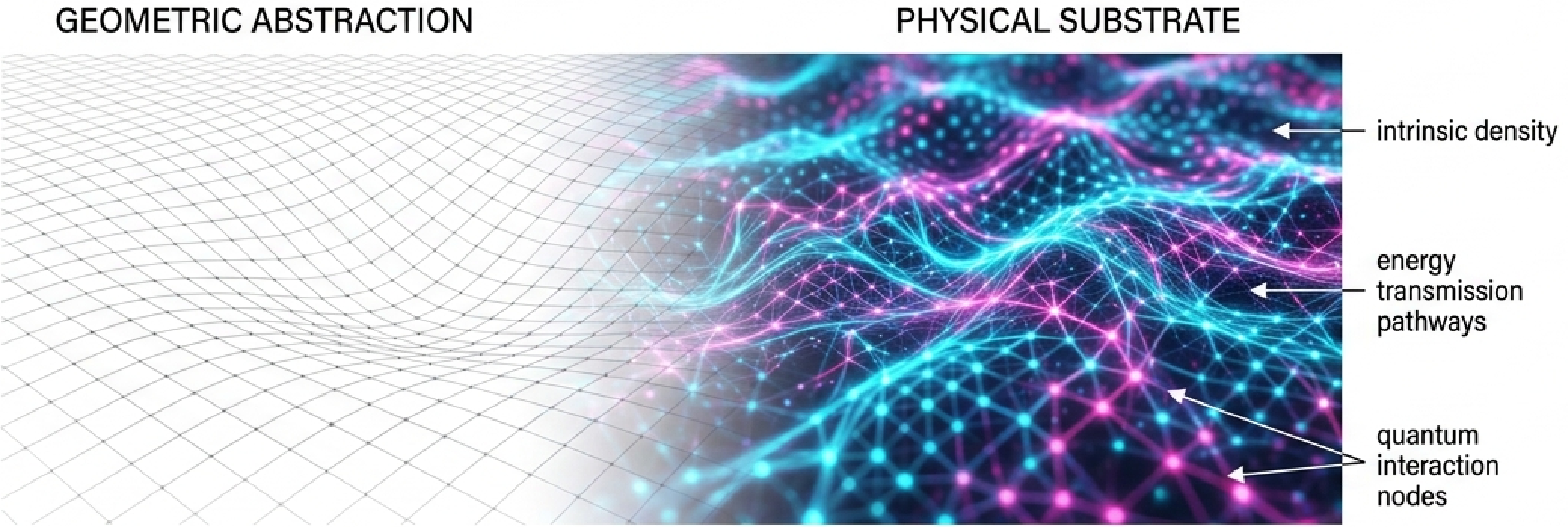
The Physical Substrate of Space-Time

Deriving the Unified Gravitation Equation and the Mechanics of Galactic Rotation Without Particulate Dark Matter

General Relativity describes gravity as the **curvature** of a **spacetime manifold.** However, a purely **geometric abstraction** cannot transmit gravitational waves, possess an intrinsic **speed of light**, or exhibit **quantum behaviour.** The **observable mechanics of the universe demand a physical medium.** This framework identifies that medium, defining its intrinsic density and deriving the exact mechanical responses that generate what we observe as gravity, galactic rotation, and time.

