficient in F1-cov is determined from first principles: ρ_s from the intrinsic equilibrium substrate density (see Section 2), c from the Spaticle medium propagation speed (Paper 17 Sections 4.4 to 4.5 and 6.6), and kappa = 1/c^2 from the P17 Lagrangian coupling structure. No free parameters remain. The various source terms appearing across F1-cov are intended as effective representations of the same source-side forcing in different approximation regimes, but the mapping between them should be stated explicitly. In F1 the source is written as J[T_μν], the general functional of the stress-energy tensor. In F1-cov the source is (1/c^2) g^{μν} ∇_μ∇_ν Ψ_matter, the covariant Laplacian of the matter potential. In the Newtonian weak-field limit these reduce to the same quantity: $\nabla^2\Psi$_matter = 4πGρ_matter, the standard Poisson source. The three formulations are therefore consistent representations of the same source in three regimes: general covariant, weak-field covariant, and Newtonian.

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

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

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

This is determined entirely by the intrinsic Spaticle field equilibrium density ρ_s approximately 5.9×10^{-27} kg/m^3, whose physical basis and robustness are described in Section 2 of this paper.

$$m_{eff}^2 \propto \lambda\Psi_{vac}^2 \propto \rho_s c^2$$

The coefficient $m_{eff}^2 \propto 3\lambda\Psi_{vac}^2$ has the physical interpretation of an effective mass squared for the carrier perturbation. Using the P17 vacuum condition $\lambda\Psi_{vac}^2 = \rho_s c^2$:

The effective mass term.

$$\Box(\delta\Psi) - 3\lambda\Psi_{vac}^2 \cdot \delta\Psi = \kappa \nabla_\mu T^\mu{}_{matter} \quad \textit{(F1-lin)}$$

In settled regimes the Spaticle field rests at its vacuum configuration Ψ_{vac} satisfying the self-consistency condition $\lambda\Psi_{vac}^2 = \rho_s c^2$ (Paper 17, §4.5). Writing $\Psi = \Psi_{vac} + \delta\Psi$ where $\delta\Psi$ is the carrier perturbation, the linearised equation for $\delta\Psi$ is:

Linearisation around the vacuum state.

where $\Box = g^{\mu\nu} \nabla_\mu \nabla_\nu$ is the covariant d'Alembertian, λ is the quartic self-interaction coupling ($\lambda = \rho_s/4$, fixed by the Spaticle vacuum density), $\kappa = 1/c^2$ is the source-to-substrate coupling, and T^μ_{matter} is the matter stress-energy tensor. This equation is manifestly Lorentz-covariant and holds at all scales.

$$\Box\Psi - \lambda\Psi^3 = \kappa \nabla_\mu T^\mu_{matter} \quad \textit{(P17-EOM)}$$

Varying the full Spaticle field action (Paper 17, §4.2-4.4) with respect to the field Ψ gives the covariant equation of motion:

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 DM1 and DM2.

9.7 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 $dS_{GR}^{settled}/dt \approx 0$. These equations follow directly from the effective dynamics of Section 9.3 by first-order linearisation around the settled state.

$\tau_c \cdot d(\delta S_{carrier})/dt + \delta S_{carrier} \approx -\tau_c \cdot dS_{GR}^{settled}/dt$ (F3)

$\delta S_{carrier}(t) \approx -\int \exp(-(t-t')/\tau_c) \cdot [dS_{GR}^{settled}(t')/dt']\, dt'$ (F4)

9.8 Tensor-Scalar Decomposition: The Ψ/Ψ → $h_{\mu\nu}$ Mapping

A standard concern about scalar-field extensions of gravity is the relationship between the scalar degree of freedom and the tensor metric perturbations $h_{\mu\nu}$ of general relativity. In linearised gravity, the metric perturbation $h_{\mu\nu}$ decomposes under Lorentz symmetry into irreducible representations: the spin-2 transverse-traceless sector (2 degrees of freedom), the spin-1 vector sector (2 degrees of freedom), and the spin-0 scalar trace sector (1 degree of freedom). Standard GR gravitational waves are entirely in the spin-2 sector. The scalar carrier field δΨ maps onto the spin-0 sector: $\delta\Psi(x,t) \leftrightarrow (1/\sqrt{2})\, h^{(0)}(x,t) = (1/\sqrt{2})\, \eta^{\mu\nu} h_{\mu\nu}$. (7.7.1)

This means carrier reconfiguration residuals predicted by F1-cov are scalar-sector (spin-0) residuals. They do not interfere with or modify the transverse-traceless gravitational-wave signal $h_{\mu\nu}^{(2)}$ measured in standard strain analysis. They appear as a subdominant scalar component detectable through the trace of $h_{\mu\nu}$ instead of through the standard cross/plus polarisation decomposition. The spin-2 sector obeys the standard wave equation $\Box h_{\mu\nu}^{(2)} = 0$ in vacuum, completely unchanged. All standard GR gravitational-wave predictions remain exactly as calculated by numerical relativity. The BFUT addition is a scalar sector companion field, governed by F1-cov, whose transient behaviour during rapid-reconfiguration events produces the carrier residuals. At second order in perturbation theory, scalar-sector perturbations mix with tensor-sector perturbations through the nonlinear Einstein equations; a full quantitative calculation of this second-order mixing is outside the scope of this paper.

9.9 The Constitutive Law for the Dynamics Operator D

The abstract dynamics operator D introduced in §9.2 is derived from the linearised Spaticle field equation of motion. From F1-cov in the slow-variation frame, the operator D acting on the carrier state variable δΨ is: $D[\delta\Psi] \equiv \tau_c \cdot \partial(\delta\Psi)/\partial t + \delta\Psi -$

$(L\_rlx^2/3)\nabla^2(\delta\Psi)$. (D-law). This is a damped Klein-Gordon operator derived by linearising the full nonlinear Spaticle field equation of motion around Ψ_vac. It is not postulated.

9.11 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 $\delta S\_carrier$ during rapid-transition events. These residuals are absent in metric realism (which has no sub-metric timescale τ_c and predicts no carrier reconfiguration residuals) and present in BFUT. The distinction is therefore empirical, not philosophical.

The nineteenth-century aether failed because it introduced a measurable preferred reference frame detectable through first-order Michelson-Morley experiments. The Spaticle field does not: it is Lorentz-covariant by construction (BFUT P14), consistent with special relativity, and its carrier dynamics are governed by the covariant equation F1-cov. Every local observer measures local propagation through their own local substrate state; local propagation equilibrium always yields c; Lorentz symmetry therefore emerges operationally. BFUT modifies substrate ontology, not operational Lorentz invariance. If $\tau\_c = 0$, F1-cov reduces to standard GR identically. The causal distinction is falsifiable.

10. 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.

10.1 Quasi-Static and Slowly Evolving Regimes

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

$$\delta S\_carrier(t) \approx 0 \quad \text{(quasi-static or slowly evolving regimes).}$$

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 $\xi(t)$, defined as:

$$\xi(t) = \tau\_c \cdot |[1/S\_GR\text{^}settled(t)] \cdot dS\_GR\text{^}settled(t)/dt| \quad (F5)$$

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 distinct from ξ_org, the emergent spatial coherence length of organised rotational domains.

At the limit $\tau_c \to 0$, F1-cov recovers GR identically and the framework is observationally inert.

10.2 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.

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

The covariant carrier field equation F1-cov derived in Section 9.6 is a Yukawa-type equation in the static limit. The complete derivation chain from F1-cov to the domain radius DDR proceeds as follows. In the static, weak-field case, F1-cov reduces to a screened Poisson equation whose solution outside a permanent point source of mass M is $\delta\Psi(r) = -(GM / c^2 r) \times \exp(-r / L_{cosm})$, where L_{cosm} approximately 5.82 Gly is a cosmological coherence scale emerging from the substrate equilibrium structure. Since all gravitationally significant structures have R_d much less than L_{cosm}, the exponential is negligibly different from unity at all domain scales. The domain boundary condition then gives $GM / (c^2 R_d) = \delta\Psi_{noise}$, and using the substrate-density relation the domain equation resolves to the substrate-density form: DDR equation: $R_d = (3M / (8 \pi \rho_s))^{(1/3)}$ [DDR, substrate-density form]. This is the canonical DDR equation. It is derived entirely from substrate dynamics, requires no cosmological model input, and depends only on the intrinsic equilibrium substrate density ρ_s whose physical basis is described in Section 2. For reference, if one uses the effective mapping Lambda_eff = 8 π G ρ_s / c^2 as a derived quantity only, the form DDR equation: R_d = (3GM / (Lambda_eff c^2))^(1/3) is recovered identically. The substrate-density form is primary; the Lambda_eff form is a derived notational variant. The carrier field F1-cov in its static weak-field limit separately gives: nabla^2(delta_Psi) - (1/L_rlx^2) delta_Psi = (kappa/c^2) nabla^2(Psi_matter) [equation 8.3a, carrier field equation, L_rlx scale], where L_rlx = L_nat approximately 50 AU at equilibrium is the substrate relaxation length governing carrier dynamics. These two screened Poisson equations have different physical roles and different Yukawa scales: L_cosm sets gravitational domain radii through DDR; L_rlx sets carrier relaxation timescales through F1-cov. They are not in conflict; they describe different physical regimes of the same underlying substrate field equation.

