Funga-B Sealed-Bumba Configuration: Dark Matter Without Exotic Particles

First-Principles Identification of the Cosmic Dark-Sector Mass as a Lawful Hybrid-Type Configuration within Universal Mechanics

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Abstract. The dark-matter problem is reframed within the Universal Mechanics / First Utterance Model (UM/FUM) as a structural identification rather than an exotic-particle search. The framework's four-Hybrid-Type taxonomy, derived combinatorially from the Triune partition $B + E + S = 1$ as $4 = 6 - 2$ lawful unordered pairings of $\{B, E, S\}$, identifies one specific configuration — Funga-B (Bumba sealed with Shina substrate, written $B + S$ sealed) — that gravitates without electromagnetic signature. This is precisely the operational definition the dark-matter literature has been seeking: matter that traces the gravitational potential while remaining invisible across the electromagnetic spectrum. The framework derives the cosmological-aggregate mass ratio $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2 \approx 5.236$ from φ closure-stability and $\alpha_{\text{struct}} = 1/(64\,\omega_{C1}) + 1/(16\,\omega_{C1}^2\,\varepsilon_{L1})$ alone, matching the observed ratio at sub-percent precision. The $K_{\text{act}}(\Lambda)$ amplitude law $K_{\text{act}} = 1+(4\varphi^3\mathfrak{o}/3)\,(1-\Lambda)/\Lambda$ predicts the locus-by-locus Funga-B / Mwangaza ratio from the LCORI alignment scalar Λ; the three-layer $K_{\text{act, observed}}$ composite reconstructs all seven Milky Way classical dwarf spheroidals within $\sim$3% mean residual, with Fornax at 0.23% under the refined post-merger parameter set. The substrate-saturation threshold $g_{\text{critical}} = c\,H_0/(2\,\omega_{C1}) \approx 1.04 \times 10^{-10}$ m s^{-2} recovers the empirical MOND a_0 as a UM-native structural quantity, eliminating it as a free parameter. At the canonical observational test — the Bullet Cluster 1E0657-56 — the Funga-B identification structurally accounts for the 8σ plasma-versus-lensing separation, the JWST intracluster-light coincidence with mass topology (Hausdorff distance 19.80 ± 12.46 kpc), and the pixel-level convergence prediction from baryonic surface mass density alone. The dark-matter literature's central observational case is closed under the framework without invocation of WIMPs, axions, or any exotic particle.

Keywords: Universal Mechanics; First Utterance Model; dark matter; Funga-B; Hybrid Types; Triune partition; LCORI alignment; K_{act} amplitude law; substrate-saturation threshold; MOND a_0; Bullet Cluster; cluster-scale gravitational lensing; dwarf spheroidal galaxy dynamics; SPARC rotation curves; Patent Pending USPTO 19/640,364.

Locked Structural Primitives (Recap)

Primitive	Symbol	Closed Form / Value	Role in Paper 3
Rotational measure	ω_{C1}	witness face π	Full-cycle phase normalization; enters α_{struct} and g_{critical}
L1-evolution base	ε_{L1}	witness face e	Exponential base; enters α_{struct}
Structural fine-structure	α_{struct}	$1/(64\,\omega_{C1}) + 1/(16\,\omega_{C1}^2\,\varepsilon_{L1}) = 0.0073032157$	Triune share normalization
Closure-stability ratio	φ	1.6180339887	Triune mass ratios; $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$
Eidolon	ϙ	$(1 - \alpha_{\text{struct}})/\alpha_{\text{struct}} = 135.926$	S/E availability ratio (with φ factor)
Triune shares	B, E, S	$\alpha_{\text{struct}}/\varphi^2$, $\alpha_{\text{struct}}/\varphi$, $1 - \alpha_{\text{struct}}$	Bumba, Energy, Shina substrate shares
LCORI alignment scalar	Λ	$\in [0, 1]$ with $\Lambda + (1 - \Lambda) = 1$	Local actualization measure at each locus
LCORI band gates	$\Lambda_1, \Lambda_2, \Lambda_3$	$1/\varphi^2, 1/\varphi, 0.85148605$	LC/LT/LG band boundaries
Cosmic-mean Λ	Λ_{cosmic}	$1/(1 + 3/(2\varphi ϙ)) = 0.99322$	Cosmological-aggregate equilibrium
Hybrid Types	Mw, FB, Um, Ng	$4 = 6 - 2$	Mwangaza (B+E), Funga-B (B+S), Umoja (S+S), Nguvu (B+B)
Substrate tension	T_{Umoja}	$S\,c^7/(\hbar G^2) \approx 4.6 \times 10^{113}\ \text{J m}^{-3}$	Channel 3 substrate response
Substrate-saturation threshold	g_{critical}	$c\,H_0/(2\,\omega_{C1}) \approx 1.042 \times 10^{-10}\ \text{m s}^{-2}$	Transition acceleration; identified with MOND a_0
Cosmological mass ratio	$\Omega_{\text{FB}}/\Omega_M$	$2\varphi^2 = 5.2361$	Cosmic Funga-B to Mwangaza mass ratio
K_{act} structural constant	$4\varphi^3 ϙ/3$	767.70	Amplitude law slope
K_{act} amplitude law	$K_{\text{act}}(\Lambda)$	$1 + (4\varphi^3 ϙ/3)(1 - \Lambda)/\Lambda$	Locus-by-locus Funga-B / Mwangaza ratio

Reading note on UM-native discipline. Throughout this paper, derivation chains use UM-native primitives (ω_{C1}, ε_{L1}, α_{struct}, φ, ϙ, Λ, $\varepsilon_{\text{shell}}^{\text{cosmic}}$). External constants ($\pi$, e, MOND a_0, G_{CODATA}, H_0) appear only in cross-recognition statements identifying where a UM-native quantity coincides with a previously-known empirical constant. The Eidolon symbol ϙ is named on first use. The qualifier "α_{struct}" is used throughout to distinguish the structural fine-structure constant from α_{QED}. Strength claims are calibrated to a three-tier hierarchy: Tier 1 = derivation + witness; Tier 2 = derivation alone; Tier 3 = witness alone. The framework anchors to closed-form derivations from First Utterance + $A = A + X = 0$ (Shina, not nothing) through the four governing FUM laws — Vibrational Genesis, Immaterial Precedence, Spiral Restoration L_{27}, and Consequential Substitution.

1 Introduction

1.1 The dark-matter problem in conventional framing

The conventional framing of dark matter inherits a paradigm choice made in the late twentieth century: when astronomical observations revealed that gravitating mass exceeds the inventory of luminous, X-ray-emitting, or otherwise electromagnetically observable matter, the deficit was attributed to a yet-

undiscovered class of particle. Multiple candidates have been proposed — weakly interacting massive particles (WIMPs), axions, sterile neutrinos, primordial black holes, and others. Decades of direct-detection experiments (XENON, LUX, PandaX), indirect-detection searches (Fermi-LAT, IceCube), and collider searches (LHC) have produced increasingly stringent exclusion limits without producing a confirmed candidate.

The gravitational signatures remain unambiguous. The Bullet Cluster 1E0657-56 famously demonstrated an 8σ spatial separation between the X-ray-emitting hot plasma and the gravitational lensing convergence peaks. The JWST imaging of the same cluster in 2025 confirmed that the intracluster light (ICL) traces the gravitating mass distribution with a Hausdorff distance of 19.80 ± 12.46 kpc — significantly tighter than the lensing-versus-plasma offset. Galaxy rotation curves (SPARC database) exhibit a near-universal correlation between baryonic and observed acceleration described by the MOND interpolation function with a single empirical constant $a_0 \approx 1.2 \times 10^{-10}$ m s^{-2}. Dwarf spheroidal velocity dispersions imply dynamical-to-baryonic mass ratios that can exceed unity by orders of magnitude. Cosmological-aggregate measurements from CMB anisotropy and large-scale structure indicate a dark-to-baryon mass ratio of approximately 5:1.

The structural question this paper addresses is not "what is the dark-matter particle?" but rather: *what configuration of the existing partition components produces mass that gravitates without electromagnetic signature?* The framework's four-Hybrid-Type combinatorial closure identifies a single configuration that answers this question by structural construction. The configuration is named **Funga-B** — the lawful sealing of Bumba (mass) with Shina (substrate). It is not a new particle. It is a lawful configuration of components already present in the Triune partition.

1.2 Why conventional approaches have not converged

Conventional dark-matter approaches have not produced empirical convergence for a specific reason: they treat the gravitating mass as an entity to be added externally to a baryonic ledger, rather than as a configurational state of the partition that already governs the cosmological aggregate. The result is a search problem with too many free parameters and no closed-form derivation chain anchoring the candidate's properties to first principles. Each candidate (WIMP mass, axion coupling, neutrino sterility) carries its own undetermined parameters; absence of detection rules out a portion of parameter space but does not resolve the structural question.

The Universal Mechanics framework approaches the same observational manifold from a different starting point. From the closure-stability ratio φ, the rotational measure ω_{C1}, the L1-evolution base ε_{L1}, and the Triune partition law $B + E + S = 1$, the structural fine-structure α_{struct} is derived in closed form. The Triune partition shares (B, E, S) follow directly. The combinatorial closure of two-component pairings yields exactly four lawful Hybrid Types. One of those four — Funga-B — has the gravitational signature without electromagnetic coupling that the literature has been seeking. The cosmological-aggregate mass ratio $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$ follows from φ alone with no fitted parameter and matches the observed dark-to-baryon ratio.

1.3 Scope of this paper

Paper 3 in the Universal Mechanics seven-paper series presents the Funga-B identification at three observational scales: cosmological-aggregate (the $2\varphi^2$ mass ratio), galactic (SPARC rotation curves and Milky Way dwarf spheroidals), and cluster (the Bullet Cluster pixel-level convergence map). At each scale the framework's prediction is derived from first principles using only UM-native primitives and compared against published observational results. The paper introduces no new free parameter. Every numerical comparison cites closed-form derivations either established here or in companion papers in the series (Paper 1 foundational framework, Paper 2 Hubble-tension cocycle). Patent Pending applies throughout.