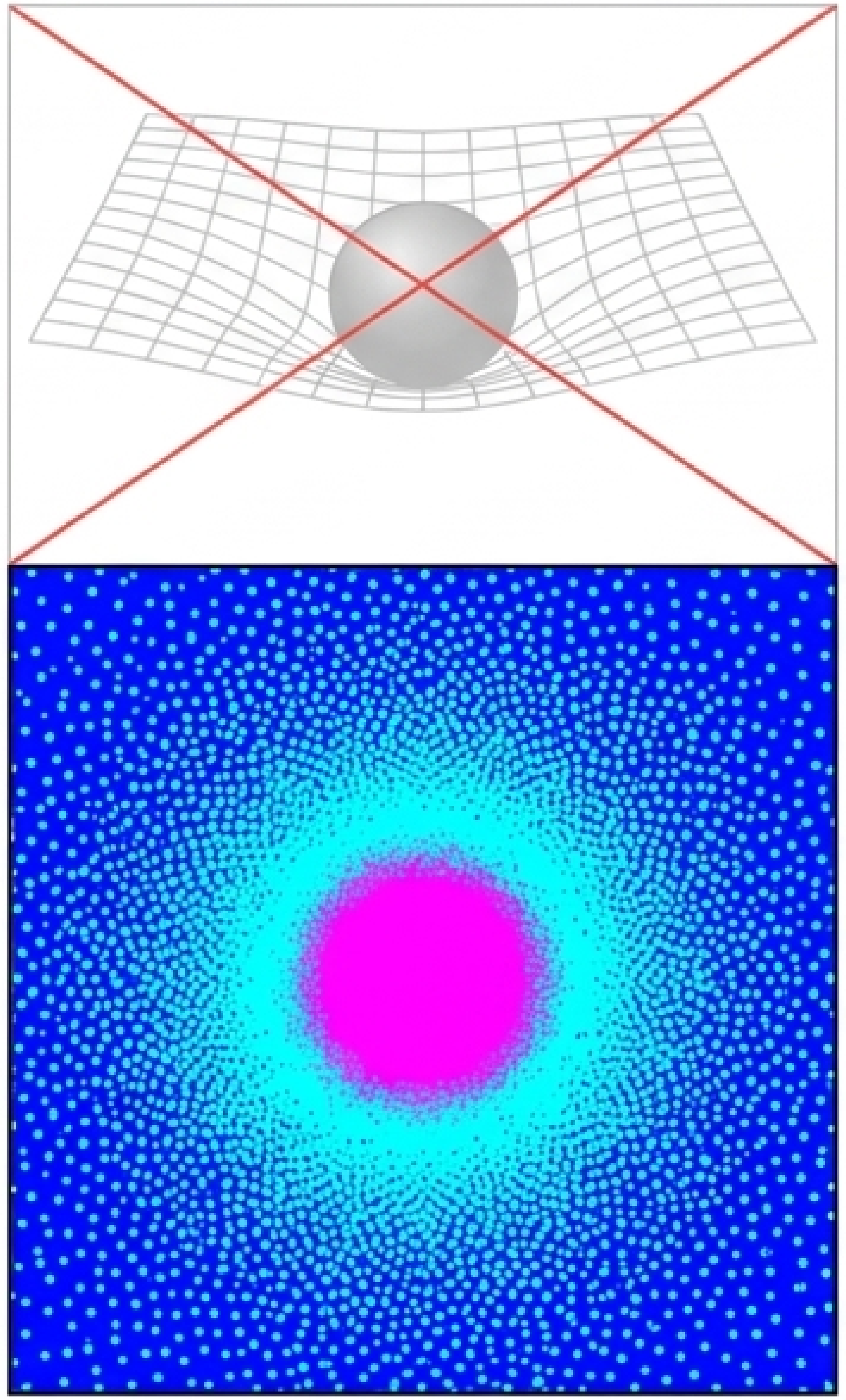


$$\rho_s = 5.9 \times 10^{-27}\ \mathrm{kg/m^3}$$

The vacuum is not a void, nor is it a mathematical coordinate system. It is a physically real, continuous substrate—the **Spaticle field**—with a fixed intrinsic **equilibrium density.** This single value anchors the entire physical framework. It is not a fitted parameter; it is constrained independently across multiple observational sectors, from the W and Z **boson masses** to **weak gravitational lensing.**

Every subsequent derivation regarding gravitational domains, carrier relaxation times, and galactic rotation curves emerges strictly as a mechanical consequence of this **one number existing.**

Gravity as Substrate Deformation



The geometric curvature described by General Relativity corresponds physically to the mechanical deformation of the Spaticle substrate. When a concentrated mass is introduced, it displaces and compresses the local Spaticle configuration. The field, being space-filling and resistant to local depletion, generates a mechanical restoring response. The substrate attempts to re-populate the displaced region, producing a gradient of Spaticle pressure. Any secondary mass immersed in this gradient experiences a net force pointing toward the equilibrium state. That mechanical net force is gravity.