The domain radius. The gravitational deformation domain R_d of a structure of mass M is the radius at which delta_Psi(r) falls to the level of ambient Spaticle field fluctuations. The full domain equation in substrate-density form is: DDR equation: R_d = (3M / (8 π ρ_s))^(1/3) [DDR, substrate-density form]. The rotational term in the generalised DDR formula is (1 + v_rot^2/c^2)^(1/3) where v_rot = omega times R_object is the physical surface velocity of the rotating structure. This form is derived from F1-cov: the carrier field source term responds to the physical velocity of the matter, not to the substrate coherence length L_rlx. For all realistic objects (v_rot much less than c) the rotational contribution to the domain is negligible, less than 0.003% for all objects from Earth to the Milky Way. Organised rotation maintains a larger domain because the rotating mass continuously re-entrains the substrate deformation against relaxation, consistent with Paper 9's finding that rotational organisation is the most durable large-scale gravitational configuration. The DDR domain structure describes emergent coherent gravitational persistence, not simple isolated exponential decay from a point source. Nested coherent domains overlap and reinforce one another across scales, allowing organised gravitational structures to persist far beyond the local substrate relaxation scale.

Generalised Domain Formula for Extended Objects

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

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

The domain radius is then:

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

The max() condition enforces the physical constraint that the domain boundary is always exterior to the object itself. The gravitational influence of any object extends at least to its own surface. The formula cannot predict a domain boundary inside the source. For all known physical objects, from grains of matter to superclusters, the domain formula gives a result vastly larger than the physical extent, so the max() condition never triggers in practice. It is stated explicitly to close the theoretical gap identified when the source size approaches the domain scale.

Computed Domain Radii and Boundary Accelerations

Using $\rho_s = 5.9 \times 10^{-27}$ 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)**	**R_d**	**g_boundary (m/s^2)**	**g_boundary / g_Earth**
Earth	5.97×10^{24}	5.24 ly (1.6 pc)	1.62×10^{-19}	1
Jupiter	1.90×10^{27}	35.8 ly (11 pc)	1.11×10^{-18}	6.8
Sun	1.99×10^{30}	363 ly (111 pc)	1.12×10^{-17}	69
Milky Way	1.20×10^{41}	435 kpc	4.43×10^{-14}	273,000

Resolution of Seeliger's Paradox

In BFUT the paradox does not arise. Every mass has a finite deformation domain beyond which its gravitational influence falls to the ambient substrate noise level and is physically zero, not merely small. The sum of gravitational influences at any point is therefore a sum over a finite number of sources whose domains actually reach that location. The nested hierarchy ensures this sum is well-defined and finite at every point in the infinite universe. Seeliger's paradox is resolved not by introducing a compensating term but by the physical finiteness of each structure's gravitational domain, which is a direct consequence of the substrate having non-zero equilibrium density ρ_s.

10.4 DM1 Nested-Domain Gravity: Numerical Reconstruction and Multi-Scale Analysis

The DM1 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 $\rho_s = 5.9 \times 10^{-27}$ kg/m^3, with all domain radii from DDR: $R = (3M / (8 \pi \rho_s))^{(1/3)}$.

Domain Radii

From the generalised DDR formula with $M_{eff} = M \times (1 + v_{rot}^2/c^2)$: Earth = 5.24 ly (1.6 pc); Jupiter = 35.8 ly; Sun = 363 ly (111 pc); Milky Way = 435 kpc; Local Group = 1.40 Mpc. Rotation contributes less than 0.003% for all objects from the exact DDR formula. The boundary gravitational acceleration at each domain: Earth 1.62×10^{-19} m/s^2; Jupiter 1.11×10^{-18} m/s^2 (7x Earth); Sun 1.12×10^{-17} m/s^2 (69x); Milky Way 4.43×10^{-14} m/s^2 (273,000x). The Milky Way boundary sits well below the MOND empirical scale $a0 = 1.2 \times 10^{-10}$ m/s^2.

Where DM1 = Newton (no detectable difference)

Rapid gravitational transitions are limited by finite carrier reorganisation. Local denser regions settle faster than the equilibrium baseline of approximately 6.96 hours.

Where DM1 is Better than Newton

Galaxy rotation curves under DM1: organised Spaticle entrainment supplies extra support at large radii. On 175 SPARC galaxies the results are shape agreement 86.3 percent, flat classification 93.0 percent, non-flat 27.8 percent, and median outer relative residual 0.25 (Appendix A). No per-galaxy retuning of the DM1 constants is used.

Large-Scale Structure: Mitigating the High-Ratio Concern

Beyond the Local Group domain boundary, DM1/Newton(MW alone) ratios of 10-1000x are computed at 3-10 Mpc. Three considerations mitigate this. First, the correct comparison is Newton with all contributing masses (MW + LG + Virgo at 17 Mpc + Great Attractor at 65 Mpc), not Newton from MW alone. With correct 3D geometry, the total Newtonian acceleration at 3 Mpc already reaches 7.3×10^{-13} m/s^2, consistent with observed peculiar velocities of 150 km/s at that scale. DM1 makes the multi-source gravitational environment explicit without requiring particulate dark matter.

Second, peculiar velocities are not simply $g \times t_{Hubble}$. The correct relation is $v_{pec} = H0 \times f \times \delta$ from linear perturbation theory ($f = \Omega_m^{0.55}$ approximately 0.46), requiring integration of the DM1 field equations over cosmic history. This is an open numerical target.

Third, the coherent rotating mass at Local Supercluster scale is a free parameter constrained by observation. Back-calculation from observed peculiar velocities gives a required coherent LSC mass of approximately 4.6 x 10^14 M_sun, which is 0.46 times the Virgo Cluster total mass, physically reasonable, since only the coherently rotating fraction contributes to domain amplification. This mass should be fitted to the CF4 peculiar velocity survey and the Valade et al. 2024 basin-of-attraction boundaries, which P9 documents as consistent with the BFUT nested hierarchy. At 3-10 Mpc, DM1 predicts the correct sign and qualitative order of magnitude of gravitational enhancement consistent with observed peculiar velocity fields. Precise quantitative predictions at these scales require full perturbation theory integration of the DM1 field equations.

10.6 Additional systems under DM1 entrainment

Additional systems spanning ultra-diffuse galaxies, compact relics, high-redshift disks, and mergers are discussed under DM1 physics in Appendix D.

Additional systems outside SPARC are assessed with the DM1 speed-band and entrainment structure (and, where mass and radius exist, the full M_extra 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 DM1 framework. Detailed conclusions are collected in Appendix D.

FCC 224 (Buzzo et al. 2025): ultra-diffuse galaxy in the Fornax Cluster outskirts. Under DM1, 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 (Comeron et al. 2023): compact relic galaxy in the Perseus Cluster with high central velocity dispersion. Under DM1 the outer extra-mass fraction at several effective radii can approach or slightly exceed the tightest reported dynamical limits; the result is recorded as partial in Appendix D.

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 $z = 4.26$ (Neeleman et al. 2020): massive rotating disk with a flat rotation curve near 272 km/s confirmed by ALMA. Under DM1 the multi-radius amplitude is not cleanly held at all radii with the trial mass; the result is recorded as partial in Appendix D.

Together with the 175 SPARC galaxies under DM1, the KiDS-1000 stacks under DM2, 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.

15. Application to Galaxy Rotation Curves

The substrate carrier field equation derived in this paper, when applied at galactic scales through the full Spaticle field Lagrangian of BFUT Paper 17, produces a testable modification to the gravitational potential in galactic outer discs. This section presents the derivation, the empirical calibration, and the sequential validation across a sample of 175 galaxies.

15.1 Substrate-Deformation Poisson Equation at Galactic Scales

In the weak-field galactic regime, the substrate field equation of BFUT Paper 17 reduces to a substrate-deformation Poisson equation. The gravitational potential Ψ is sourced not only by baryonic density ρ_b but by the Spaticle field density ρ_s and a gradient-sourced density term ρ_∇ arising from spatial variations of the carrier field φ:

$$\nabla^2\Psi = 4\pi G(\rho_b + \rho_s + \rho_\nabla) \qquad (G1)$$

The gradient-sourced density term is:

$$\rho_\nabla = \alpha|\nabla\Psi|^2 \qquad (G2)$$

where the coupling constant α is determined by the Spaticle field equation of state. The field compressibility gives $c\_s^2 \approx \lambda\rho\_s$, and the coupling structure of the Lagrangian yields:

$\alpha = 1/c\_s^2, \quad c\_s^2 \approx \lambda\rho\_s \qquad (G3)$

The Spaticle field density ρ_s is the intrinsic equilibrium substrate density with working value ρ_s approximately 5.9 x 10^-27 kg/m^3, as derived from the BFUT substrate identity established in BFUT Paper 14 and characterised in Section 2 of this paper. The term ρ_∇ scales with the spatial gradient of the carrier field, not with total mass. Where baryonic density changes steeply, as in the transition between a galactic disc and the outer halo, $|\nabla\Psi|$ is large and ρ_∇ is significant. Where density is smooth, ρ_∇ is negligible and the equation reduces to standard GR. The modification operates precisely where it is needed and recovers standard GR exactly where GR is confirmed.

15.2 Physical Causal Chain: From Baryons to Flat Rotation Curves

Importantly, the additional rotational support appearing in the BFUT galaxy fits is not introduced through invisible halo matter or phenomenological force insertion. The enhancement emerges from organised substrate-deformation dynamics themselves. The complete causal chain is as follows.

Rapid gravitational transitions are limited by finite carrier reorganisation. Local denser regions settle faster than the equilibrium baseline of approximately 6.96 hours.

This mechanism is independently supported by BFUT Paper 6 on gravitational vortices, which demonstrates that coherent rotational organisation naturally produces large-scale persistent gravitational structure, and by BFUT Paper 9 on nested rotational hierarchy across cosmic scales, which establishes that rotational organisation recurs at every scale and cannot be treated as a local exception.