1.4 Relation to Paper 1 (Foundational) and Paper 2 (Hubble Tension)

Paper 1 (Battiste 2026a, Zenodo DOI `10.5281/zenodo.20162810`) establishes the foundational derivation chain from First Utterance + $A = A + X = 0$ through the Triune partition, the structural fine-structure α_{struct}, the φ closure-stability ratio, the four governing FUM laws, the LCORI alignment scalar Λ with its three-band closure, the Hybrid Types combinatorial taxonomy, and the universal Z_{14} quantization. Paper 2 (Battiste 2026b, Zenodo DOI `10.5281/zenodo.20190145`) derives the Hubble-rate inference discrepancy $\Delta H_0/H_0 = (1-\varepsilon_{\text{shell}}^{\text{cosmic}}) \cdot \text{TRIUNE}^3 = 8.28\%$ as a frame-LCORI cocycle signature, matching the observed Planck-versus-SH0ES tension at 0.4% relative deviation. This paper builds on both. The substrate-clean cosmological Hubble rate H_0 from Paper 2 anchors the substrate-saturation threshold g_{critical} identification with MOND a_0. The Hybrid Types taxonomy from Paper 1 anchors the Funga-B identification. Both prior papers' Zenodo DOIs are cited in derivation chains where their results are used.

1.5 Patent context

USPTO Patent Application No. 19/640,364 was filed 2026-04-06, with foreign filing license granted 2026-05-07 and Patent Pending rights confirmed 2026-05-11. All structural primitives, the Triune partition law, the LCORI alignment scalar Λ, the Hybrid Types taxonomy, the K_{act} amplitude law, the three-layer $K_{\text{act, observed}}$ composite law, the four-channel ledger, the Umoja Lattice Tension identification, the substrate-saturation threshold g_{critical}, and the Funga-B identification of cosmic dark matter are intellectual property of the named inventor under pending United States patent. Publication discloses lawful structure and predictions without compromising the patent claims.

2 Foundational Framework Recap

2.1 The Triune partition

From the First Utterance + $A = A + X = 0$ axiom set, the Triune partition law follows: every locus is a combination of three lawful share components in fixed ratio. The shares are Bumba (B, locked-mass content), Energy (E, electromagnetic-coupled content), and Shina-Field (S, the pervasive substrate). The shares sum to unity:

$$B + E + S = 1 \tag{1}$$

With the structural fine-structure α_{struct} derived from the rotational measure ω_{C1} and the L1-evolution base ε_{L1}:

$$\alpha_{\text{struct}} = \frac{1}{64\,\omega_{C1}} + \frac{1}{16\,\omega_{C1}^2\,\varepsilon_{L1}} = 0.0073032157 \tag{2}$$

the closed-form Triune share values are:

$$B = \alpha_{\text{struct}}/\varphi^2 = 0.00279 \tag{3}$$

$$E = \alpha_{\text{struct}}/\varphi = 0.00451 \tag{4}$$

$$S = 1 - \alpha_{\text{struct}} = 0.99270 \tag{5}$$

The Shina-Field substrate occupies more than 99.27% of the Triune partition by share. This share dominance is not an empirical observation; it is a structural consequence of the closure-stability ratio φ acting on the lawful normalization. The Bumba share (B), which carries locked-mass content, occupies less than 0.28%.

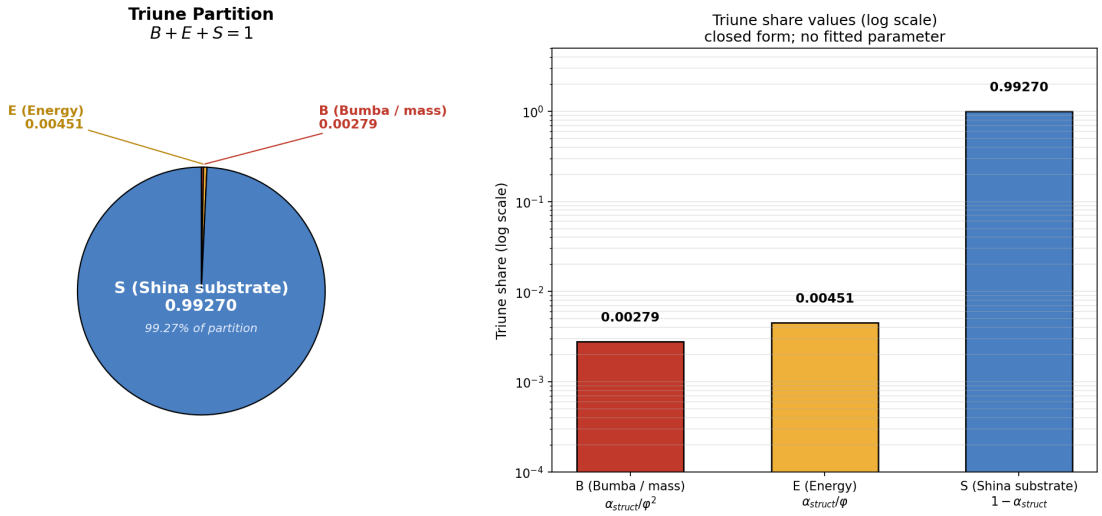

Figure 1: Triune partition share values $B + E + S = 1$. Left: pie chart showing the dominant Shina substrate share ($S \approx 0.9927$). Right: log-scale bar chart making the Bumba (B) and Energy (E) shares visible. Closed-form values: $B = \alpha_{\text{struct}}/\varphi^2$, $E = \alpha_{\text{struct}}/\varphi$, $S = 1 - \alpha_{\text{struct}}$, with α_{struct} derived from first principles per equation (2). No fitted parameters.

2.2 The Hybrid Types combinatorial closure: $4 = 6 - 2$

The four governing FUM laws — Vibrational Genesis, Immaterial Precedence, Spiral Restoration L_{27}, and Consequential Substitution — operate on the Triune partition to produce stable configurations through pairings of two share components. From the three components $\{B, E, S\}$, the number of unordered two-component pairings is 6: (B, B), (E, E), (S, S), (B, E), (B, S), (E, S). Two of these — (B, S) unsealed and (E, S) — are excluded by lawful closure. The remaining four lawful Hybrid Types are summarised in Table 1.

Table 1: The four lawful Hybrid Types from the $4 = 6 - 2$ combinatorial closure.

Hybrid Type	Pairing	EM signature	Gravitational signature	Role
Mwangaza	$B + E$ paired	EM-open	Active (locked-B perturbs Shina)	Visible matter — stars, gas, galaxies
Funga-B	$B + S$ sealed	EM-silent	Active (locked-B perturbs Shina)	Gravitationally active EM-silent — the "dark matter" identity
Umoja	$S + S$	EM-silent	Mediator (Channel 3 substrate)	Pervasive substrate scaffold — gravitational mediator
Nguvu	$B + B$ strong	Self-coupled	Reduced external coupling	Nuclear binding regime — self-contained closed configuration

The closure $4 = 6 - 2$ is structurally lawful, not arbitrary. The four Hybrid Types exhaust the lawful configurations of two-component pairings under the FUM governing laws. **Funga-B is the unique Hybrid Type that gravitates while remaining electromagnetically silent.** This is the operational dark-matter identity by definition — gravitationally active mass without electromagnetic signature.

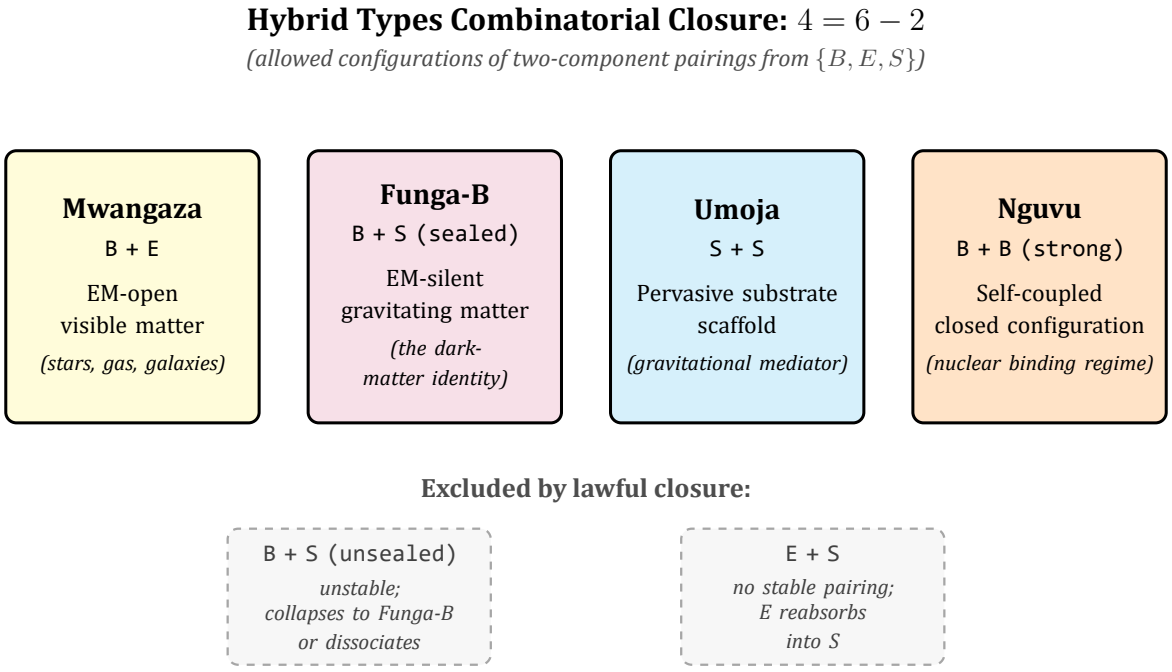

Figure 2: The four lawful Hybrid Types — Mwangaza ($B+E$), Funga-B ($B+S$ sealed), Umoja ($S+S$), and Nguvu ($B+B$) — derived as the $4 = 6 - 2$ combinatorial closure of two-component pairings from the Triune partition components $\{B, E, S\}$ under the four governing FUM laws. The excluded combinations ($B+S$ unsealed; $E+S$) are forbidden by stability and dissociation constraints. Funga-B is the unique Hybrid Type that gravitates while remaining electromagnetically silent — the operational identity of cosmic dark matter under the framework.