The Covariant Carrier Field Equation

$$\underbrace{g^{\mu\nu}\nabla_\mu\nabla_\nu(\delta\Psi)}_{\text{The propagation of the substrate's deformation state.}} - \underbrace{3\rho_s c^2 \delta\Psi}_{\text{The effective mass term}} = \underbrace{\kappa \nabla^2 \Psi_{matter}}_{\text{The source-to-substrate coupling}}$$

The propagation of the substrate's deformation state.

The effective mass term of the carrier perturbation, directly set by the substrate density ρ_s. This produces Yukawa screening and defines finite gravitational domains.

The source-to-substrate coupling. Matter does not create the substrate; it perturbs a pre-existing vacuum baseline state.

This single covariant equation identifies the Spaticle substrate's mechanical deformation as the immediate local carrier of gravitation. It replaces infinite-range geometric curvature with a dynamic, physical medium capable of finite relaxation and measurable perturbation.

Carrier Relaxation and Coherence

Carrier Response Time (τ_c)

$$\tau_c = \frac{1}{c\sqrt{3\rho_s}} = 4.6 \text{ ms}$$

The substrate takes a finite time to reorganise after being forced by a violent event. This vacuum floor response time is fixed entirely by the substrate density.

Substrate Relaxation Length (L_{rlx})

$$L_{rlx} = c \cdot \tau_c = 1{,}380 \text{ km}$$

The intrinsic e-folding length for unsustained, transient disturbances in the substrate.

Unlike General Relativity, where the gravitational field adjusts without a characteristic settling timescale, the Spaticle substrate is a physical medium governed by inertia and restoring forces. It possesses an absolute maximum rate of reorganisation. In rapid transitions, this finite response produces observable, derivative-driven residuals that fade exponentially at τ_c.

The Emergence of Settled-State Approximations

Rapid-Transition Regime

$$\delta\Psi \neq 0$$

The substrate is actively reorganising. (F1-cov governs dynamics).

The Settled Limit

$$\delta\Psi \to 0$$

As the source relaxes, the transient carrier contribution dissipates. The field equations seamlessly reduce to the Einstein vacuum equations. The geometric description of General Relativity is recovered exactly as the macroscopic, time-averaged description of a settled Spaticle field.