15.3 Local Force Law versus Large-Scale Domain Persistence

The BFUT framework operates across two physically distinct regimes that must be carefully distinguished. Locally, inside a deformation domain and well within its boundary, the BFUT force law approximates Newton and GR exactly. The Yukawa correction factor $(1 + r/\xi\_org)$ times $\exp(-r/\xi\_org)$ is indistinguishable from 1 for r much less than ξ_org. No modification to Newtonian gravity is introduced at solar-system or inner-galactic scales. At domain scales and beyond, organised deformation persistence through rotational entrainment produces additional effective gravitational support that flattens rotation curves. These are two different physical regimes operating on two different scales. BFUT does not modify Newtonian gravity everywhere. It modifies the domain structure that determines how far organised gravitational influence extends.

15.4 Physical Interpretation of the Gradient-Sourced Density Term

The gradient-sourced density term rho_gradient proportional to |gradient of phi|^2 requires explicit physical interpretation. It represents stored organised substrate deformation energy associated with spatial curvature gradients in the carrier field. Where the baryonic density profile changes steeply, as at the transition between a galactic disc and the surrounding substrate domain, the spatial gradient of the carrier field is large and this stored deformation energy is significant. It is not an additional particulate halo component. It represents organised substrate deformation energy maintained by rotational entrainment: the substrate's own physical response to organised rotation, amplified precisely where baryonic density falls and the dark matter anomaly is observed. The Spaticle field is not mimicking dark matter. Within BFUT it is proposed as the physical phenomenon historically inferred through observations attributed to dark matter, through a physical mechanism that connects to the deformation-domain structure (DDR), the carrier equation (F1-cov), coupling constants, and the nature of time: roles entirely absent from any dark matter hypothesis.

15.5 Yukawa Screening and Rotational Domain Extension: The Interplay

A potential question: if Yukawa screening suppresses gravity at large scales, how does the framework simultaneously produce flat rotation curves at large galactic radii? The resolution is that Yukawa screening applies to isolated static systems undergoing unforced relaxation. Coherent rotating organised systems are not in unforced relaxation. Rotational entrainment continuously sustains organised structure back into the substrate, preventing the domain boundary from relaxing at the bare Yukawa rate. An isolated static mass produces a domain that decays exponentially at the coherence length. A coherently rotating galactic system dynamically maintains an enlarged domain whose effective size is set by the rotational amplification factor R. These are two different physical situations within the same framework. Yukawa screening and rotational domain extension are not in conflict: one applies to unforced relaxation, the other to dynamically maintained organised rotation. The interplay is what makes flat rotation curves possible without invoking gravitational phenomena historically attributed to dark matter.

15.6 Rotation Velocity Decomposition

The observed circular rotation velocity decomposes as:

$$v^2(r) = v_b^2(r) + v_s^2(r) \qquad (G4)$$

where $v_b^2(r)$ is the standard GR baryonic contribution, computed following SPARC [5] methodology as $v_b = \sqrt{v_{gas}^2 + v_{disk}^2 + v_{bulge}^2}$, and $v_s^2(r) = r\, d\Psi_s/dr$ is the Spaticle field contribution derived from the gradient-sourced potential Ψ_s. The baryonic surface density profiles are taken directly from published SPARC photometry with no per-galaxy tuning.

15.7 Empirical Calibration

The two parameters of the DM1 model, A and α, were fixed on an initial sample of 20 galaxies drawn from the SPARC database. The calibration minimised the root-mean-square residual between the predicted and observed rotation velocities across the full radial range. The resulting formula is:

$$M_{extra}(<R) = 4\pi\rho_s \cdot A \cdot (M_{bar}/10^{10}M_\odot)^\alpha \cdot f(V_{char}) \cdot R_{ref}^2 \cdot R \cdot \xi(R) \qquad (DM1)$$

where $f_b = \langle v_b/v_{obs} \rangle$ is the mean baryonic fraction across the galaxy's radial profile. This relation is physically consistent with the Lagrangian: the Spaticle field response is stronger where baryonic matter explains less of the observed dynamics. Once calibrated on the initial 20-galaxy sample, A and α were held fixed for all subsequent validation. No per-galaxy parameter adjustment was applied at any subsequent stage.

To state this transparency point with full explicitness: the DM1 constants A and α were fixed once and applied identically across all 175 galaxies. The speed-band structure $f(V_{char})$ and radial factor $\xi(R)$ were not tuned per galaxy; they follow from the same functional form for all galaxies. No parameter in the model was adjusted to improve the fit of any individual galaxy after the initial calibration step. The 175-galaxy validation is therefore a genuine test of a globally fixed formula, not a post-hoc description of individual galaxy data.

15.8 Application to the SPARC sample

DM1 uses global constants (Appendix A). Applied to the full SPARC sample of 175 galaxies, the reported classification rates are shape agreement 86.3 percent, flat classification 93.0 percent, non-flat classification 27.8 percent, and median outer relative residual 0.25. Detailed per-galaxy results are given in Appendix A.

15.9 Residual Distribution Across 175 Galaxies

The rotation-curve model was applied uniformly to all 175 SPARC galaxies. The DM1 constants A and α were fixed once and held unchanged across the full sample. No per-galaxy parameter adjustment was made at any stage. Table 2 presents the residual distribution across the full 175-galaxy sample.

Table 2. Residual distribution across 175-galaxy sample.

SPARC under DM1 (summary)

Shape 86.3%; flat 93%; non-flat 28%; median outer |rel| residual 0.25 (Appendix A)

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; the gradient-sourced term assumes azimuthal symmetry, 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 DM1: organised Spaticle entrainment supplies extra support at large radii. On 175 SPARC galaxies the results are shape agreement 86.3 percent, flat classification 93.0 percent, non-flat 27.8 percent, and median

outer relative residual 0.25 (Appendix A). No per-galaxy retuning of the DM1 constants is used.

Weak gravitational lensing validation of the finite-domain substrate framework has been completed using public KiDS-1000 galaxy-galaxy lensing data from Brouwer et al. (2021) [24]. The BFUT finite-domain profile $\Delta\Sigma(r) = A\cdot\exp(-r/L_d) + B/(1 + r/L_r)$ was applied to the four GAMA stellar-mass binned Excess Surface Density profiles without modification to any parameter derived from the rotation-curve programme. The results are presented in the following section.

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 in the rotational term of DDR. No per-galaxy free parameters are adjusted. The 4% of galaxies with residuals above 60 km/s are identified as cases of environmental interaction, recent merger activity, or incomplete baryonic decomposition. Extended outlier analysis is deferred to subsequent work.

Rapid gravitational transitions are limited by finite carrier reorganisation. Local denser regions settle faster than the equilibrium baseline of approximately 6.96 hours.

15.10 GR Recovery and Cross-Domain Consistency

The BFUT substrate equation (G1) recovers standard GR in smooth-gradient regimes. When $\nabla_\mu\nabla_\nu T^{\mu\nu}_{matter} \approx 0$, the source term for φ vanishes, giving $\nabla\varphi \approx 0$ and $\rho_\nabla \approx 0$. The local perturbation equation reduces to $\nabla^2(\delta\Psi) = 4\pi G(\delta\rho_b)$, where $\delta\Psi = \Psi - \Psi_{background}$ and $\delta\rho_b$ is the local baryonic density perturbation above the cosmological mean. The uniform ρ_s background in G1 contributes only to the homogeneous cosmological solution $\Psi_{background}$ and renormalises the effective gravitational constant at cosmological scales; it does not appear in the local perturbation equation. This recovers standard Newtonian gravity for local perturbations. All precision GR tests are therefore unaffected by this modification: perihelion precession of Mercury, Shapiro delay, gravitational lensing by the Sun, and binary pulsar orbital decay all operate in regimes of smooth baryonic gradients where ρ_∇ is negligible. In low surface brightness galaxies, where baryonic density is low but the fractional gradient relative to total mass is high, the gradient term dominates and the model produces its largest deviation from standard GR, consistent with the observed extreme flatness of rotation curves in those systems. In galaxy clusters, large-scale gradient integration produces the larger apparent mass discrepancy observed in lensing and X-ray analyses. Gravitational lensing map analysis is in preparation as an additional test domain.

16. Gravitational-wave memory as a bridge concept

Gravitational-wave memory 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 spacetime 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 A_mem and a transient reconfiguration residual A_tr·exp(−(t−t_0)/τ_c). BFUT carrier reconfiguration residuals correspond to the second term: they decay on the timescale τ_c and are absent in the settled state. Gravitational-wave memory corresponds to a non-zero A_mem. The two are physically distinct and occupy different temporal windows in the post-event signal.

$$\delta S\_carrier(t) = A\_mem\cdot\Theta(t-t\_0) + A\_tr\cdot\exp(-(t-t\_0)/\tau\_c)\cdot\Theta(t-t\_0) \quad (F14)$$

17. Weak gravitational lensing: KiDS-1000 under DM2

Under DM2, stacked weak lensing is described by organised Spaticle density producing extra mass that grows with radius. The working constants are A = 38, alpha = 0.5, and R_ref = 300 kpc, with ρ_s = 5.9 x 10^-27 kg m^-3.

M_extra(<R) = 4 pi ρ_s * A * (M_gal/10^10 M_sun)^alpha * R_ref^2 * R, with V_pred^2(R) = G*M_gal/R + G*M_extra(<R)/R.

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

Across the four stellar-mass bins, chi-square quality is in the range of approximately 2 to 3. One global amplitude and one mass-scaling exponent serve all bins. Full detail is given in Appendix B.

DM1 and DM2 share the same physical idea at different organisation scales: resolved disks with speed structure (DM1) versus stacked lensing (DM2).

Formal model-comparison statistics for alternative halo profiles are not required to state the DM2 results; the reported fit quality is that of DM2 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; DM2 is offered here as a substrate-based account of the stacked signal instead of as a particle-dark-matter halo fit.

18. Extended future domains

The present work focuses on the transient decaying component A_tr instead of the persistent memory term A_mem. The memory offset, while physically real and observationally important in its own right, is a separate phenomenon from the carrier reconfiguration residuals that are the primary prediction of this paper.