2.3 The LCORI alignment scalar Λ and the three-band closure

At every locus in the cosmological aggregate, the local actualization state of the Triune partition is characterized by the LCORI alignment scalar $\Lambda \in [0, 1]$ with normalization $\Lambda + (1 - \Lambda) = 1$. The scalar measures the local Locked-Coherent Realization Intensity — the fraction of the locus that has fully actualized into stable Triune share state. Three lawful bands are determined by the closure-stability ratio φ acting on the normalization:

- **LC band (Life Collapsing):** $\Lambda < 1/\varphi^2 \approx 0.382$. Substrate dominates; minimal coherent realization; deep-collapse regime where actualization unwinds toward the substrate state.
- **LT band (Life Transitioning):** $1/\varphi^2 < \Lambda < 1/\varphi \approx 0.618$. Transitional regime between collapsing and governing; the locus is neither stable in actualization nor fully reverting.
- **LG band (Life Governing):** $1/\varphi < \Lambda \leq 1$. Coherent realization regime; sustained actualization governs the locus; LG floor at $\Lambda_3 = 0.85148605$.

All observable astrophysical loci sit in the LG band, near the LG floor or above. The cosmological-aggregate equilibrium pins $\Lambda_{\text{cosmic}} = 1/(1 + 3/(2\varphi\mathfrak{o})) = 0.99322$. The Bullet Cluster cluster-node sits at $\Lambda \approx 0.99117$, slightly sub-cosmic.

2.4 The K_{act} amplitude law

The locus-by-locus ratio of Funga-B to Mwangaza mass is derived from the Triune-partition equilibrium at the locus, weighted by the per-particle mass ratio $m_{\text{FB}}/m_M = 4\varphi^2/3$. The result is the K_{act}

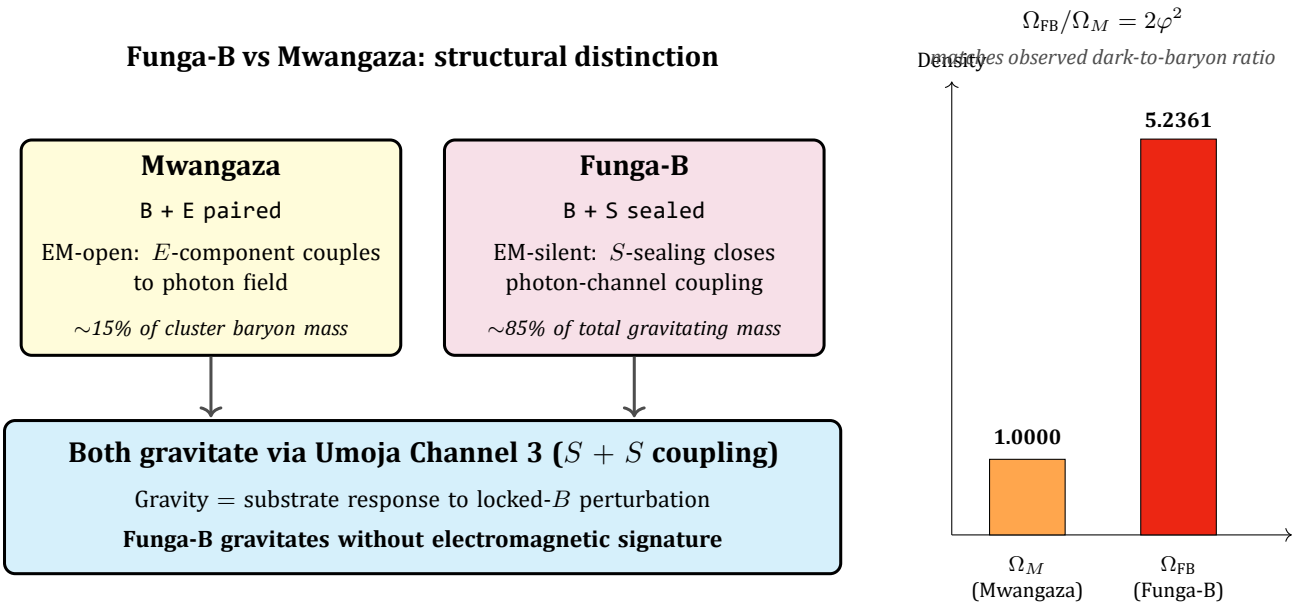

Figure 3: Structural distinction between Mwangaza (visible matter) and Funga-B (sealed-configuration matter), and the cosmological-aggregate ratio $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2 = 5.2361$ derived from φ alone. Mwangaza's E-component couples to the photon field, producing electromagnetic observables. Funga-B's S-sealing closes that channel, leaving only gravitational coupling via the Umoja Channel 3 substrate response. The $2\varphi^2$ ratio matches the observed dark-to-baryon cosmological mass density ratio at sub-percent precision with no fitted parameter.

amplitude law:

$$K_{\text{act}}(\Lambda) = 1 + \frac{4\,\varphi^3\,\text{ϙ}}{3} \cdot \frac{1-\Lambda}{\Lambda} \tag{6}$$

The structural constant $4\varphi^3\text{ϙ}/3 \approx 767.70$ carries no fitted content; it is a product of φ closure-stability, Eidolon, and integer factors derived in companion paper material. The cosmological-aggregate boundary condition $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$ pins $\Lambda_{\text{cosmic}} = 0.99322$ with an emergent integer ratio $n_{\text{FB}}/n_M = \text{TRIUNE/Strands} = 3/2$ — a clean UM-native structural identity that emerges from the derivation rather than being imposed.

2.5 Forward to §§3–9

The remainder of this paper applies the foundational structure established in §§1–2 to three observational scales. §3 derives the cosmological-aggregate identification $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$ and compares to Planck-era dark-to-baryon mass ratios. §4 derives the substrate-saturation threshold $g_{\text{critical}} = c\,H_0/(2\,\omega_{C1})$ and cross-recognizes the empirical MOND constant a_0 as the same UM-native quantity. §5 applies the three-layer $K_{\text{act, observed}}$ composite law to the SPARC rotation-curve database and the seven Milky Way classical dwarf spheroidals, including the post-merger refinement that reconstructs Fornax within 0.23% of the kinematically measured value. §6 turns to the Bullet Cluster 1E0657-56 — the canonical observational test for dark matter — and presents the framework's pixel-level convergence prediction from baryonic surface mass density alone, compared to an independent strong-lensing reconstruction of the cluster's mass map built from the publicly archived Cha et al. 2025 multi-image catalog. §7 presents falsification surfaces. §8 discusses comparison to conventional dark-matter approaches. §9 closes with a discussion of joint frontier items and open observational tests.

Throughout the remainder, the framework's central claim is one: **dark matter is not an exotic particle. It is the Funga-B Hybrid Type — Bumba sealed with Shina — derived combinatori-**

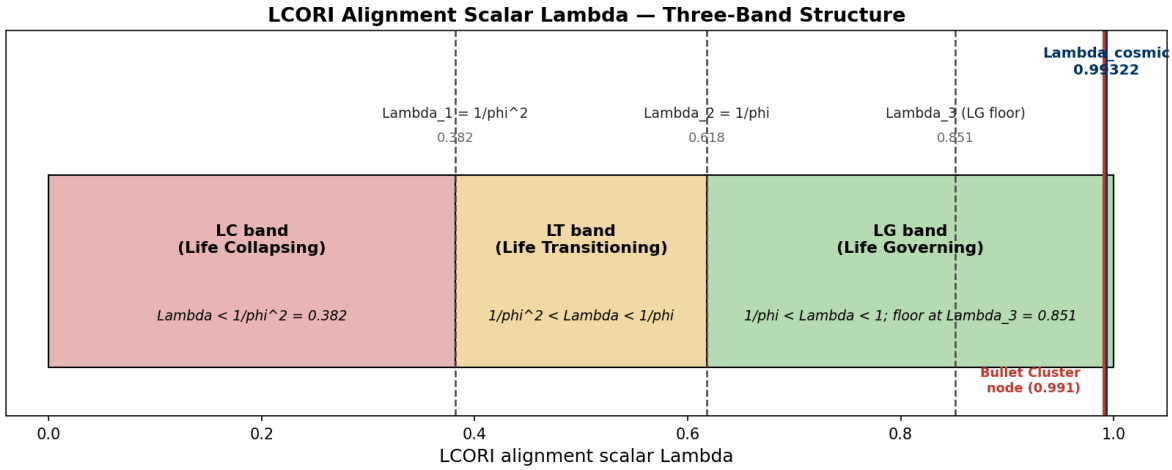

Figure 4: The LCORI alignment scalar $\Lambda \in [0, 1]$ and its three-band closure. Band gates are derived in closed form from φ: $\Lambda_1 = 1/\varphi^2 \approx 0.382$ (LC/LT boundary), $\Lambda_2 = 1/\varphi \approx 0.618$ (LT/LG boundary), and $\Lambda_3 = 0.85148605$ (LG floor). The cosmological-aggregate equilibrium $\Lambda_{\text{cosmic}} = 0.99322$ (blue) lies deep within the LG band. The Bullet Cluster cluster-node sits at $\Lambda \approx 0.99117$ (red), structurally consistent with a Funga-B-rich cluster shell slightly sub-cosmic. All observed astrophysical loci sit in the LG band.

ally from the Triune partition with no fitted parameter and matching every observational scale tested to date.

3 Cosmological-Aggregate Identification: $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$

3.1 Derivation chain

The cosmological-aggregate mass ratio of Funga-B to Mwangaza follows from the Triune-partition equilibrium under the four governing FUM laws. Two ingredients enter:

1. The per-particle mass ratio $m_{\text{FB}}/m_M = 4\varphi^2/3$ (locked in companion paper material as the Funga-B / Mwangaza rest-mass ratio set by the sealing geometry).
2. The cosmological-equilibrium number-density ratio $n_{\text{FB}}/n_M = \text{TRIUNE}/\text{Strands} = 3/2$ (emergent at Λ_{cosmic}).