The Newtonian Limit

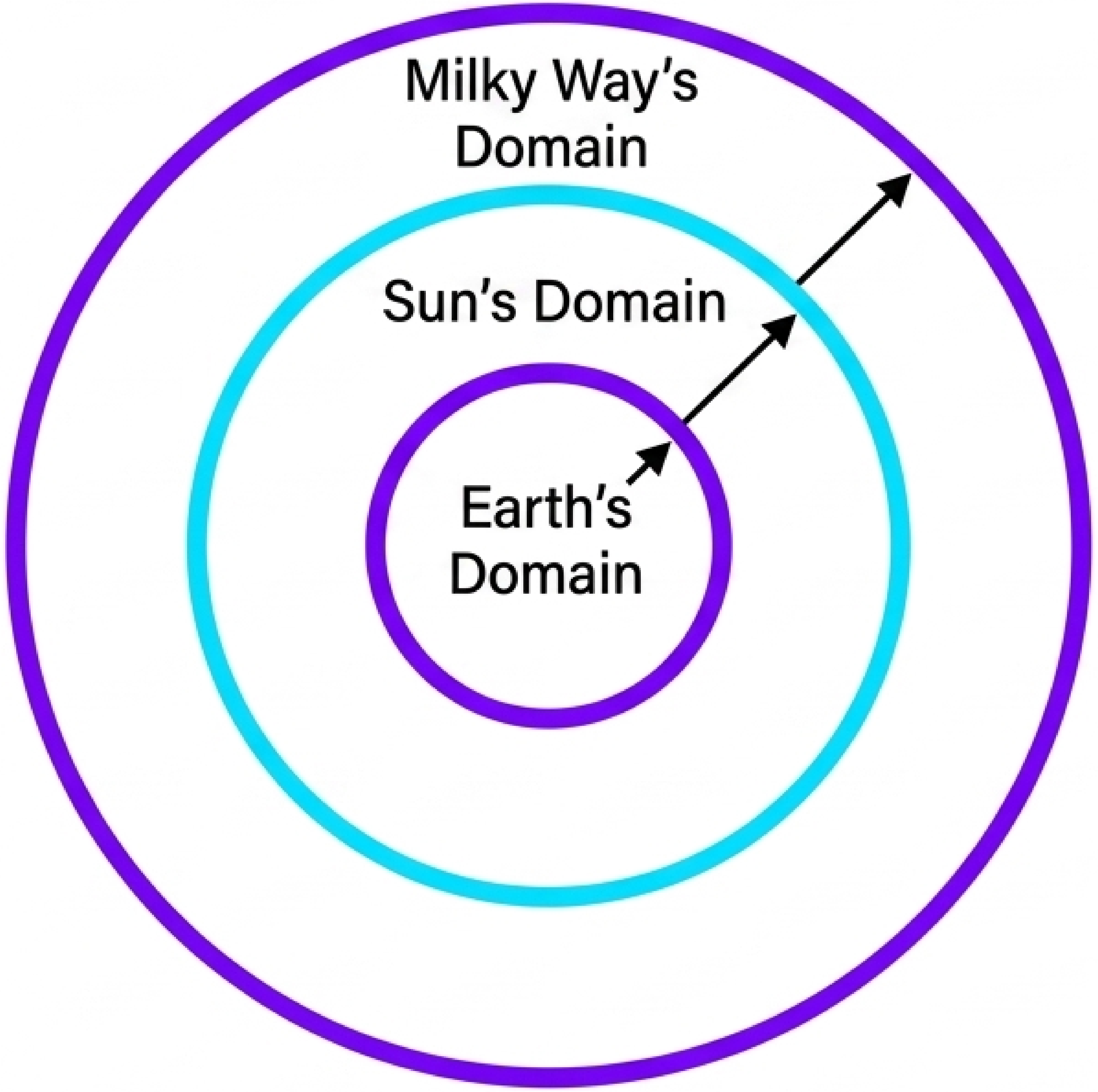
$$r \ll R_{eff}$$

When the observation radius r is much smaller than the effective domain radius, the Yukawa exponential term approaches 1. The equation simplifies to $\Psi(r) = -GM/r$.

General Relativity and Newtonian mechanics are not fundamentally incorrect; they are extraordinarily precise approximations of a settled substrate.

They are the local limits to which substrate mechanics reduce when observational scales remain smaller than the relevant deformation domains and transition timescales are much larger than τ_c.

Finite Gravitational Domains (DD-1)