Several other classes of violent astrophysical events are natural candidates for exhibiting carrier reconfiguration residuals at levels that may eventually become observationally accessible. They are presented here as future observational domains, not immediate proof targets, because they involve more complex, less well-constrained source-side dynamics that make it more difficult to construct clean, falsifiable predictions at the current stage of BFUT formalism development.

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.

In all of these systems the physical reasoning follows the same logic: if the Spaticle field is real and has finite reorganisation dynamics, then the most violent and most rapidly evolving source-side configurations are the natural environments in which carrier-level physics should be most prominently expressed. The challenge for each system is that the source-side dynamics are complex and difficult to model cleanly, introducing confounding factors that make the separation of carrier reconfiguration residuals from standard GR predictions harder to achieve. Derivation Scope incorporating deeper Spaticle-field constitutive laws should eventually yield specific predictions for these systems.

19. Interpretation of phenomenological demonstrations

The current simulation and phenomenological demonstration suite associated with BFUT P18 serves a specific and clearly delimited purpose that must be stated explicitly in order to neither overclaim nor underclaim the evidentiary status of these demonstrations.

The existing simulations are conceptual and phenomenological illustrations of the carrier reconfiguration residual class under simplified assumptions. They are not claims of final first-principles derivation from a microscopic Spaticle-field constitutive law. Their purpose is to visualise the observational logic of localised, transition-linked carrier reconfiguration residuals in gravitational-wave and timing signals, and to demonstrate how such effects would appear qualitatively in realistic signal contexts given a simplified reconfiguration model.

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 approximately 6.96 hours.

Future higher-fidelity simulations incorporating richer Spaticle-field dynamics should refine the predicted morphology and amplitude scaling of carrier reconfiguration residuals across all three primary test domains.

The phenomenological simulations in this paper represent a restricted kernel-response class, not arbitrary residual injection. The observable signal is expressed as a convolution of the derivative of the settled GR-equivalent signal with a causal response kernel K_c, whose shape is constrained by the physical requirement of finite response time τ_c. Generic model-fitting procedures do not share this derivative-driven, transition-localised structure and therefore cannot be conflated with the BFUT residual class.

$$S_{obs}(t) = S_{GR}^{settled}(t) + \int K_c(t-t') \cdot [dS_{GR}^{settled}(t')/dt']\, dt' \quad \text{(F15)}$$

$$K_c(\Delta t) \propto -\exp(-\Delta t/\tau_c) \cdot \Theta(\Delta t) \quad \text{(F16)}$$

20. 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 the Einstein field equations as the correct macroscopic description of the Spaticle field's settled behaviour under source-side organisation, with GR as a limiting approximation of substrate-coherence gravity instead of as the parent framework. It does not challenge the extraordinary precision of solar-system tests, binary pulsar timing, or large-scale cosmological observations; it is explicitly constructed to reproduce all of those results in quasi-static and slowly evolving regimes. It does not claim to have solved all of gravitational ontology; it makes a targeted and falsifiable claim about a specific class of transitional phenomena in a specific class of observational regimes.

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.

The conceptual contribution of separating the three questions of Section 3 has consequences beyond BFUT. Gravitational ontology and gravitational measurement methodology are both sharpened by forcing the distinction between source-side descriptor and local carrier into the open. Even if Derivation Scope were to show that the Spaticle field's reconfiguration dynamics leave no observational trace at any accessible precision, the logical question of what entity is in a changed local state when gravitation is measured would remain unanswered by standard theory alone. P18 converts that question into a measurement programme.

Standing validation in this paper is reported in Appendix A (SPARC under DM1), Appendix B (KiDS-1000 under DM2), and Appendix D (additional systems and merger morphology). Numerical illustrations must use the same standing equations only.

20.1 Closure via BFUT Papers 19 and 19A

20.2 Framework scope and limitations

BFUT P18 supplies the minimal dynamical content needed to define the residual class and the test statistics. The domain boundary condition in DDR uses an ambient substrate noise floor delta_Psi_noise whose magnitude is estimated from substrate parameters (ρ_s and lambda_SI). The bridge from the screened Poisson equation to the domain radius formula uses this boundary condition, which is grounded in the static-limit treatment of F1-cov.

The effective decomposition S_obs(t) = S_GR^settled(t) + delta_S_carrier(t) is a model-class statement. The abstract substrate relation D[Psi] = J[T_munu] is a schematic representation of substrate dynamics. The response functional F[Psi] maps the substrate state to observable signals within the scope developed here.

20.3 Derivation scope

The D-law constitutive form, the three explicit forms of the response functional F, the derivation of tau_c from ρ_s, and the a-priori event-class scaling predictions are all delivered in BFUT Paper 19 (DOI: 10.5281/zenodo.20145568). The second-order tensor-scalar mixing coefficient is outside the scope of both papers. The full list of derivations delivered across P18 and P19 is preserved below.

- Derivation of an explicit constitutive law for the operator D, the internal dynamics governing the Spaticle field's evolution under source-side forcing.
- Derivation of the response functional F relating substrate state to macroscopic measurable gravitational signals, including the connection between the Spaticle-field state variable Ψ and the metric perturbation h_{μν} of standard GR.
- Event-class scaling predictions that would allow the amplitude of carrier reconfiguration residuals to be estimated as a function of astrophysical source parameters: mass ratio, orbital eccentricity, total energy, and similar quantities.
- Higher-fidelity numerical simulations of carrier reconfiguration events that go beyond the current phenomenological scaffold and incorporate richer substrate dynamics.

Derivation of quantitative relations linking τ_c and L_rlx to underlying Spaticle-field substrate physics, including the identification of the physical processes that set the carrier reorganisation timescale and the conditions under which τ_c may vary across astrophysical event classes.

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

The equilibrium relaxation length follows from tau_nat: L_nat = c * tau_nat approximately 50 AU at ρ_s. This is the undisturbed-medium scale only. Local denser media have shorter response times and correspondingly shorter local scales.

The correct calibration hierarchy begins with isolated simple bodies where mass is known, rotation is weak, orbital behaviour is extremely well measured, and dominance boundaries are observable. This gives the cleanest constraints on L_rlx, $\beta = 1$ (the geometric exponent, derived in Paper 19 §14), and $k = G/c^2$ (the dimensional coupling) before introducing rotational amplification. The full isolated-body substrate equation and its empirical calibration programme are developed in BFUT Paper 19 §15. The five primary calibration routes are:

1. Hill sphere radii (Earth, Moon, Jupiter): the Hill sphere operationally defines the deformation-domain boundary. All Hill sphere radii should lie on the DDR curve with the same ξ_{org}.

2. GPS and altitude clock-dilation measurements: the BFUT time-dilation formula introduces an exponential correction $e^{-r/L_{rlx}}$ absent from standard GR. For current GPS altitudes the correction is below measurement precision; at deep-space probe altitudes it becomes measurable.

On the nature of gravitational time dilation in the BFUT framework: local propagation capacity is always locally maximal and self-consistent. An observer in a strong gravitational field does not experience their own time as slow, their clocks, chemistry, and internal processes all run normally in their own frame. Gravitational time dilation is a path-comparison result: it appears when two observers at different substrate depths compare their accumulated proper-time histories. The geometric difference in substrate traversal between their two paths is what both observers measure as a time-rate difference when they compare. No local observer detects a sluggishness in their own frame. This is consistent with local Lorentz covariance and with the formula $d\tau/dt = \eta(x)$, which expresses a ratio between paths, not an absolute local slowing.

3. Planetary spheres of influence and stellar influence radii: these standard celestial mechanics quantities are reinterpreted as deformation-domain extents. All should lie on the DDR curve.

4. Escape-dynamics transition behaviour: the distances where orbital capture ceases and stable binding disappears are domain-transition indicators. BFUT predicts an exponential cutoff, not gradual $1/r^2$ weakening at these scales.

Lagrange-point stability structure: L1/L2/L3 positions should be shifted relative to standard GR predictions by terms of order $e^{-r/L_{rlx}}$, testable at current spacecraft precision for heliocentric missions.

If the same $k = G/c^2$, $\beta = 1$, and L_{rlx} simultaneously fit all five calibration datasets, the framework achieves cross-dataset internal consistency from solar-system scales through galactic rotation curves to supercluster basins. The coupling constants α_s, α, and the W/Z masses emerge from constrained invariant reconstruction: the substrate constraint structure admits only a small family of dimensionless invariant combinations consistent with rotational symmetry, dimensional closure, and condensation topology. The BFUT values lie within this constrained family, reflecting structured constraint, not arbitrary parameter fitting. The complete derivation of the isolated-body calibration programme, including the dimensional closure of k, the uniqueness proof for $\beta = 1$, and the domain radius equation for each calibration body, is presented in BFUT Paper 19 §15.

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.

20.5 Roadmap to full theory

BFUT Paper 19 delivers the D-law constitutive form in Section 7.8, the response functional F in its three explicit forms in Section 7.9, the connection between τ_c and substrate physics through ρ_s, and a-priori event-class scaling predictions from F1-cov. The second-order tensor-scalar mixing coefficient and the full noise floor derivation are outside the scope of both papers. These boundaries do not affect the central claim or the observational programme of BFUT P18.

BFUT Paper 19 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 $y_t = 1$, and the inter-generational suppression from α_{em} 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.

20.6 A-priori event-class scaling predictions

Before any post-hoc fitting to gravitational-wave data, the carrier framework makes three a-priori quantitative predictions about the morphology of carrier reconfiguration residuals.

These predictions are derived directly from F1-cov and the constitutive law of §9.9. They precede data fitting and constitute the falsifiable core of the observational programme.

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.

20.7 Derivation scope and programme boundaries

The present paper establishes the effective carrier framework. The following items are derived and complete within this paper.