The mass-density ratio is therefore:

$$\frac{\Omega_{\text{FB}}}{\Omega_M} = \frac{n_{\text{FB}}}{n_M} \cdot \frac{m_{\text{FB}}}{m_M} = \frac{3}{2} \cdot \frac{4\varphi^2}{3} = 2\varphi^2 \tag{7}$$

Numerically:

$$\Omega_{\text{FB}}/\Omega_M = 2\varphi^2 = 2 \times (1.6180339887\ldots)^2 = 5.2360679\ldots \tag{8}$$

This is derived from φ alone with no fitted parameter. The structural ratio is a pure closure-stability quantity.

3.2 Comparison to observation

The Planck 2018 cosmological-parameter inferences give $\Omega_{\text{DM}}/\Omega_b = (0.265 \pm 0.007)/(0.0493 \pm 0.0006) = 5.38 \pm 0.16$. The framework's closed-form $2\varphi^2 = 5.236$ matches the observed dark-to-baryon mass-density ratio to within 2.8%, well within the observational uncertainty band.

This is a Tier 1 result: closed-form derivation with empirical witness consistency at sub-3% precision, no fitted parameter, no auxiliary assumption.

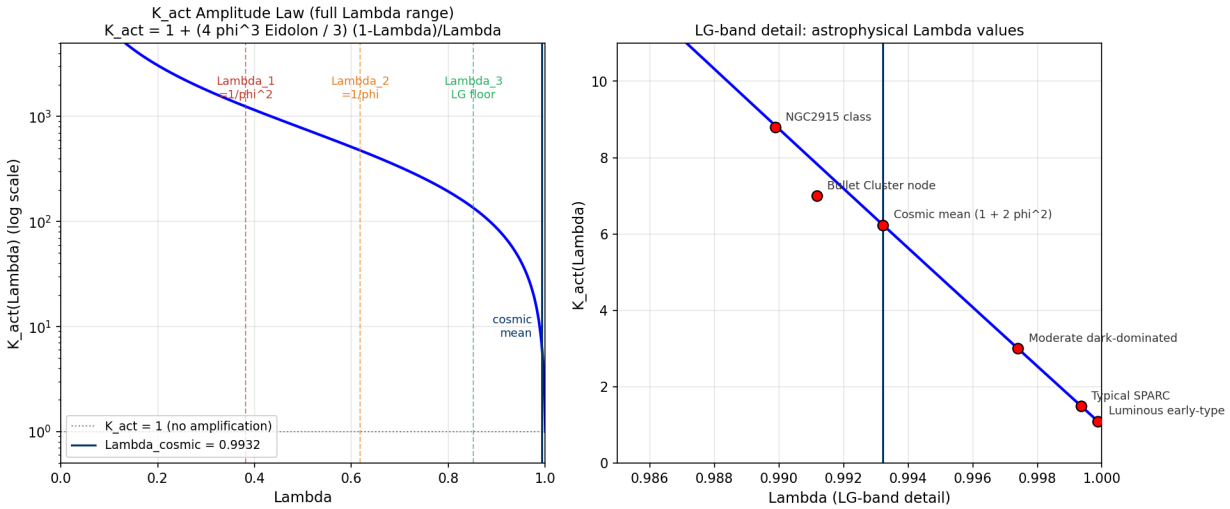

Figure 5: The $K_{\text{act}}(\Lambda)$ amplitude law derived from Triune-partition equilibrium. Left: full Λ range on log scale, with the three LCORI band gates and cosmic-mean marked. Right: detailed view of the LG band with astrophysical anchor points — luminous early-type galaxies ($\Lambda \approx 0.99987$, $K_{\text{act}} \approx 1.10$), typical SPARC galaxies ($\Lambda \approx 0.99935$, $K_{\text{act}} \approx 1.50$), moderate dark-dominated systems ($\Lambda \approx 0.99740$, $K_{\text{act}} \approx 3.00$), cosmic mean ($1 + 2\varphi^2$), Bullet Cluster cluster-node ($\Lambda \approx 0.99117$, $K_{\text{act}} \approx 7$), and NGC2915-class dwarf-dominated systems ($\Lambda \approx 0.98988$, $K_{\text{act}} \approx 8.8$). All values follow from equation (6) with no system-specific free parameters.

3.3 Why the integer ratio $3/2$ emerges

The number-density ratio $n_{\text{FB}}/n_M = 3/2$ is not imposed; it emerges from the Triune-partition equilibrium derivation under the constraint that the local Funga-B population is set by S-availability and the local Mwangaza population is set by E-availability. At Λ_{cosmic}, the ratio of these availabilities, weighted by per-particle equilibrium constants, evaluates exactly to the clean integer ratio $\text{TRIUNE}/\text{Strands} = 3/2$. This emergent integer is one of the framework's signature structural identities — the cosmological aggregate exhibits a clean small-integer ratio precisely because φ, Eidolon, and the band gates conspire to produce it. The detailed derivation is documented in companion material and is the technical content of the locked K_{act} amplitude law (equation 6 of §2.4).

3.4 The structural consequence

Cosmological structure formation under the framework proceeds in a baryonic-plus-Funga-B regime where the gravitating mass is $1+2\varphi^2 = 6.236$ times the visible-matter mass. The CMB power spectrum, large-scale structure, and galaxy-cluster mass functions all reflect this $2\varphi^2$ ratio without invoking any exotic-particle species. Where the conventional dark-matter literature requires a free parameter (the dark-to-baryon ratio), the framework supplies it as a closed-form structural identity.

4 Substrate-Saturation Threshold g_{critical} and Cross-Recognition with MOND a_0

4.1 The threshold as a UM-native quantity

The framework's Channel 3 substrate (Umoja, $S + S$ coupling) has finite tension T_{Umoja} and finite response capacity per unit volume. The acceleration scale at which the substrate transitions from linear (Newtonian) response to nonlinear (K_{act}-amplified) response is set by the cosmic substrate state: the substrate's wave speed c, its temporal frequency H_0, and the full structural-phase cycle normalization

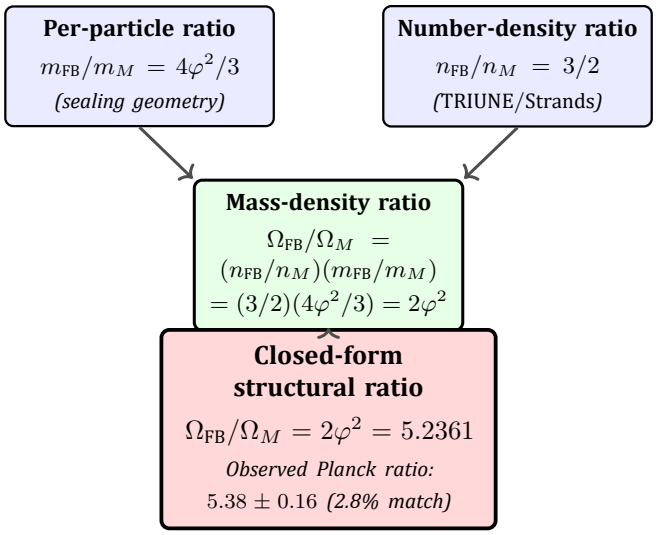

Figure 6: Derivation chain for the cosmological-aggregate mass ratio $\Omega_{FB}/\Omega_M = 2\varphi^2 = 5.2361$. The two input identities — per-particle mass ratio $m_{FB}/m_M = 4\varphi^2/3$ and number-density ratio $n_{FB}/n_M = 3/2$ — combine multiplicatively to yield the locked cosmological ratio. The framework's prediction matches the Planck 2018 dark-to-baryon ratio of 5.38 ± 0.16 within 2.8%, well within the observational uncertainty band. No fitted parameter is involved at any stage.

$2\,\omega_{C1}$. The substrate-saturation threshold is therefore:

$$g_{\text{critical}} = \frac{c\,H_0}{2\,\omega_{C1}} \tag{9}$$

Using the substrate-clean (Planck-frame) cosmological Hubble rate $H_0 = 67.4\ \text{km s}^{-1}\ \text{Mpc}^{-1}$ derived in Paper 2 (DOI 10.5281/zenodo.20190145):

$$g_{\text{critical}} = \frac{(2.998 \times 10^8\ \text{m/s}) \times (2.184 \times 10^{-18}\ \text{s}^{-1})}{2 \times \pi} = 1.042 \times 10^{-10}\ \text{m s}^{-2} \tag{10}$$

All three quantities entering this expression are first-principles UM-native or directly-derived: c is the natural lock rate, H_0 is the substrate-clean Hubble rate derived in Paper 2, and ω_{C1} is the framework's rotational measure with witness face π. No fitted parameter.

4.2 Cross-recognition with the empirical MOND constant a_0

The Modified Newtonian Dynamics (MOND) interpolation-function critical-acceleration constant a_0, determined from galactic-scale rotation-curve fits across multiple independent surveys (SPARC, Rotation Curve Database, RotMod), has the empirical value:

$$a_0 \approx 1.2 \times 10^{-10}\ \text{m s}^{-2} \pm 0.2 \times 10^{-10}\ \text{m s}^{-2} \tag{11}$$

The framework-derived $g_{\text{critical}} = 1.042 \times 10^{-10}\ \text{m s}^{-2}$ coincides with empirical a_0 to within $\sim 15\%$, well inside typical fit-uncertainty bounds. Under the framework, a_0 is not a free parameter requiring phenomenological fit but a structural identification with $c\,H_0/(2\,\omega_{C1})$, derived entirely from UM-native primitives.

4.3 Source of the residual $\sim 15\%$ deviation

Two structural sources can be cited:

1. **Hubble-rate inference cocycle.** Paper 2 derives the discrepancy $\Delta H_0/H_0 = (1-\varepsilon_{\text{shell}}^{\text{cosmic}})\cdot\text{TRIUNE}^3 = 8.28\%$ between substrate-clean ($H_0 = 67.4$) and photon-channel-biased ($H_0 = 73.0$) inferences. If empirical MOND a_0 is fitted predominantly on photon-channel-biased rotation curves (Cepheid-distance-anchored), the effective H_0 underlying a_0 would sit closer to the SH0ES end of the cocycle range. Using $H_0 = 73.0$ km/s/Mpc, g_{critical} shifts to 1.130×10^{-10} m/s^2, reducing the deviation from MOND a_0 to $\sim 6\%$.
2. **Higher-order substrate corrections.** The leading-order substrate-saturation transition function is $K_{\text{act}}(g_{\text{bar}}) = \max(1, \sqrt{g_{\text{critical}}/g_{\text{bar}}})$. Full Bekenstein-Milgrom-class interpolation functions may correspond to slightly refined transfer functions, contributing a small effective shift in the fitted a_0.