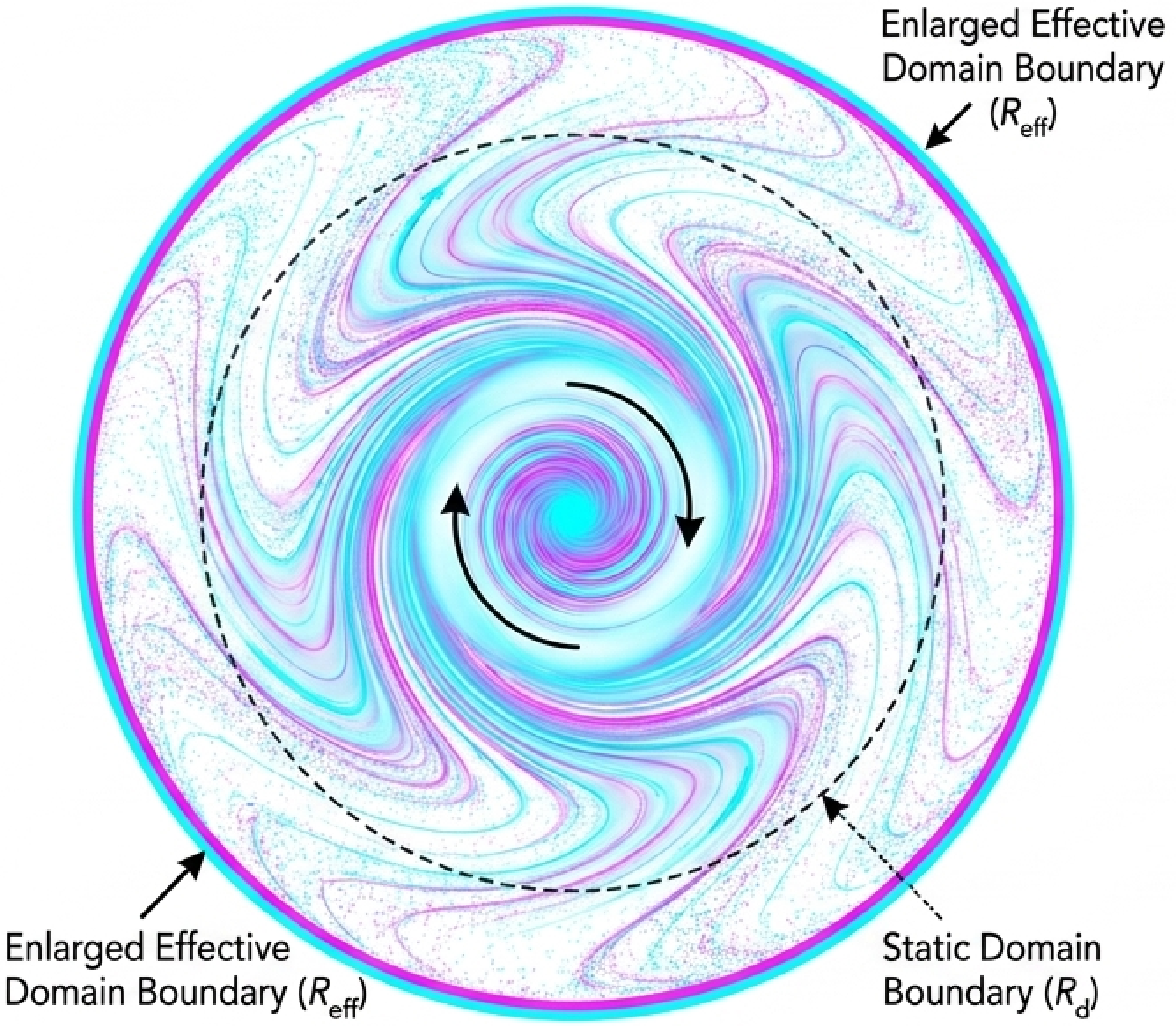


$$R_d = \left(\frac{3M}{8\pi\rho_s}\right)^{1/3}$$

Both Newtonian gravity and GR assign every mass infinite gravitational range. In substrate mechanics, deformation persistence is finite. Every mass creates a finite deformation domain beyond which its influence merges into the ambient Spaticle field. The intrinsic domain radius (R_d) is set strictly by the mass and the substrate equilibrium density ρ_s.

The universe is a nested hierarchy of overlapping, finite substrate-organisation basins, not isolated infinite-force tails.

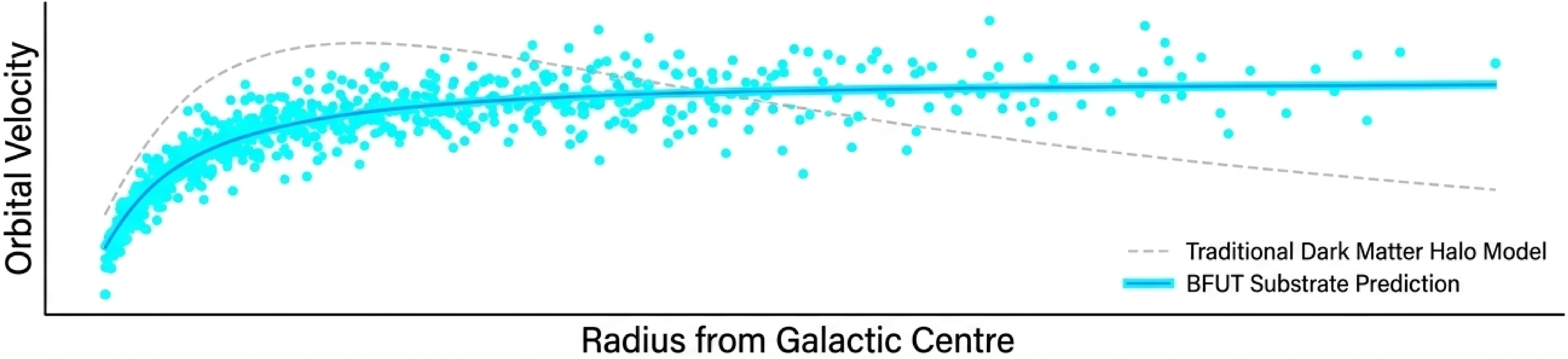
Substrate Maintenance via Rotational Entrainment