Standing in this paper: F1-cov as general carrier equation; DDR equation for domain radius; equilibrium carrier time approximately 6.96 hours with density dependence; DM1 and DM2 as organised-regime laws with SPARC and KiDS tests in Appendices A and B.

Closed in BFUT Paper 19: Quantitative coupling constant closure. The fine structure constant, strong coupling constant, W/Z masses, and $\sin^2\theta_W$ are all derived from ρ_s and the Paper 16 coefficients. Additionally, all six quark masses are derived from the top quark saturation condition $y_t = 1$ and the electromagnetic coupling α_{em} acting as the inter-generational circulation suppression operator, producing the complete fermionic hierarchy $m_f = m_t \times \alpha_{em}^{(n_f)}$ with the down-type sector shifted by the 3/4 P16 bifurcation occupancy fraction.

20.8 Numerical illustrations

This section implements the DM1 / F1-cov field equations numerically across three simulation domains: galaxy rotation curves, spatial domain boundary profiles, and large-scale peculiar velocity consistency. All simulations use the same substrate parameters throughout: $\rho_s = 5.9 \times 10^{-27}$

kg/m^3 (intrinsic equilibrium substrate density, source of all domain radii via DDR), and τ_nat ≈ 6.96 hours at equilibrium density (carrier relaxation time at equilibrium substrate density).

Simulation 1: Galaxy rotation support under DM1 (see Appendix A for full SPARC results)

Galaxy rotation curves under DM1: organised Spaticle entrainment supplies extra support at large radii. On 175 SPARC galaxies the results are shape agreement 86.3 percent, flat classification 93.0 percent, non-flat 27.8 percent, and median outer relative residual 0.25 (Appendix A). No per-galaxy retuning of the DM1 constants is used.

Numerical illustrations of carrier response use density-dependent local time, with equilibrium baseline approximately 6.96 hours.

Simulation 3: Spatial Domain Boundary Profile

The Yukawa gravitational acceleration profile was computed analytically for the nested domain hierarchy: MW (435 kpc), LG (1.40 Mpc), and calibrated LSC (4.13 Mpc) with coherent mass 9.2 x 10^44 kg. Inside the MW domain (r less than 435 kpc): g_DM1 = g_Newton to better than 1 part in 10^9. The enhancement factor DM1/Newton(MW) rises from 1.0 at the MW boundary to approximately 9x at the LG boundary and continues rising as the calibrated LSC contributes beyond. The smooth Fermi-function domain weighting produces continuous differentiable transitions with no artificial collapse or cutoff. The domain structure is consistent with the basin-of-attraction boundaries identified by Valade et al. 2024.

Simulation 4: Effective G and Peculiar Velocity Consistency

The effective gravitational constant at wavenumber k is G_eff(k)/G = k^2/(k^2 + 1/ξ_org^2). Since ξ_org at cosmological scales approaches L_cosm ≈ 5.82 billion light years, G_eff/G exceeds 99.9% at all scales up to 5000 Mpc, the entire observable universe. The Yukawa modification to G is negligible at every structure scale ever measured. DM1 does not suppress G. The gravitational enhancement at large scales comes from ADDITIONAL coherent contributions from nested larger structures, not from modification of G itself.

The peculiar velocity prediction v_pec = g x t_H x f_growth (f = 0.46) with calibrated LSC coherent mass of 9.2 x 10^44 kg (0.46 x Virgo Cluster mass) gives: approximately 60 km/s at 1 Mpc, 140 km/s at 3 Mpc, 200 km/s at 5 Mpc, 240 km/s at 10 Mpc, consistent with observed peculiar velocities from CF4 and Tully et al. surveys within the observational scatter. The LSC coherent mass calibration places DM1 in quantitative agreement with the observed peculiar velocity field without requiring dark matter infall or arbitrary halo profiles, consistent with the Spaticle substrate generating these effects through organised rotational deformation structure. Precise quantitative prediction at 3-10 Mpc scales requires full perturbation theory integration of the DM1 field equations, which remains an open quantitative quantities within the derivation scope of this paper.

Numerical illustrations in this programme address: (i) DM1 rotation support; (ii) domain structure from the DDR equation; (iii) density-dependent carrier time.

20.9 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 well-founded. Its error is ontological, not empirical: the assumption that the missing component must consist of undetected mass in the form of new particles.

The physical mechanism is now identified. The DDR equation derived in this paper governs two effects within one unified formula. First, it defines the finite gravitational dominance domain of each astrophysical structure: the radius at which its gravitational influence gives way to the next larger nested structure in the cosmic hierarchy. Second, the rotational term (1 + v_rot^2/c^2)^(1/3) encodes the physical process by which organised rotation entrains the Spaticle field, continuously re-pumps substrate deformation against relaxation, and generates additional gravitational support at outer galactic radii. This organised substrate deformation maintained by rotational entrainment is what the dark matter observational programme has been detecting. The physical agent is rotation acting on the Spaticle field. Rotating galaxies sustain enlarged deformation domains; the gravitational support from these domains flattens rotation curves and produces the lensing excess. The particle assumption has repeatedly failed experimental confirmation precisely because this mechanism involves no new particle, only the physical response of the existing Spaticle substrate to organised rotation.

The Spaticle field additionally occupies roles that dark matter models never anticipated. It is the physical substrate of space itself, the immediate local carrier of gravitation (Section 8), the medium through which gravitational waves propagate at c, the source of finite deformation domains from first principles (DDR, Section 10.3), and the entity whose transitional dynamics produce the carrier reconfiguration residuals forming the primary new observational programme of this paper (Sections 11 to 14). Its density ρ_s simultaneously fixes the carrier response time τ_c approximately 6.96 hours (equilibrium), the coherence length L_{rlx}, and the domain radii of every astrophysical structure through DDR. The full extension of these roles into quantum mechanics, coupling constants, particle masses, and the nature of time is developed in BFUT Papers 19 and 19A. The comprehensive multi-scale validation of the dark matter identification across seven independent physical sectors is presented in BFUT Paper 25 (DOI: 10.5281/zenodo.20535295).

The conclusion within the scope of this paper: dark matter has been correctly observed for decades and is now correctly identified for the first time. It is the Spaticle field: the physical substrate of space whose rotational entrainment by galaxies, encoded in the rotational term of DDR, generates the additional gravitational support the dark matter programme correctly measured. The comprehensive derivation and validation across seven independent physical sectors spanning forty orders of magnitude is presented in BFUT Paper 25 (DOI: 10.5281/zenodo.20535295).

20.10 The Spaticle field as the physical substrate of the Higgs field

The Higgs field exists. It is experimentally confirmed by detection of the Higgs boson at 125.25 GeV. It breaks electroweak symmetry and generates particle masses exactly as the Standard Model predicts. Nothing in this paper contradicts that.

The BFUT claim established across Papers 14 through 19 is more fundamental: the Spaticle field is the physical substrate from which the Higgs field emerges. This paper has shown that F1-cov produces the gravitational sector of the Spaticle field dynamics. The Higgs mechanism is the electroweak sector of the same substrate.

20.10.1 The identification

The vacuum self-consistency condition lambda_SI x Psi_vac^2 = ρ_s x c^2 (P17 Section 4.5) is precisely the Higgs vacuum condition. The Higgs VEV v = 246 GeV maps from the Spaticle vacuum amplitude through the r_p anchor. The Higgs boson is the quantised oscillation of delta_Psi around Psi_vac, with mass m_H = sqrt(m_top x m_Z) = 125.51 GeV (measured 125.25 GeV, deviation 0.21%).

20.10.2 The Spaticle field is more than the Higgs field

This paper establishes the gravitational sector: F1-cov, the carrier field equation, domain radii, galaxy rotation curves, and lensing profiles. All follow from the same ρ_s that fixes the Higgs VEV. The Spaticle field unifies the following domains from one substrate:

Domain	**Quantified result**
Electroweak sector (Higgs)	m_W = 80.0 GeV (0.5%), m_Z = 91.24 GeV (0.05%), m_H = 125.51 GeV (0.21%)
Gravitational carrier (this paper)	F1-cov; tau_nat ~6.96 h at equilibrium; density-dependent locally
Galaxy rotation curves	DM1 on 175 SPARC: shape 86.3%, flat 93%, non-flat 28%, med outer |rel| 0.25 (Appendix A)
Weak gravitational lensing	DM2 on KiDS-1000: chi-square quality ~2 to 3 (Appendix B)
Carrier / domain programme	F1-cov; tau_nat ~6.96 h at equilibrium; density-dependent locally
Quantum mechanics	L = n x ħ from single-valuedness of delta_Psi in F1-cov (P19)

Dark matter phenomenon	Seven independent physical sectors converge on ρ_s (P25, DOI: 10.5281/zenodo.20535295)

The Higgs field is the electroweak projection of the Spaticle field. F1-cov (this paper) is the gravitational projection. Both emerge from one substrate. $\rho\_s = 5.9 \times 10^{-27}$ kg/m³ is independently constrained from particle masses, galaxy dynamics, and gravitational lensing. When the QFT vacuum energy mode sum is corrected for a single field, with zero-point energy set to zero for empty modes, it collapses exactly to $\rho\_s \cdot c^2$, addressing the cosmological constant problem within the substrate-density picture. The BFUT framework is proposed to be consistent with the Standard Model at the electroweak level.

21. Conclusion

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. No alternative gravitational model simultaneously predicts all three.

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.

The present work is best understood as a first-stage falsifiable framework paper: it identifies the carrier question, defines a restricted residual class, and specifies where the first decisive tests should be performed. This paper accomplishes the conversion of an ontological clarification into a concrete measurement programme: identifying the carrier question, defining a restricted residual class, and specifying where the first decisive tests are to be performed.

#	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 instead of through 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.	`ρ_s = 5.9 x 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 configurations to extraordinary precision.	The substrate takes a finite time to reorganise after being forced by a violent event. This time is governed by ρ_s.	
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; ell_relax governs only transient single-event disturbances.	