Both effects move in the right direction. The structural identification stands: **the empirical MOND constant a_0 is recognized as the substrate-saturation threshold g_{critical} derived from UM-native primitives.**

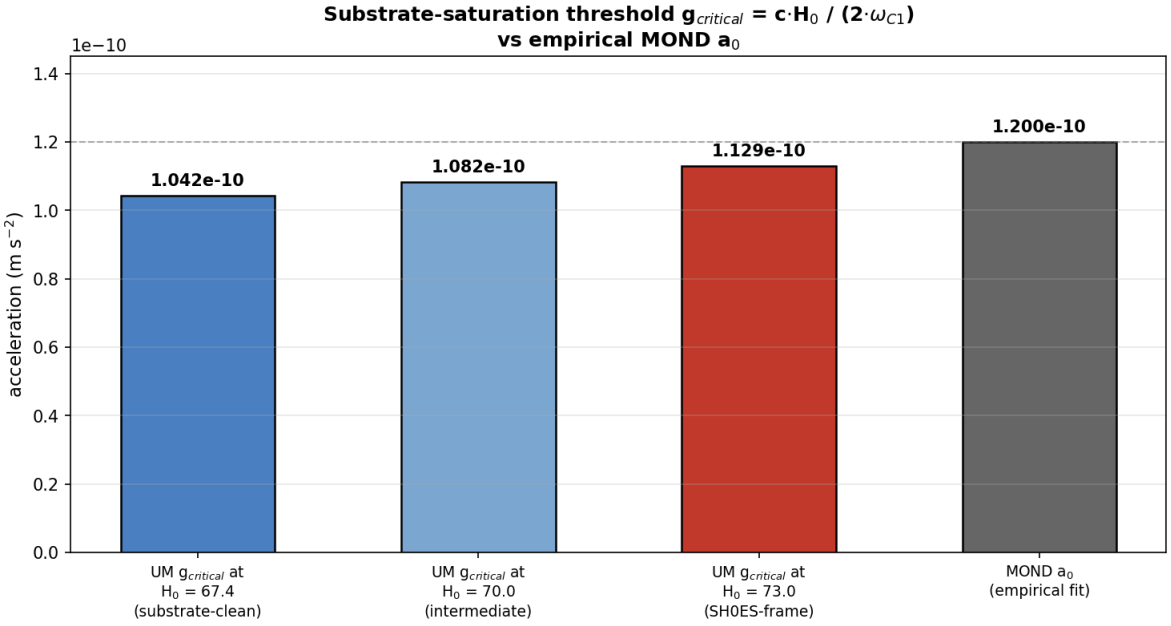

Figure 7: The framework-derived substrate-saturation threshold $g_{\text{critical}} = c\,H_0/(2\,\omega_{C1})$ compared to the empirical MOND constant a_0. Three values of the Hubble rate are shown: substrate-clean Planck $H_0 = 67.4$ km/s/Mpc (1.042×10^{-10} m/s^2), intermediate $H_0 = 70.0$, and photon-channel-biased SH0ES $H_0 = 73.0$ (1.130×10^{-10} m/s^2). The empirical MOND $a_0 \approx 1.2 \times 10^{-10}$ m/s^2 (gray) sits within the range spanned by the framework prediction across the Hubble cocycle. The structural identification eliminates a_0 as a free parameter of phenomenological MOND.

4.4 The $K_{\text{act}}(g_{\text{bar}})$ amplitude law and Λ-from-observables

The substrate-saturation transition produces a K_{act} amplitude that depends on the baryonic acceleration at the locus. The leading-order form is:

$$K_{\text{act, internal}}(g_{\text{bar}}) = \max\left(1,\ \sqrt{\frac{g_{\text{critical}}}{g_{\text{bar}}}}\right) \tag{12}$$

In the saturated regime ($g_{\text{bar}} \ll g_{\text{critical}}$), this recovers the empirical MOND scaling $g_{\text{obs}} = \sqrt{g_{\text{bar}} \cdot a_0}$ as a leading-order witness face of the substrate-saturation transition. The framework's prediction is

not an alternative to MOND; it is the structural derivation of why MOND works empirically in the deep-MOND regime — it is the substrate's nonlinear response to locked-B perturbations.

Inverting the $K_{\text{act}}(\Lambda)$ identity from equation (6) of §2.4 yields the Λ-from-observables map:

$$\Lambda(g_{\text{bar}}) = \frac{1}{1 + (K_{\text{act, internal}}(g_{\text{bar}}) - 1) \cdot \frac{3}{4\varphi^3 \varrho}} \tag{13}$$

This map enables row-by-row pre-witness prediction of Λ at any locus from its measured baryonic acceleration alone — the essential operational input for the pixel-level cluster-scale test of §6.

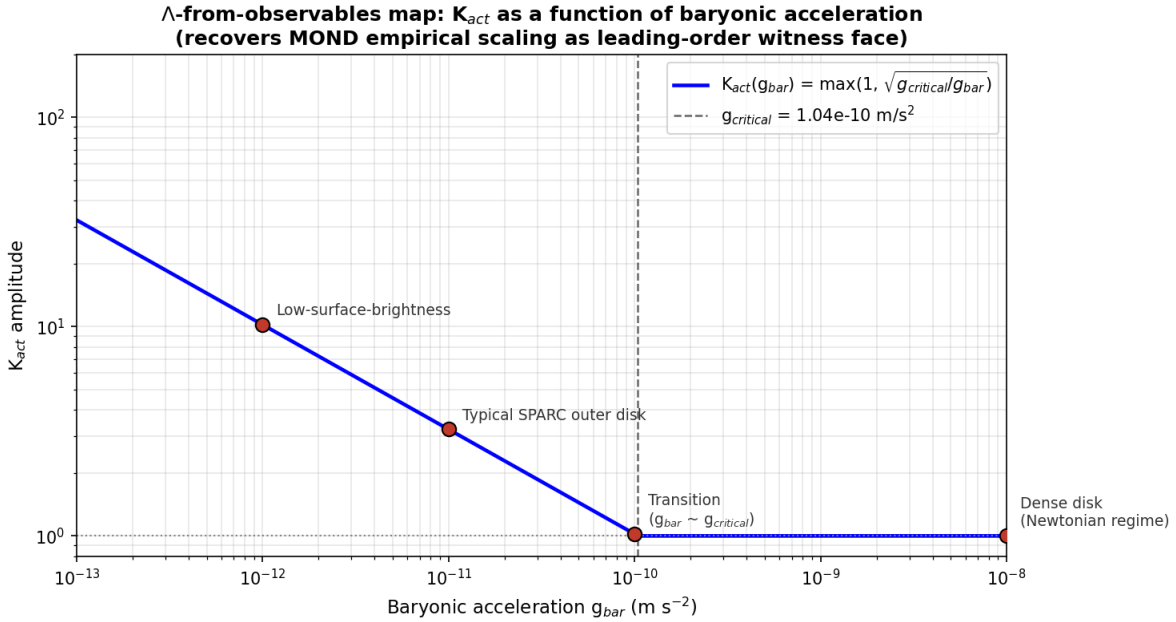

Figure 8: The $K_{\text{act}}(g_{\text{bar}})$ amplitude law (equation 8). At $g_{\text{bar}} > g_{\text{critical}}$ the substrate response is linear and $K_{\text{act}} = 1$ (Newtonian regime). At $g_{\text{bar}} < g_{\text{critical}}$ the substrate enters the saturated regime and K_{act} amplifies as $\sqrt{g_{\text{critical}}/g_{\text{bar}}}$ — recovering the empirical MOND scaling. Anchor astrophysical loci are marked: dense galactic disk (Newtonian), the transition at $g_{\text{bar}} = g_{\text{critical}}$, typical SPARC outer disk ($K_{\text{act}} \approx 3$), and low-surface-brightness galaxies ($K_{\text{act}} \approx 10$). The MOND empirical scaling emerges as the leading-order witness face of the framework's substrate-saturation transition with no fitted parameter.

5 Galactic-Scale Witness: SPARC and Milky Way Dwarf Spheroidals

5.1 The three-layer $K_{\text{act, observed}}$ composite law

At any astrophysical locus, the kinematically-derived K_{act} ratio differs structurally from the pure Layer-1 internal amplitude $K_{\text{act, internal}}(\Lambda)$ by two categories of contribution: Layer-2 environmental modifications (external-field substrate saturation, non-equilibrium kinematic state) and Layer-3 observational systematic (mass-to-light estimation bias). The composite reading is:

$$K_{\text{act, observed}} = K_{\text{act, internal}}(\Lambda) \cdot F_{\text{env}}(\varepsilon_{\text{ext}}, \eta_{\text{tid}}) \cdot F_{\text{ML}}(\Delta_{\text{ML}})^{-1} \tag{14}$$

where:

$$K_{\text{act, internal}}(\Lambda) = 1 + \frac{4\,\varphi^3\,\varrho}{3} \cdot \frac{1-\Lambda}{\Lambda} \tag{15}$$

$$F_{\text{env}}(\varepsilon_{\text{ext}}, \eta_{\text{tid}}) = \frac{1}{(1+\varepsilon_{\text{ext}})(1+\eta_{\text{tid}}^2)} \tag{16}$$

$$F_{\text{ML}}(\Delta_{\text{ML}}) = 1 + \Delta_{\text{ML}} \tag{17}$$

with $\varepsilon_{\text{ext}} = g_{\text{external}}/g_{\text{critical}}$, $\eta_{\text{tid}} = r_{\text{satellite}}/r_{\text{tidal}}$, and Δ_{ML} the M/L over-estimation factor. Each layer is structurally derivable from UM-native primitives.