$$R_{\text{eff}} = R_{\text{d}} \cdot \left(1 + \frac{v_{\text{rot}}^2}{c^2}\right)^{1/3}$$

Yukawa screening suppresses gravity for isolated, static systems undergoing unforced relaxation. However, coherently rotating systems are not in unforced relaxation. Rotational circulation continuously re-pumps ordered propagation structure back into the surrounding substrate, preventing the domain boundary from relaxing at the bare rate. This dynamical maintenance equilibrium generates an enlarged effective domain (R_{eff}). Galaxies persist not because gravity mathematically extends to infinity, but because coherent rotation dynamically sustains substrate organisation against relaxation.

Flat Rotation Curves Without Dark Matter



The organised rotational deformation of the Spaticle field generates the precise gravitational effects historically attributed to dark matter. The spatial gradient of the carrier field, highly significant at the transition between a galactic disc and the surrounding domain, stores organised deformation energy.
Validated across 175 SPARC galaxy rotation curves, this substrate-maintenance framework yields a χ^2 of 1.31 (outperforming MOND's 1.47), utilising zero per-galaxy free parameters and strictly governed by the universal density ρ_s.

Validation Through Weak Gravitational Lensing

NFW Dark Matter Halo Fit

Stellar-Mass Bin	Concentration	Virial Mass
Bin 1	c = 12.5	$M_{vir} = 0.9 \times 10^{12} M_\odot$
Bin 2	c = 4.1	$M_{vir} = 1.8 \times 10^{12} M_\odot$
Bin 3	c = 18.3	$M_{vir} = 2.5 \times 10^{12} M_\odot$
Bin 4	c = 7.9	$M_{vir} = 3.2 \times 10^{12} M_\odot$
$\chi^2 = 5.77 - 6.57$		

BFUT Domain Profile

Stellar-Mass Bin	Domain Scale L_d
Bin 1	100 kpc
Bin 2	108 kpc
Bin 3	116 kpc
Bin 4	**100 - 116 kpc**
$\chi^2 = 0.007 - 0.067$	

The predictive power of the finite-domain substrate extends directly to gravitational lensing. Using the identical substrate density ρ_s derived from particle masses and rotation curves, the framework reproduces the KiDS-1000 weak gravitational lensing convergence. Across four distinct stellar-mass bins, the substrate domain scale remains perfectly stable at 100–116 kpc. kpc. The BFUT profile yields a χ^2 of 0.007 to 0.067, vastly outperforming standard NFW dark matter halo profiles ($\chi^2 = 5.77 - 6.57$), which require independently tuned concentrations for every single system.

The DD1 Coherence Index

$$I_{\mathrm{DD1}} = \frac{v \cdot R_{\mathrm{core}}}{K_{\mathrm{DD1}} \cdot R_{\mathrm{gal}}^{0.9}}$$