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
4	**Gravitational domain radius [DDR/DM1]**	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_domain = (3*M / 8*pi*ρ_s)^(1/3)Sun: 363 lyMilky Way: 435 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 long-range nature of gravity as observed.	The substrate perturbation acquires an effective mass term set by ρ_s. The implied range is approximately 5.82 billion light years - far exceeding any astrophysical structure - so all local GR tests are unaffected.	`m_eff^2 ∝ lambda * Phi_vac^2 ∝ ρ_s * c^2`
LEVEL 2 - one step from ρ_s: quantities derived from tau_c, ell_relax, or R_domain				
6	**Covariant carrier field equation** [F1-cov]	Einstein's field equations G_mn = (8*pi*G/c^4)*T_mn describe how mass-energy curves spacetime. They are exact in the classical regime and have been validated to extraordinary precision	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^mn nabla_m nabla_n (dPhi) - 3*ρ_s*c^2 * dPhi= (1/c^2) nabla^2 Psi_matter`

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		across many experimental domains.		
7		In GR the vacuum solution is flat Minkowski spacetime. The gravitational field is sourced by matter and energy; it carries no independent gravitational content in the absence of sources.		
8	**Transition parameter ξ** [Observability]	GR is a complete self-consistent theory. Its predictions are tested and confirmed across an enormous range of regimes. A departure from GR would require a physical mechanism operating at specific conditions.	ξ specifies exactly when BFUT deviations become observable: only when the event timescale is comparable to tau_c. Solar system tests have ξ approximately 10^-20. GR is exact for ξ much less than 1.	`ξ(t) = tau_c * |dS_GR/dt| / |S_GR(t)|`
9	**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 tau_c. Zero during steady periods; maximum at violent transitions.	`S_obs(t) = S_GR(t) + dS_carrier(t)dS_carrier = -integral exp(-(t-t')/tau_c) * dS_GR/dt' dt'`

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
LEVEL 3 - two or more steps from ρ_s: observational predictions and validations				
11	**Unified gravitational equation** [Grand equation]	Gravity is described by Newtonian mechanics (weak, slow sources), GR (strong or rapidly varying sources), and supplementary dark matter components for galactic dynamics. Each framework is independently well-validated in its domain.	One equation covers all regimes: Newtonian, GR weak field, finite domains, galactic rotation, weak lensing, merger relaxation, and nested domain hierarchy all emerge as limits or applications of the same expression.	`Phi(r,t) = -(GM/r) * exp(-r/R_eff) * R(tau_c, d_t) * N(Sigma_i)R_eff = R_d*(1+v_rot^2/c^2)^(1/3)`
12	**Rotational domain enlargement [DDR/DM1 rotational]**	Galactic rotation curves require additional gravitational mass beyond visible baryons. The Lambda-CDM framework introduces dark matter halos whose profiles are fitted to the observed rotation data of each galaxy.	Rotation continuously re-pumps substrate deformation against relaxation. A coherently rotating galaxy sustains a gravitational domain far larger than a static mass would produce. No dark matter, no per-galaxy fitting.	`R_eff = R_d * (1+v_rot^2/c^2)^(1/3)Stable domain when:Gamma(omega) >= 1/tau_c`
13	**Galaxy rotation velocity** [Validation]	Lambda-CDM models rotation curves as v^2(r) = v_b^2(r) + v_DM^2(r), where the dark matter halo contribution is determined by fitting the NFW profile parameters	DM1 supplies organised extra mass; SPARC results in Appendix A.	`v^2(r) = v_b^2(r) + v_s^2(r)nabla^2 Phi = 4*pi*G * (rho_b + ρ_s + rho_grad)rho_grad = alpha * |nabla-phi|^2`

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		to each galaxy's observed rotation data.		
15	**Weak gravitational lensing profile** [Validation]		DM2 describes stack lensing; results in Appendix B.	`Delta_Sigma(r) = A*exp(-r/L_d) + B/(1+r/L_r)L_d: 100-116 kpc (stable)`
LEVEL 4 - grand implications: what all of the above means together				
20	**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 GR field equations emerge as the macroscopic settled-state description of the Spaticle substrate. GR is correct and complete in all regimes where the substrate is settled. BFUT extends GR instead of replacing it.	`Settled limit (dPhi -> 0):G_mn = (8*pi*G/c^4) * [T^matter_mn + T^Phi_mn]=> standard GR`
21	**Resolution of Seeliger's paradox** [Implication]	In an infinite static universe with Newtonian gravity, the gravitational potential diverges. GR resolves this through the cosmological constant and the dynamic nature of spacetime, which allows consistent	Every mass has a finite domain. The sum of gravitational influences at any point converges naturally. No cosmological assumption or compensating term is required. The	`g_total(r) = sum_i g_i(r) * exp(-r/R_domain,i)Sum is finite for all ρ_s > 0`

#	Formula / What it does	Standard model and GR position	BFUT P18: what changes and why it extends current physics	Formula
		infinite-universe solutions.	resolution follows directly from ρ_s being non-zero.	
22	**Dark matter identification** [Grand result]	Lambda-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.	Dark matter is organised Spaticle field deformation maintained by rotational entrainment. Not a particle. Three independent observational sectors (rotation curves, lensing, GW timing) all converge on the same ρ_s.	

Appendix A. SPARC validation under the DM1 entrainment formula

This appendix reports the complete application of the DM1 density-driven entrainment formula to all 175 galaxies in the SPARC database (Lelli, McGaugh and Schombert 2016). The same table is intended for reuse in other papers that cite the SPARC test (including P25).

A1. Formula (DM1)

Global constants: A = 2500; alpha = 0.5; R_ref = 15 kpc; c0 = 0.02; c1 = 1.0; rs_frac = 0.5; ρ_s = 5.9 x 10^-27 kg m^-3.

Speed factor f(V_char) relative to V_max (highest outer characteristic speed in the sample, approximately 337 km/s):

- 0 to 15 percent of V_max: hard low branch, V1 = 0.15*V_max, f = 0.05*(V/V1)^3
- 15 to 40 percent of V_max: slower rise toward 1
- Above 40 percent of V_max: saturated, f = 1

Radial organisation: xi(R) = c0 + (c1 - c0)*(1 - exp(-R/(rs_frac*R_max))).

Extra mass: M_extra(<R) = 4*pi*ρ_s*A*(M_bar/10^10 M_sun)^alpha*f(V_char)*R_ref^2*R*xi(R).

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): 86.3% (151/175)
- Flat correct: 93.0% (146/157)
- Non-flat correct: 27.8% (5/18)
- Median outer relative residual: 0.252
- Fraction with outer relative residual < 0.20: 35.4%
- Fraction with outer relative residual < 0.25: 49.7%

A3. Second-level note on non-flat failures

Of galaxies observed non-flat but predicted flat, the large majority have a baryonic curve V_bar 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 V_bar itself is flat.

A4. Full galaxy table

Columns: Galaxy; N points; M_bar (solar masses); V_char (km/s); speed band (1=low, 2=mid, 3=high); f; observed flat; predicted flat; shape correct; median outer relative residual.

Galaxy	N	M_bar	V_char	Band	f	ObsF	PredF	Shape	Med|rel|
CamB	9	1.124e+08	15.1	1	0.0013	N	Y	N	0.185
D512-2	4	4.173e+08	36.5	1	0.0188	Y	Y	Y	0.399
D564-8	6	1.000e+08	23.6	1	0.0051	Y	Y	Y	0.548
D631-7	16	6.587e+08	55.5	2	0.5760	Y	Y	Y	0.503
DDO064	14	5.458e+08	45.3	1	0.0358	Y	Y	Y	0.403
DDO154	12	3.906e+08	46.6	1	0.0389	Y	Y	Y	0.602
DDO161	31	2.978e+09	63.6	2	0.6192	Y	Y	Y	0.300
DDO168	10	7.521e+08	53.4	2	0.5646	Y	Y	Y	0.366
DDO170	8	2.423e+09	60.0	2	0.5998	Y	Y	Y	0.318
ESO079-G014	15	6.617e+10	160.8	3	1.0000	Y	Y	Y	0.130

ESO116-G012	15	7.533e+09	108.2	2	0.8574	Y	Y	Y	0.323
ESO444-G084	7	2.907e+08	59.2	2	0.5955	Y	Y	Y	0.571
ESO563-G021	30	3.826e+11	315.6	3	1.0000	Y	Y	Y	0.154
F561-1	6	7.413e+09	50.0	1	0.0482	Y	Y	Y	0.108
F563-1	17	8.113e+09	106.0	2	0.8452	Y	Y	Y	0.479
F563-V1	6	1.740e+09	28.5	1	0.0089	Y	Y	Y	0.053
F563-V2	10	7.286e+09	116.6	2	0.9020	Y	Y	Y	0.415
F565-V2	7	2.218e+09	75.9	2	0.6849	Y	Y	Y	0.475
F567-2	5	3.744e+09	49.3	1	0.0462	Y	Y	Y	0.208
F568-1	12	1.459e+10	128.8	2	0.9672	Y	Y	Y	0.405
F568-3	18	1.638e+10	99.8	2	0.8125	N	Y	N	0.278
F568-V1	15	9.818e+09	112.9	2	0.8821	Y	Y	Y	0.439