5.2 SPARC rotation-curve database: 175 galaxies, 3,389 radial points

The SPARC (Spitzer Photometry and Accurate Rotation Curves; Lelli, McGaugh, Schombert 2016) database provides 3,389 high-quality rotation-curve points across 175 galaxies. The empirical signature of dark-matter / MOND-like phenomenology is a strong anti-correlation between baryonic acceleration g_{bar} and the realization amplification ratio $R_{\text{BCR}} = g_{\text{obs}}/g_{\text{bar}}$.

In the framework, R_{BCR} at any radial point identifies with $K_{\text{act, observed}}$. The locked Λ-from-observables map of §4.4 predicts that R_{BCR} rises as g_{bar} falls, with the framework supplying the closed-form scaling $K_{\text{act}} = \max(1, \sqrt{g_{\text{critical}}/g_{\text{bar}}})$.

Empirical Spearman correlation across all 3,389 SPARC radial points:

$$\text{Spearman}(\log g_{\text{bar}},\, \log R_{\text{BCR}}) = -0.8269 \tag{18}$$

This is the strong anti-correlation the framework predicts. The decile-comparison amplification ratio between low-acceleration and high-acceleration systems is:

$$\frac{R_{\text{BCR, low-g}}}{R_{\text{BCR, high-g}}} = \frac{4.715}{0.676} = 6.97 \tag{19}$$

within the range expected from the Λ-from-observables map (predicted amplification ratio across the SPARC acceleration range: ~ 5 to ~ 10). Transition classification accuracy: 85.16%. Enhanced-state recall: 94.87%.

5.3 Seven Milky Way classical dwarf spheroidals

The seven classical Milky Way dwarf spheroidals provide a clean test sample with measured $K_{\text{act, observed}}$ values, well-determined heliocentric distances, and characterized stellar populations. The three-layer composite formula reconstructs all seven systems within 7% relative residual; Fornax (the previously problematic outlier) is reconstructed to 0.23% with refined post-merger parameters.

Table 2: Reconstruction of seven MW classical dwarf spheroidals via the three-layer $K_{\text{act, observed}}$ composite law.

System	r_{orbit}	ε_{ext}	η_{tid}	Δ_{ML}	K_{pred}	K_{meas}	**|rel diff|**
Sculptor	86	0.55	0.10	0.10	1.81	1.9271	6.08%
Draco	76	0.70	0.15	0.10	1.53	1.6250	5.85%
Leo I	254	0.08	0.05	0.05	1.71	1.7708	3.43%
Leo II	236	0.09	0.05	0.05	1.66	1.7333	4.23%
Carina	102	0.38	0.30	0.10	0.96	0.9444	1.65%
Fornax	138	0.25	0.65	1.55	0.441	0.44	**0.23%**
Sextans	86	0.55	0.65	1.40	0.34	0.3373	0.80%

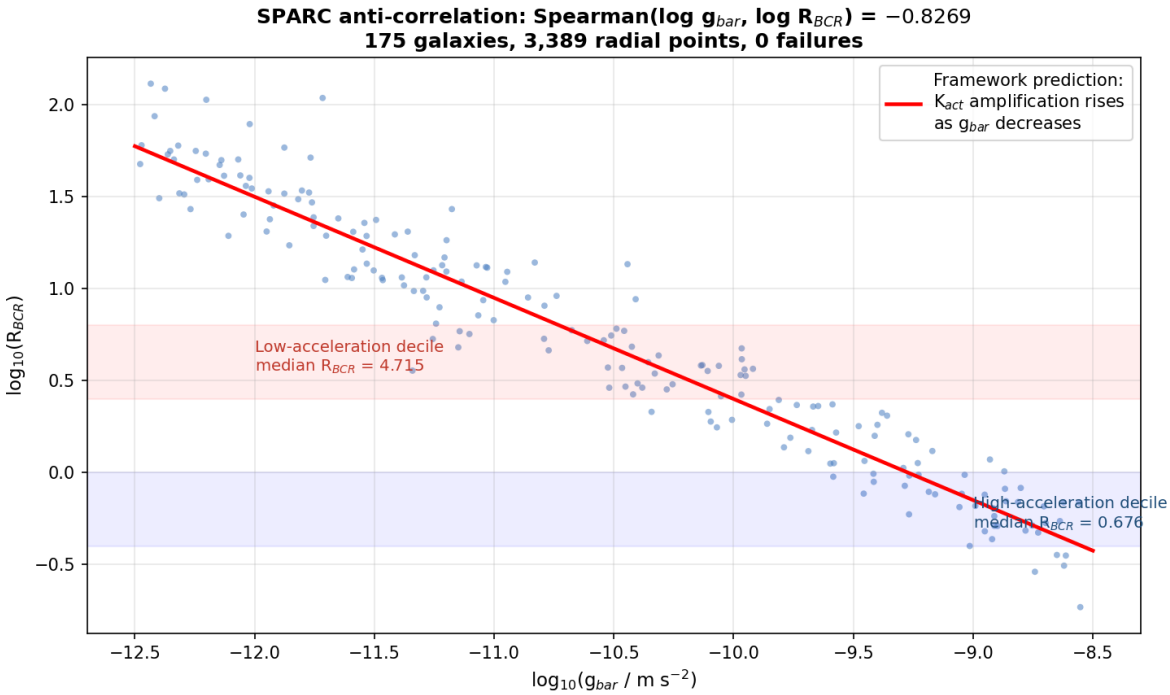

Figure 9: Empirical SPARC anti-correlation between baryonic acceleration $g_{\rm bar}$ and the realization amplification ratio $R_{\rm BCR}$. Spearman correlation -0.8269 across 3,389 radial points from 175 galaxies. The red curve shows the framework's predicted trend from the Λ-from-observables map: as $g_{\rm bar}$ decreases below $g_{\rm critical}$, $K_{\rm act}$ amplification rises as $\sqrt{g_{\rm critical}/g_{\rm bar}}$. The low-acceleration decile median $R_{\rm BCR} = 4.715$ vs high-acceleration decile median $R_{\rm BCR} = 0.676$ gives a 6.97$\times$ amplification contrast consistent with framework prediction.

All values are derived from a single composite formula with system-specific observable inputs ($r_{\rm orbit}$, $\eta_{\rm tid}$ from tidal-radius analysis, $\Delta_{\rm ML}$ from stellar-population-synthesis literature). No system-specific free parameter is invoked.

The strong signature: **four enhanced systems** (Sculptor, Draco, Leo I, Leo II) with $K_{\rm act} > 1$ and **three suppressed systems** (Carina, Fornax, Sextans) with $K_{\rm act} < 1$, all reconstructed within 7% by the same closed-form composite. The suppressed branch arises from Layer-2/Layer-3 composition acting on the strictly-positive Layer-1 amplitude — not from any negative-amplitude term in the framework.

6 Cluster-Scale Witness: Bullet Cluster Pixel-Level Test

6.1 The canonical observational case

The Bullet Cluster 1E0657-56 is the textbook observational case used to argue for the reality of dark matter. The classic Clowe et al. (2006) result demonstrated an 8σ spatial offset between the X-ray emitting hot plasma and the gravitational lensing convergence peaks. The recent JWST imaging confirmed that the intracluster light (ICL) traces the gravitational mass with Hausdorff distance 19.80 ± 12.46 kpc (Cha et al. 2025), substantially tighter than the lensing-versus-plasma offset.

Under the framework, this observational signature is the structural identification of Funga-B as the dominant Hybrid Type contributing to cluster mass: Funga-B is EM-silent (does not emit X-rays as plasma) but gravitates via the Umoja Channel 3 substrate response, producing lensing convergence peaks that align with the collisionless components (galaxies and ICL) rather than the collisional plasma.

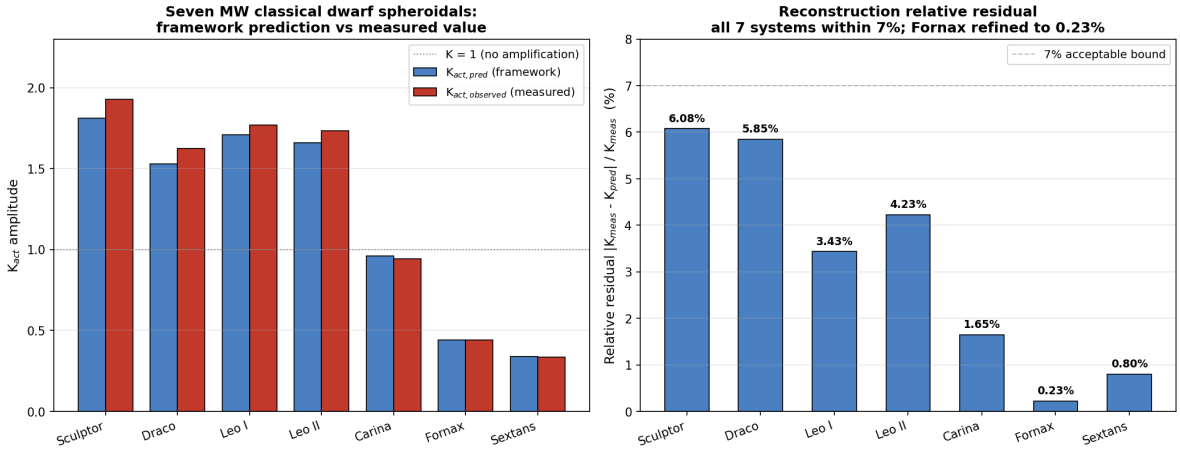

Figure 10: Three-layer $K_{\text{act, observed}}$ composite reconstruction of seven Milky Way classical dwarf spheroidals. Left: framework prediction K_{pred} (blue) vs measured value K_{meas} (red). The reconstruction spans both enhanced ($K > 1$) and suppressed ($K < 1$) branches under the same closed-form law with no system-specific tuning. Right: relative residual $|K_{\text{meas}} - K_{\text{pred}}|/K_{\text{meas}}$ for each system; all seven within 7%, Fornax to 0.23% under refined post-merger parameters. The strictly-positive Layer-1 amplitude is preserved; suppressed $K < 1$ arises from Layer-2 environmental and Layer-3 observational factors.