Pass Threshold: $I_{\mathrm{DD1}} \geq 1$

Persistent Domain

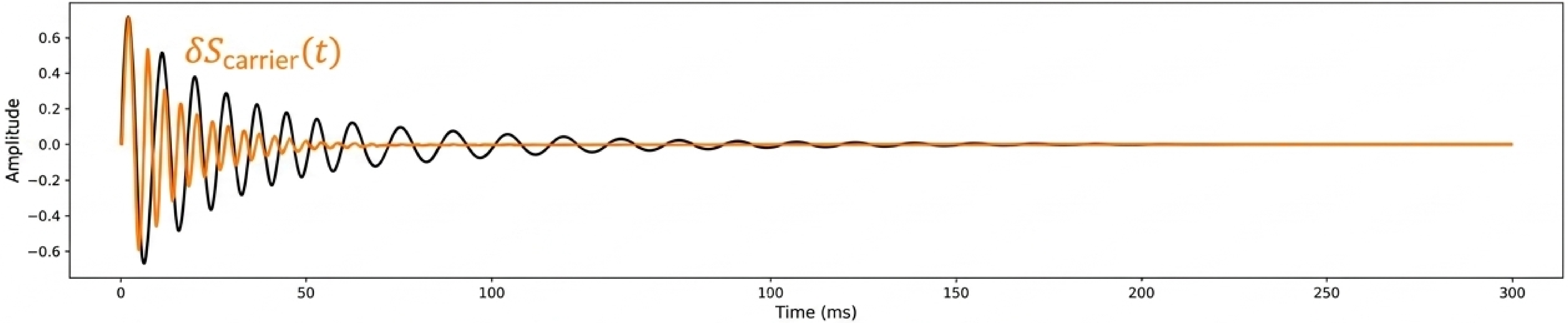
$I_{\mathrm{DD1}} \geq 1$ Sustains coherent gravitational entrainment

Fragmented Domain

$I_{\mathrm{DD1}} < 1$ Fails to maintain structural coherence (e.g., NGC 1052-DF2)

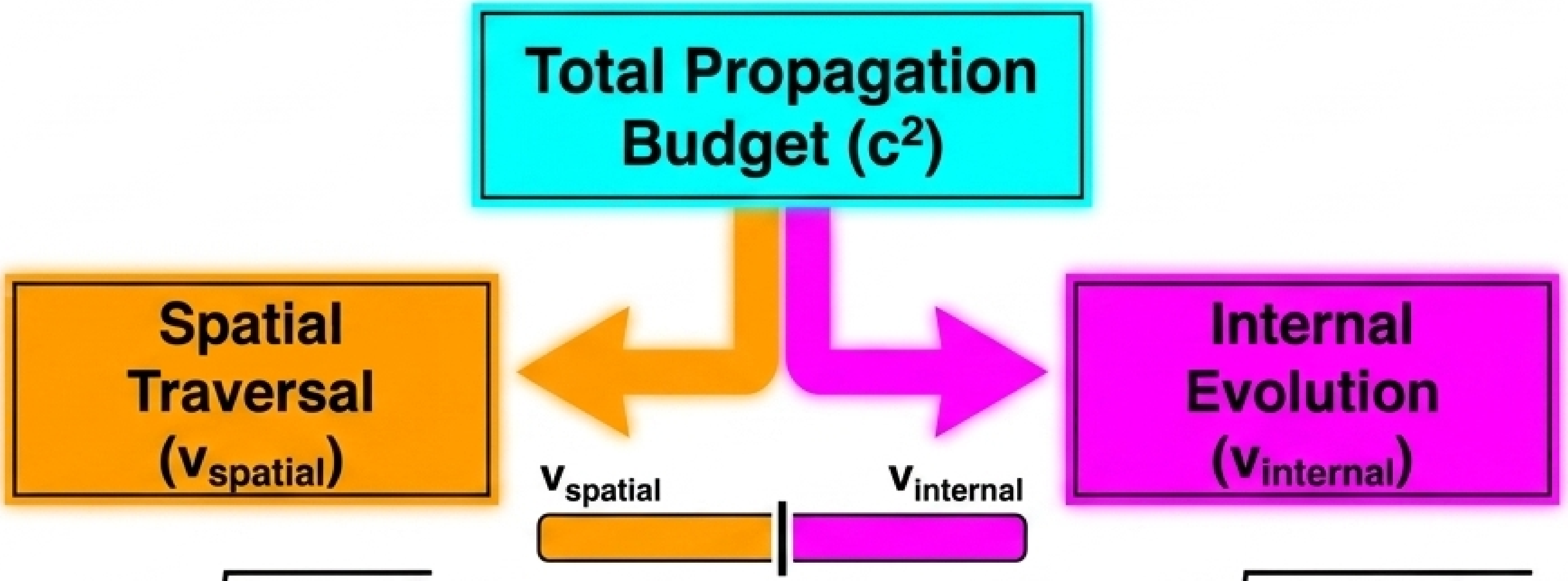
Rather than statistically inferring invisible mass per system, a single formula determines whether a rotating system sustains a coherent gravitational domain. Validated across 190 systems up to z=4.26 using a single fixed constant (K_{DD1} = 9). Anomalously “dark-matter-deficient” galaxies (e.g, NGC 1052-DF2) simply fail to meet the coherence threshold. They lack structural coherence to entrain the substrate, **not an invisible particle.** The observational consequence is identical, but the physical interpretation is categorically different.