F571-8	13	1.157e+10	125.1	2	0.9475	Y	Y	Y	0.298
F571-V1	7	4.853e+09	81.9	2	0.7170	Y	Y	Y	0.355
F574-1	14	1.002e+10	97.0	2	0.7976	Y	Y	Y	0.303
F574-2	5	5.320e+09	35.3	1	0.0170	Y	Y	Y	0.169
F579-V1	14	1.809e+10	112.1	2	0.8782	Y	Y	Y	0.211
F583-1	25	7.018e+09	73.5	2	0.6719	N	N	Y	0.429
F583-4	12	2.714e+09	64.3	2	0.6228	Y	Y	Y	0.244
IC2574	34	3.123e+09	57.4	2	0.5861	N	Y	N	0.254
IC4202	32	2.272e+11	243.8	3	1.0000	Y	Y	Y	0.033
KK98-251	15	3.334e+08	29.8	1	0.0102	N	Y	N	0.339
NGC0024	29	5.306e+09	103.2	2	0.8305	Y	Y	Y	0.282
NGC0055	21	1.078e+10	85.6	2	0.7364	Y	Y	Y	0.183
NGC0100	21	4.647e+09	84.3	2	0.7297	Y	Y	Y	0.309

NGC0247	26	1.212e+10	101.7	2	0.8225	Y	Y	Y	0.243
NGC0289	28	1.196e+11	172.9	3	1.0000	Y	Y	Y	0.243
NGC0300	25	4.694e+09	91.8	2	0.7695	Y	Y	Y	0.374
NGC0801	13	4.104e+11	218.9	3	1.0000	Y	Y	Y	0.092
NGC0891	18	1.596e+11	218.6	3	1.0000	Y	Y	Y	0.123
NGC1003	36	1.676e+10	109.2	2	0.8623	Y	Y	Y	0.388
NGC1090	24	9.806e+10	164.1	3	1.0000	Y	Y	Y	0.064
NGC1705	14	8.129e+08	71.4	2	0.6611	Y	Y	Y	0.543
NGC2366	26	1.218e+09	50.8	2	0.5508	Y	Y	Y	0.293
NGC2403	73	1.797e+10	129.2	2	0.9690	Y	Y	Y	0.295
NGC2683	11	8.388e+10	162.5	3	1.0000	Y	Y	Y	0.131
NGC2841	50	2.604e+11	288.2	3	1.0000	Y	N	N	0.321
NGC2903	34	8.850e+10	187.8	3	1.0000	Y	Y	Y	0.106

NGC2915	30	1.575e+09	82.1	2	0.7178	Y	Y	Y	0.563
NGC2955	24	3.776e+11	261.2	3	1.0000	Y	Y	Y	0.076
NGC2976	27	3.334e+09	71.7	2	0.6622	N	N	Y	0.098
NGC2998	13	2.072e+11	211.7	3	1.0000	Y	Y	Y	0.081
NGC3109	25	8.038e+08	60.4	2	0.6020	Y	Y	Y	0.520
NGC3198	43	6.238e+10	150.4	3	1.0000	Y	Y	Y	0.218
NGC3521	41	9.695e+10	213.9	3	1.0000	Y	N	N	0.236
NGC3726	12	8.641e+10	160.7	3	1.0000	Y	Y	Y	0.167
NGC3741	21	3.175e+08	45.6	1	0.0365	Y	Y	Y	0.681
NGC3769	12	2.749e+10	117.8	2	0.9085	Y	Y	Y	0.260
NGC3877	13	9.744e+10	168.4	3	1.0000	Y	Y	Y	0.261
NGC3893	10	7.181e+10	179.4	3	1.0000	Y	Y	Y	0.103
NGC3917	17	3.048e+10	136.6	3	1.0000	Y	Y	Y	0.095

NGC3949	7	4.318e+10	163.0	3	1.0000	Y	Y	Y	0.161
NGC3953	8	1.796e+11	221.5	3	1.0000	Y	Y	Y	0.158
NGC3972	10	1.915e+10	127.4	2	0.9596	Y	Y	Y	0.085
NGC3992	9	2.661e+11	245.6	3	1.0000	Y	Y	Y	0.149
NGC4010	12	2.258e+10	124.0	2	0.9414	Y	Y	Y	0.080
NGC4013	36	8.566e+10	173.7	3	1.0000	Y	Y	Y	0.164
NGC4051	7	8.538e+10	157.0	3	1.0000	Y	Y	Y	0.281
NGC4068	6	4.906e+08	36.1	1	0.0181	N	Y	N	0.176
NGC4085	7	2.882e+10	131.5	2	0.9814	Y	Y	Y	0.243
NGC4088	12	1.287e+11	170.5	3	1.0000	Y	Y	Y	0.236
NGC4100	24	6.903e+10	171.1	3	1.0000	Y	Y	Y	0.103
NGC4138	7	4.768e+10	151.0	3	1.0000	Y	Y	Y	0.073
NGC4157	17	1.219e+11	184.0	3	1.0000	Y	Y	Y	0.075

NGC4183	23	1.826e+10	110.2	2	0.8681	Y	Y	Y	0.220
NGC4214	14	1.450e+09	80.3	2	0.7085	Y	Y	Y	0.449
NGC4217	19	9.180e+10	184.1	3	1.0000	Y	Y	Y	0.049
NGC4389	6	2.492e+10	96.5	2	0.7946	Y	Y	Y	0.699
NGC4559	32	3.370e+10	122.0	2	0.9308	Y	Y	Y	0.126
NGC5005	18	2.010e+11	263.2	3	1.0000	Y	Y	Y	0.201
NGC5033	22	1.335e+11	204.5	3	1.0000	Y	Y	Y	0.209
NGC5055	28	1.738e+11	183.9	3	1.0000	Y	N	N	0.086
NGC5371	19	3.827e+11	219.8	3	1.0000	Y	Y	Y	0.233
NGC5585	24	5.789e+09	86.1	2	0.7392	Y	Y	Y	0.301
NGC5907	19	2.328e+11	216.4	3	1.0000	Y	Y	Y	0.119
NGC5985	33	2.910e+11	291.0	3	1.0000	Y	Y	Y	0.180
NGC6015	44	4.314e+10	157.6	3	1.0000	Y	Y	Y	0.274

NGC6195	23	4.333e+11	249.6	3	1.0000	Y	Y	Y	0.224
NGC6503	31	1.655e+10	115.7	2	0.8971	Y	Y	Y	0.307
NGC6674	15	2.556e+11	240.2	3	1.0000	Y	Y	Y	0.264
NGC6789	4	1.000e+08	53.5	2	0.5656	N	Y	N	0.509
NGC6946	58	7.728e+10	165.0	3	1.0000	Y	Y	Y	0.032
NGC7331	36	2.860e+11	237.8	3	1.0000	Y	Y	Y	0.069
NGC7793	46	9.950e+09	101.3	2	0.8206	Y	Y	Y	0.096
NGC7814	18	8.003e+10	214.8	3	1.0000	Y	Y	Y	0.208
PGC51017	6	3.476e+08	18.4	1	0.0024	Y	Y	Y	0.153
UGC00128	22	2.794e+10	129.8	2	0.9725	Y	Y	Y	0.378
UGC00191	9	5.006e+09	74.1	2	0.6752	N	N	Y	0.289
UGC00634	4	8.858e+09	107.8	2	0.8548	Y	Y	Y	0.403
UGC00731	12	3.660e+09	72.4	2	0.6664	Y	Y	Y	0.360

UGC00891	5	1.229e+09	59.4	2	0.5966	Y	Y	Y	0.412
UGC01230	11	2.160e+10	106.0	2	0.8454	Y	Y	Y	0.307
UGC01281	25	8.713e+08	49.2	1	0.0459	N	Y	N	0.475
UGC02023	5	1.508e+09	48.1	1	0.0429	N	Y	N	0.162
UGC02259	8	3.380e+09	87.0	2	0.7441	Y	Y	Y	0.376
UGC02455	8	4.819e+09	49.2	1	0.0461	N	Y	N	0.594
UGC02487	17	5.466e+11	337.4	3	1.0000	Y	Y	Y	0.286
UGC02885	19	5.799e+11	293.0	3	1.0000	Y	Y	Y	0.194
UGC02916	43	1.798e+11	210.0	3	1.0000	Y	Y	Y	0.031
UGC02953	115	2.772e+11	287.3	3	1.0000	Y	N	N	0.145
UGC03205	48	1.344e+11	219.6	3	1.0000	Y	N	N	0.083
UGC03546	30	1.097e+11	196.3	3	1.0000	Y	N	N	0.087
UGC03580	47	2.125e+10	109.6	2	0.8647	Y	N	N	0.221

UGC04278	25	4.123e+09	76.8	2	0.6898	N	N	Y	0.347
UGC04305	22	1.878e+09	33.4	1	0.0144	Y	Y	Y	0.175
UGC04325	8	3.799e+09	91.5	2	0.7679	Y	Y	Y	0.303
UGC04483	8	1.000e+08	23.1	1	0.0047	Y	Y	Y	0.394
UGC04499	9	4.068e+09	71.6	2	0.6618	Y	Y	Y	0.248
UGC05005	11	1.456e+10	91.1	2	0.7660	N	Y	N	0.337
UGC05253	73	2.088e+11	240.3	3	1.0000	Y	N	N	0.144
UGC05414	6	1.646e+09	56.7	2	0.5823	Y	Y	Y	0.186
UGC05716	12	2.841e+09	73.1	2	0.6699	Y	Y	Y	0.415
UGC05721	23	1.487e+09	79.4	2	0.7038	Y	Y	Y	0.494
UGC05750	11	1.101e+10	68.2	2	0.6439	N	N	Y	0.225
UGC05764	10	4.293e+08	52.9	2	0.5620	Y	Y	Y	0.480
UGC05829	11	2.580e+09	58.7	2	0.5932	N	Y	N	0.267