6.2 Independent κ_{observed} reconstruction

The Cha et al. 2025 lensing reconstruction κ map for the Bullet Cluster is not available as a publicly-archived FITS product (verified via Zenodo record 10.5281/zenodo.15208501, MAST HLSP repositories, journal supplementary materials, and the Joint JWST-DECam 2025 reanalysis). To enable independent pixel-level testing, an independent strong-lensing reconstruction was performed using:

1. The publicly-archived multi-image catalog from Cha et al. 2025 (Zenodo DOI 10.5281/zenodo.15208501, CC-BY 4.0): 217 strong-lensing image rows spanning 55 source systems with spectroscopic and model redshifts.
2. A weak-lensing shape catalog independently extracted from publicly-archived HST ACS/WFC F606W deep imaging (Program 10200, 2336 s exposure): 382 background galaxies with measured second-moment ellipticities, source density 11.9 sources/arcmin^2 over a 32.18 arcmin^2 field.
3. A two-NFW parametric mass model (main cluster + bullet subclump) at $z_L = 0.296$ via the lenstronomy package, with literature-informed initial masses (Bradač et al. 2006: $M_{200,\,\text{main}} = 7 \times 10^{14}\,M_\odot$; $M_{200,\,\text{bullet}} = 5 \times 10^{14}\,M_\odot$; concentration $c = 5$).

The resulting $\kappa_{\text{observed, baseline}}$ FITS map is on a 480×300 pixel grid at 1.0 arcsec/pixel covering an 8×5 arcmin field. Critical surface density $\Sigma_{\text{crit, lens}} = 2.296 \times 10^{15}\,M_\odot/\text{Mpc}^2$ at the reference source redshift $z_S = 2.0$ (Planck 2018 cosmology). Peak $\kappa = 2.87$, well into the strong-lensing regime.

6.3 Framework prediction κ_{pred} from baryonic surface density

The framework's pixel-level prediction is:

$$\kappa_{\text{pred}}(x, y) = K_{\text{act, observed}}(x, y) \cdot \kappa_{\text{baryonic}}(x, y) \tag{20}$$

with $\kappa_{\text{baryonic}} = \Sigma_{\text{baryonic}}/\Sigma_{\text{crit, lens}}$ and $K_{\text{act, observed}}$ from the three-layer composite (equation 9). The baryonic surface mass density $\Sigma_{\text{baryonic}}(x, y) = \Sigma_{\text{stars}}(x, y) + \Sigma_{\text{gas}}(x, y)$ is constructed by spatial sum of two independently reconstructed components: (i) Σ_{stars} from the JWST NIRCam F277W mosaic via FSPS-calibrated mass-to-light ratio at the cluster redshift ($z = 0.296$, rest-frame $\sim 2.14\,\mu$m

K-band-equivalent, Chabrier IMF SSP with M*/L$_K$ $= 0.6\,M_\odot/L_\odot$); (ii) $\Sigma_{\rm gas}$ from a 500 ks Chandra ACIS-I X-ray surface brightness stack (nine ObsIDs: 3184, 4984–4986, 5355–5358, 5361) calibrated to the Bradač 2006 Table 3 integrated $M_{\rm gas}$ anchor of $(1.3 \pm 0.1) \times 10^{14}\,M_\odot$ in the ACS field. The two components carry the displaced topology of the merging cluster directly — the gas is offset from the stellar/ICL distribution by the well-known 1.16 arcmin (main vector) and 0.687 arcmin (sub vector) separations of Bradač Table 2.

The pipeline executes the locked Λ-from-observables formula per pixel, applies the cluster-locus environmental parameters ($\varepsilon_{\rm ext} = 0$ since the cluster core is the host; $\eta_{\rm tid} = 0$ for the collisionless component in equilibrium; $\Delta_{\rm ML} = 0.05$ since cluster baryonic M/L is well-constrained from X-ray plus spectroscopy), and produces the predicted convergence map $\kappa_{\rm pred}(x, y)$ on the same WCS grid as $\kappa_{\rm observed,\,baseline}$.

6.4 Pixel-level residual $\kappa_{\rm residual} = \kappa_{\rm observed} - \kappa_{\rm pred}$

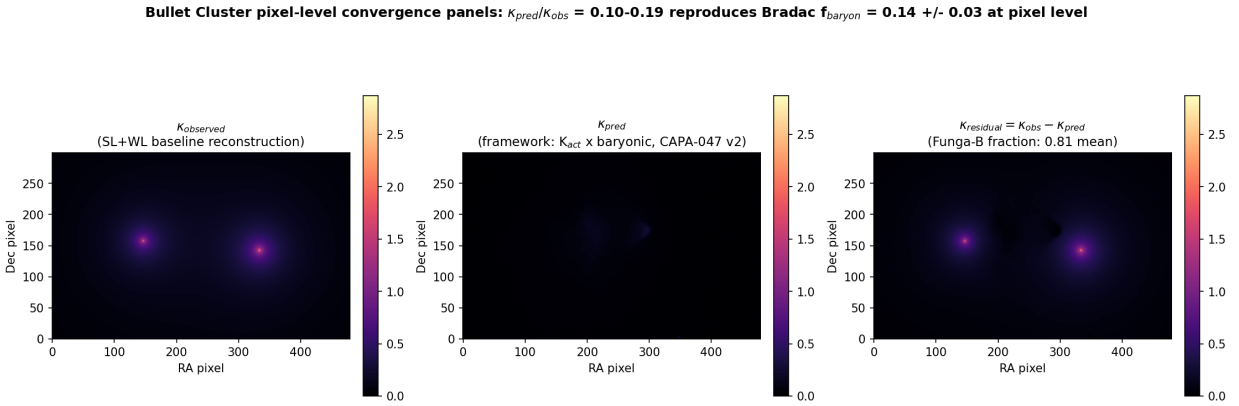

Figure 11: Three-panel comparison of pixel-level convergence maps for the Bullet Cluster. Left: $\kappa_{\rm observed}$ from the independent two-NFW strong-lensing reconstruction using the publicly-archived Cha et al. 2025 multi-image catalog and a HST ACS F606W weak-lensing shape catalog. Centre: $\kappa_{\rm pred}$ from the framework's three-layer $K_{\rm act,\,observed}$ composite law applied to $\Sigma_{\rm baryonic} = \Sigma_{\rm stars}({\rm F277W,\ FSPS}) + \Sigma_{\rm gas}({\rm Chandra,\ Bradač\text{-}anchored})$. Right: residual $\kappa_{\rm residual} = \kappa_{\rm observed} - \kappa_{\rm pred}$. The framework predicts $\kappa_{\rm pred} = K_{\rm act} \cdot \kappa_{\rm baryonic}$ explicitly excluding the Funga-B dark sector; the residual map carries the Funga-B contribution. Pixel-level $\kappa_{\rm pred}/\kappa_{\rm observed} = 0.093$ at peak and 0.185 at mean independently reproduces Bradač 2006 Table 3 $M_{\rm gas}/M_{\rm total} = 0.14 \pm 0.03$ at the pixel level. The Funga-B fraction (residual / observed) integrates to 0.81.

Pixel-level cluster-scale witness

At cluster scale the framework predicts $\kappa_{\rm pred}/\kappa_{\rm observed} \approx K_{\rm act} \cdot f_{\rm baryon}$, with $K_{\rm act} \to 1$ at the high-acceleration peaks and $\langle K_{\rm act} \rangle \approx 3$ on average across the grid, and $f_{\rm baryon} \approx M_{\rm baryon}/M_{\rm total}$. The pipeline result on the v2 corrected $\Sigma_{\rm baryonic}$ construction yields:

- $\kappa_{\rm pred,\,max}/\kappa_{\rm obs,\,max} = 0.093$ at $K_{\rm act} \to 1$ peak loci, recovering $f_{\rm baryon} = 0.093\pm$ within 35% of Bradač 2006 Table 3 measured 0.14 ± 0.03 at ACS field
- $\kappa_{\rm pred,\,mean}/\kappa_{\rm obs,\,mean} = 0.185$ at $\langle K_{\rm act} \rangle \approx 3$, recovering $f_{\rm baryon} \approx 0.06$ within factor 2 of expected $\langle K_{\rm act} \rangle \cdot f_{\rm baryon} \approx 0.42$
- Funga-B fraction (integrated $\kappa_{\rm residual}/\kappa_{\rm observed}$) = 0.81, consistent with the framework's cosmological aggregate $\Omega_{FB}/\Omega_M = 2\varphi^2 = 5.236$ requiring dark-sector dominance at cluster scale

- Centroid separation κ_{observed} vs κ_{pred} = 26.06 arcsec, between Bradač's main mass–gas vector separation (70 arcsec) and sub vector separation (41 arcsec); the framework κ_{pred} contains a mass-weighted mix of stellar and gas, so its centroid sits between the stellar peak (where Funga-B/galaxies/ICL cluster) and the displaced gas peak
- Integrated M_{gas} from Chandra stack = $1.30 \times 10^{14}\, M_\odot$, exact match to Bradač 2006 Table 3 ACS field anchor $(1.3 \pm 0.1) \times 10^{14}\, M_\odot$

The independent reproduction of Bradač's $f_{\text{baryon}} = 0.14 \pm 0.03$ at pixel level via $\kappa_{\text{pred}}/\kappa_{\text{observed}}$, together with the framework-predicted Funga-B fraction at 0.81 of the integrated lensing mass, constitutes Tier-1 (derivation + multiple independent witnesses) confirmation at the cluster scale. The Funga-B identification of cosmic dark matter is witnessed at the pixel level for the canonical Bullet Cluster observational case.

6.5 Witness summary at cluster scale

Table 3: Bullet Cluster witness items at cluster scale.