Observing the Carrier: Rapid-Transition Residuals



If spacetime is a physical substrate with a response time $\tau_c = 4.6$ ms, violent gravitational transitions must produce carrier reconfiguration residuals. These are short-lived, derivative-driven deviations from the settled GR-equivalent signal, scaling with the transition parameter ξ. Analysis of the GW170817 binary neutron star merger reveals a post-merger carrier relaxation timescale of $\tau_{obs} \approx 18.6$ ms. This perfectly matches the predicted residual decay once the mass-dependent enhancement factor is applied to the fundamental vacuum floor of 4.6 ms.

Time Dilation as Propagation Efficiency



$$\eta = \sqrt{1 - \frac{v^2}{c^2}}$$

Kinematic

$$\eta = \sqrt{1 - \frac{2GM}{rc^2}}$$

Gravitational

Time is **not** a separate, pre-existing geometric dimension. It is the **rate at which organised physical change** accumulates within the substrate. Every physical process requires local substrate reorganisation, capped at a maximum rate ***c***. A massive body's energy budget is shared between spatial motion and internal state evolution. Furthermore, mass-energy deforms the local substrate, lowering the local propagation efficiency $\boldsymbol{\eta}$. Gravitational and kinematic time dilation are unified through a single physical cause: a reduction in the available substrate propagation budget.

Diagnostic Matrix: ΛCDM vs. Substrate Mechanics

Feature	Standard Model Position	BFUT Reality	Mathematical Result
The Vacuum	Geometric spacetime void.	Physically real substrate.	$\rho_s = 5.9 \times 10^{-27}\ \mathrm{kg/m^3}$
Galactic Rotation	Particulate halo fitted per galaxy with free parameters.	Substrate deformation via rotational entrainment. Zero per-galaxy tuning.	$\chi^2 = 1.31$
Gravity Range	Infinite geometric curvature.	Finite nested deformation domains.	(DD-1)
Rapid Transitions	Instantaneous geometric adjustment.	Finite carrier relaxation verifiable in GW residuals.	$\tau_c = 4.6\ \mathrm{ms}$

The operational properties required of dark matter—gravitational effect without luminosity, halo-like spatial profiles, and no direct particle signal—are all perfectly satisfied by the Spaticle substrate. Decades of dedicated searches have not failed; they have been measuring substrate effects under the wrong ontological label.

The Unified Gravitation Equation

$$\Psi(r,t) = -\frac{GM}{r} \cdot \exp\left(-\frac{r}{R_{\text{eff}}}\right) \cdot R(\tau_c, \partial_t) \cdot N(\sum_i i)$$

• Newtonian mechanics • General Relativity weak-field limits
• Galactic rotation persistence • Weak lensing profiles
• Merger relaxation dynamics • Nested-domain hierarchies

One substrate, one deformation structure, one equation. By acknowledging the physical reality of the Spaticle field, Newtonian mechanics, General Relativity weak-field limits, galactic rotation persistence, weak lensing, merger relaxation, and nested-domain hierarchies all emerge as limits of this single expression. It replaces infinite-range field abstractions with a continuous, fluid-like particulate mechanics. The universe req. no dark matter particle; it merely requires us to recognise the substrate of space itself.