UGC05918	8	5.519e+08	42.0	1	0.0286	Y	Y	Y	0.479
UGC05986	15	6.847e+09	113.1	2	0.8834	Y	Y	Y	0.345
UGC05999	5	1.255e+10	96.3	2	0.7937	Y	Y	Y	0.283
UGC06399	9	4.232e+09	83.5	2	0.7256	Y	Y	Y	0.306
UGC06446	17	3.711e+09	82.2	2	0.7186	Y	Y	Y	0.393
UGC06614	13	1.832e+11	196.1	3	1.0000	Y	Y	Y	0.205
UGC06628	7	5.668e+09	42.1	1	0.0287	Y	Y	Y	0.246
UGC06667	9	2.143e+09	82.5	2	0.7203	Y	Y	Y	0.508
UGC06786	45	8.334e+10	222.4	3	1.0000	Y	N	N	0.216
UGC06787	71	1.125e+11	241.1	3	1.0000	Y	N	N	0.186
UGC06818	8	2.669e+09	69.2	2	0.6494	Y	Y	Y	0.280
UGC06917	11	1.213e+10	105.0	2	0.8401	Y	Y	Y	0.215
UGC06923	6	4.369e+09	79.6	2	0.7046	Y	Y	Y	0.134

UGC06930	10	1.650e+10	108.0	2	0.8561	Y	Y	Y	0.185
UGC06973	9	5.837e+10	176.0	3	1.0000	Y	Y	Y	0.168
UGC06983	17	1.169e+10	109.2	2	0.8626	Y	Y	Y	0.311
UGC07089	12	5.894e+09	73.6	2	0.6724	Y	Y	Y	0.137
UGC07125	13	8.128e+09	64.7	2	0.6249	Y	Y	Y	0.094
UGC07151	11	3.951e+09	71.6	2	0.6622	Y	Y	Y	0.156
UGC07232	4	1.437e+08	39.6	1	0.0239	Y	Y	Y	0.293
UGC07261	7	3.286e+09	73.4	2	0.6718	Y	Y	Y	0.260
UGC07323	10	6.130e+09	78.1	2	0.6967	Y	Y	Y	0.073
UGC07399	10	2.305e+09	100.2	2	0.8145	Y	Y	Y	0.505
UGC07524	31	6.618e+09	77.1	2	0.6912	Y	Y	Y	0.256
UGC07559	7	3.000e+08	29.8	1	0.0102	Y	Y	Y	0.300
UGC07577	9	1.000e+08	14.2	1	0.0011	N	Y	N	0.137

UGC07603	12	6.981e+08	61.8	2	0.6094	Y	Y	Y	0.445
UGC07608	8	9.404e+08	63.1	2	0.6165	Y	Y	Y	0.485
UGC07690	7	1.414e+09	57.4	2	0.5861	Y	Y	Y	0.174
UGC07866	7	2.551e+08	29.5	1	0.0099	Y	Y	Y	0.288
UGC08286	17	2.701e+09	82.4	2	0.7198	Y	Y	Y	0.416
UGC08490	30	2.235e+09	78.9	2	0.7008	Y	Y	Y	0.459
UGC08550	11	9.075e+08	55.4	2	0.5756	Y	Y	Y	0.424
UGC08699	41	6.044e+10	183.5	3	1.0000	Y	Y	Y	0.071
UGC08837	8	1.165e+09	43.2	1	0.0311	Y	Y	Y	0.252
UGC09037	22	9.751e+10	154.3	3	1.0000	Y	Y	Y	0.018
UGC09133	68	3.528e+11	245.0	3	1.0000	Y	N	N	0.214
UGC09992	5	7.183e+08	33.6	1	0.0146	Y	Y	Y	0.174
UGC10310	7	3.980e+09	71.4	2	0.6610	Y	Y	Y	0.223

UGC11455	36	4.351e+11	276.4	3	1.0000	Y	Y	Y	0.119
UGC11557	12	1.809e+10	79.1	2	0.7021	Y	Y	Y	0.294
UGC11820	10	5.667e+09	74.3	2	0.6763	N	Y	N	0.321
UGC11914	65	1.519e+11	287.5	3	1.0000	Y	Y	Y	0.104
UGC12506	31	2.368e+11	238.2	3	1.0000	Y	Y	Y	0.240
UGC12632	15	4.216e+09	70.4	2	0.6556	Y	Y	Y	0.308
UGC12732	16	8.601e+09	88.0	2	0.7494	Y	Y	Y	0.347
UGCA281	7	1.000e+08	27.9	1	0.0084	Y	Y	Y	0.293
UGCA442	8	5.789e+08	56.4	2	0.5807	Y	Y	Y	0.490
UGCA444	36	1.330e+08	33.4	1	0.0144	Y	Y	Y	0.502

End of Appendix A. Data source: SPARC (Lelli et al. 2016). Computations: DM1 final constants as in the master entrainment guide (6 August 2026).

Appendix B. KiDS-1000 weak lensing under the DM2 entrainment formula

This appendix reports the application of the DM2 density-driven entrainment formula to the KiDS-1000 stacked weak-lensing rotation-curve equivalents from Brouwer et al. (2021), four stellar-mass bins.

B1. Formula (DM2)

Global constants:

- $A = 38$
- $\alpha = 0.5$
- $R_{ref} = 300$ kpc
- $\rho_s = 5.9 \times 10^{-27}$ kg m^{-3}
- No disk core term and no speed-band factor (stack-scale organisation)

Extra mass:

$$M_{extra}(<R) = 4 \pi \rho_s * A * (M_{gal} / 10^{10} M_{sun})^{\alpha} * R_{ref}^2 * R$$

Predicted equivalent circular speed:

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

M_{gal} 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 rotation-curve style products (four stellar-mass bins). Official survey data products are the observational input; the DM2 constants above are the theoretical side of the comparison.

B3. Results

- Chi-square quality across the four bins lies in the range of approximately 2 to 3.
- One global amplitude A and one mass-scaling exponent alpha serve all four bins; there is no per-bin retuning of the force-law structure.

- Median absolute relative residuals by bin are of order 0.08 to 0.16 in the reductions used for this programme.

These results are the KiDS test under DM2.

B4. Relation to DM1

DM1 (SPARC) and DM2 (KiDS) share the same physical idea: organised Spaticle density producing extra mass that grows with radius. They differ in organisation scale and in which observables are available (resolved disks with V_{bar} and speed bands versus stacked lensing). The numerical constants therefore differ; the structure does not.

Appendix C. Formula reference for this paper

Central anchor: one equilibrium substrate density $\rho_s = 5.9 \times 10^{-27}$ kg m^{-3}. Only standing equations are listed.

C1. Equilibrium density

$$\rho_s = 5.9 \times 10^{-27} \text{ kg m}^{-3}$$

C2. F1-cov (general carrier equation)

F1-cov is the general covariant carrier field equation of the programme. It identifies the Spaticle substrate deformation as the local gravitational carrier. Settled limits recover Newtonian and weak-field behaviour. Rapid changes are limited by a finite, density-dependent relaxation time. F1-cov is not the equation that was integrated to produce the SPARC or KiDS numbers; those use DM1 and DM2.

C3. DDR equation (Deformation Domain Radius)

$$R_d = (3 M / (8 \pi \rho_s))^{1/3}$$

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

C4. Carrier relaxation time

$$\tau_{nat} = 1 / (c \cdot \sqrt{3 \cdot \rho_s}) \text{ approximately } 6.96 \text{ hours}$$

$$L\_nat = c * tau\_nat \text{ approximately } 50 AU$$

These values apply at equilibrium density only. Local relaxation time scales as 1/(c*sqrt(3*rho_local)): denser medium (near mass, inside entrained galaxies, inside deformation domains) settles faster; rarer medium settles slower.

C5. Combined time dilation

$$eta = sqrt(1 - v^2/c^2 - (2 G M /(r c^2)) * f(r, R\_d))$$

$$d\ tau = eta\ dt$$

f(r, R_d) is a cutoff of order 1 inside the domain and of order 0 outside. Clock rates (eta) are a different sector from DM1/DM2 force support.

C6. DM1 (SPARC / organised disks)

Constants: A = 2500; alpha = 0.5; R_ref = 15 kpc; c0 = 0.02; c1 = 1.0; rs_frac = 0.5.

Speed factor f(V_char) relative to sample V_max, with hard low branch, mid rise, and saturation above 40 percent of V_max (V1 = 0.15*V_max on the hard branch).

xi(R) = c0 + (c1 - c0)*(1 - exp(-R/(rs_frac*R_max))).

$$M\_extra(<R) = 4\ pi\ \rho\_s * A * (M\_bar/10^{10} M\_sun)^{alpha} * f(V\_char) * R\_ref^2 * R * xi(R)$$

$$V\_pred^2(R) = V\_bar^2(R) + G * M\_extra(<R) / R$$

Full galaxy-by-galaxy results: Appendix A.

C7. DM2 (KiDS-1000 stacks)

Constants: A = 38; alpha = 0.5; R_ref = 300 kpc.

$$M\_extra(<R) = 4\ pi\ \rho\_s * A * (M\_gal/10^{10} M\_sun)^{alpha} * R\_ref^2 * R$$

$$V\_pred^2(R) = G*M\_gal/R + G*M\_extra(<R)/R$$

Stack results: Appendix B.

C8. Framing

- F1-cov: general carrier layer.
- DDR: domain size.
- DM1, DM2: regime laws for organised galactic and stack scales within the same Spaticle programme; not presented as closed-form integrals of F1-cov.

- eta: clock rates.
- 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 DM1

This appendix records extra-system tests of the DM1 framework 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; extra mass remains negligible (about 0.00 to 0.09 percent) across that range.
- NGC 1052-DF4: negligible extra mass.

D2. Partial or not confirmed under strict checks

- DLA0817g: observed flat at about 272 km/s; multi-radius amplitude not cleanly held to 10-15 kpc with the trial dynamical mass.
- NGC 1277: outer extra-mass fraction at 5 Re can exceed the tightest reported limits (order 8 percent versus order 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 V_char. Lensing stays with the galaxies. This is ordinary collision physics applied to the entrainment rule (carpet / air-curtain picture).

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