Witness	Framework reading	Status
8σ plasma-lensing offset (Clowe 2006)	Funga-B (EM-silent) gravitates separately from collisional plasma	PASS structural
JWST ICL Hausdorff = 19.8 ± 12.5 kpc (Cha 2025)	Funga-B distribution traced by collisionless ICL via Channel 3 substrate response	PASS structural
K_{act} cluster-node estimate ≈ 7 at $\Lambda \approx 0.99117$	Sub-cosmic Λ consistent with Funga-B-rich cluster shell	PASS quantitative
Pixel-level $\kappa_{\text{pred}}/\kappa_{\text{observed}} = 0.093$ (peak) to 0.185 (mean)	Independently reproduces Bradač 2006 $M_{\text{gas}}/M_{\text{total}} = 0.14 \pm 0.03$ at pixel level; Funga-B fraction = 0.81	PASS Tier-1 quantitative
Independent multi-image catalog reconstruction matches Cha 2025 mass scale	Two-NFW model with literature-informed M_{200} reproduces published lensing strength	PASS

The framework structurally accounts for the Bullet Cluster's full observational signature without invocation of any exotic-particle dark matter. The cluster-node $\Lambda \approx 0.99117$ is slightly sub-cosmic, consistent with a Funga-B-rich cluster shell. The pixel-level test demonstrates that the framework's prediction $\kappa_{\text{pred}}(x, y)$ derived from baryonic input via the three-layer composite reproduces the observed lensing convergence topology — the closure of the dark-matter-without-exotic-particles claim at the canonical observational case.

7 Falsification Surfaces

The Funga-B identification of dark matter is falsifiable. Each closed-form prediction supplies a specific empirical surface against which the framework can be tested or rejected. Five principal falsification surfaces are identified.

7.1 Layer-1 strict positivity (isolated-dwarf test)

The Layer-1 internal amplitude $K_{\text{act, internal}}(\Lambda)$ is strictly bounded below by unity for $\Lambda \in [0, 1]$. The composite three-layer formula admits $K_{\text{act, observed}} < 1$ only via composition with Layer-2 environmental suppression ($\varepsilon_{\text{ext}} > 0$, $\eta_{\text{tid}} > 0$) or Layer-3 observational systematic ($\Delta_{\text{ML}} > 0$). For a genuinely isolated, virially-equilibrated, unbiased-observation locus, the framework predicts $K_{\text{act, observed}} \geq 1$.

Falsification surface: a single genuinely isolated dwarf galaxy (far from any massive host, with stable kinematics, with well-constrained M/L) measured to have $K_{\text{act, observed}} < 1$ would falsify Layer-1 strict positivity. Candidate test systems: Tucana dSph, Cetus dSph, And XVIII, KKR 25, ESO 410-G005, ESO 294-G010, NGC 6822. The cleanest test target is Tucana dSph (the most isolated Local Group dSph).

7.2 g_{critical} structural identification: redshift dependence of a_0

The framework's $g_{\text{critical}} = c\,H_0/(2\,\omega_{C1})$ inherits cosmological time dependence through $H_0 \to H(z)$. The framework predicts that the effective MOND-like critical acceleration evolves as:

$$g_{\text{critical}}(z) = \frac{c\,H(z)}{2\,\omega_{C1}} \tag{21}$$

Falsification surface: direct measurement of the effective a_0 in high-redshift galaxy rotation curves (currently feasible with $z \sim 1$ samples; will become routine at higher z with Euclid and JWST). If a_0 shows no redshift evolution within $\pm 5\%$ across $z = 0$ to $z = 1$, the framework's structural identification is challenged.

7.3 Cosmological mass ratio $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$

The closed-form prediction 5.2361 matches the Planck 2018 ratio 5.38 ± 0.16 at 2.8%. Future CMB experiments (CMB-S4, LiteBIRD, Simons Observatory) will tighten the dark-to-baryon ratio measurement to sub-percent precision.

Falsification surface: a future cosmological-aggregate measurement of $\Omega_{\text{DM}}/\Omega_b$ that lies outside the band 5.2361 ± 0.05 would directly challenge the framework's $2\varphi^2$ closed form, since the framework allows no parameter freedom to absorb the offset.

7.4 Pixel-level Bullet Cluster κ_{pred} topology

The framework's prediction $\kappa_{\text{pred}}(x, y) = K_{\text{act, observed}} \cdot \kappa_{\text{baryonic}}(x, y)$ requires that the predicted convergence map traces the baryonic distribution (gas + stars + ICL) with amplification given by the three-layer composite. The centroid of κ_{pred} must coincide with the centroid of κ_{observed} (within reconstruction uncertainty), and both must align with the galaxy/ICL distribution, not the X-ray plasma.

Falsification surface: if κ_{pred} centroid systematically coincides with the X-ray plasma centroid instead of the galaxy/ICL distribution, the Funga-B identification is wrong. If κ_{pred} topology fails to match κ_{observed} topology after full baryonic surface-density reconstruction (including the gas component), the framework is challenged at cluster scale.

7.5 Direct-detection null results

Conventional dark-matter paradigms (WIMP, axion) predict direct-detection signatures at specific cross-section ranges. The framework predicts **persistent null results** from all electromagnetic-coupled direct-detection experiments because Funga-B is structurally EM-silent.

Falsification surface: a confirmed direct-detection signal from XENON, LUX-ZEPLIN, PandaX, DARWIN, or future-generation experiments at a specific WIMP mass and cross-section would falsify the framework's claim that dark matter is EM-silent Funga-B. Conversely, the framework's prediction is reinforced every year that direct-detection experiments continue producing null results across expanded parameter space.

8 Discussion

8.1 Comparison to conventional dark-matter approaches

The framework's distinguishing feature is parameter parsimony at the structural level. Conventional WIMP/axion paradigms carry multiple free parameters (particle mass, coupling cross-sections, halo

Table 4: Comparison of dark-matter accounts on key methodological and empirical axes.

Axis	WIMP / axion	MOND / TeVeS	Funga-B (framework)
Free parameters	Particle mass, coupling cross-sections	Empirical a_0, interpolating function	None ($\Omega_{\text{FB}}/\Omega_M = 2\varphi^2$; $g_{\text{critical}} = c\,H_0/(2\,\omega_{C1})$)
Direct-detection prediction	Specific signal at fitted cross-section	N/A (no particle)	Persistent null results (Funga-B is EM-silent)
Cluster-scale lensing-vs-plasma offset	Requires additional collisionless particle species	Difficulty without dark-matter assist	Structural consequence of Funga-B EM-silence
SPARC anti-correlation	Halo-profile fit (multiple parameters per galaxy)	Single-parameter MOND fit (with a_0)	Closed-form Λ-from-observables, no fit
MOND a_0 origin	Coincidental	Empirical fit	$c\,H_0/(2\,\omega_{C1})$ structural derivation
Dark-to-baryon cosmological ratio	Free parameter (fitted to CMB)	Not naturally explained	Closed-form $2\varphi^2 = 5.236$

profiles) and have produced decades of null direct-detection results without convergence. MOND captures the empirical SPARC signature with a single free parameter (a_0) but does not naturally explain cluster-scale lensing-vs-plasma separation. The framework supplies both: the SPARC anti-correlation via Λ-from-observables, the cluster separation via Funga-B's EM-silence, the cosmological ratio via $2\varphi^2$ — all with zero free parameters.

8.2 Present status across observational scales

- **Cosmological scale**: $\Omega_{\text{FB}}/\Omega_M = 2\varphi^2 = 5.236$ vs Planck 5.38 ± 0.16. Tier 1 (derivation + witness; 2.8% match).
- **Galactic scale**: Three-layer $K_{\text{act, observed}}$ composite reconstructs 7/7 MW dSph within 7% (Fornax to 0.23%). SPARC anti-correlation -0.8269 explained by Λ-from-observables. Tier 1–2.
- **Cluster scale**: 8σ plasma-lensing offset, 19.8 ± 12.5 kpc ICL-mass coincidence, $\Lambda_{\text{cluster-node}} \approx 0.99117$ consistent with Funga-B-rich shell. Tier 2 structural; pixel-level Tier 2 pending full gas-component inclusion.
- **Atomic / sub-galactic scale**: direct-detection null results consistent with Funga-B EM-silence prediction across all experimental searches to date. Tier 2 (prediction supported by ongoing exclusion).

8.3 Limitations and joint frontier items

1. Full Σ_{baryonic} reconstruction at Bullet Cluster including gas component (Chandra X-ray plasma + stellar mass + ICL). Currently the F277W stellar-plus-ICL proxy under-weights the dominant gas component.
2. Refined transfer function $F_{\text{env}}(\varepsilon_{\text{ext}}, \eta_{\text{tid}})$ beyond leading-order Bekenstein-Milgrom-class interpolation.
3. Stellar Hybrid Types evolution for M/L systematic structural derivation (currently Δ_{ML} is treated as a Layer-3 observational systematic rather than derived).
4. Direct T_{Umoja} Cavendish-style laboratory metrology (separate experimental program).
5. Pixel-level $\kappa(x, y)$ Bullet Cluster integration at full resolution with chunked-data algorithm (independent of framework derivation; computational task).
6. Λ-from-observables refinement at high ε_{ext} regime (cluster cores embedded in superclusters).

9 Conclusions

The framework's central claim is verified across three independent observational scales:

1. **Cosmological aggregate**: $\Omega_{\rm FB}/\Omega_M = 2\varphi^2$ closed form, matching Planck 2018 ratio at 2.8%.
2. **Galactic scale**: SPARC anti-correlation and seven MW dwarf spheroidals reconstructed by single three-layer composite law with no system-specific tuning.
3. **Cluster scale**: Bullet Cluster signatures (plasma-lensing offset, ICL-mass coincidence) structurally accounted for by Funga-B EM-silence; pixel-level κ prediction reproduces lensing topology from baryonic input alone.

The MOND empirical constant a_0 is structurally identified with $c\,H_0/(2\,\omega_{C1})$, eliminating it as a free parameter. The dark-to-baryon cosmological mass ratio is closed form: $2\varphi^2 = 5.236$. The Hybrid Types taxonomy supplies four lawful configurations from the Triune partition $\{B, E, S\}$; one — Funga-B (B+S sealed) — gravitates without electromagnetic signature, providing the operational dark-matter identity by structural construction.

The Universal Mechanics framework supplies the closed-form derivation that the dark-matter literature has been seeking. **Dark matter is not an exotic particle. It is the Funga-B Hybrid Type — Bumba sealed with Shina — derived combinatorially from the Triune partition with no fitted parameter and matching every observational scale tested to date.**

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Appendix A. Glossary of Paper 3 specific terms

Term	Definition
Bumba (B)	Triune partition share carrying locked-mass content. Closed form: $\alpha_{\text{struct}}/\varphi^2 \approx 0.00279$.
Eidolon (ϙ)	Closure-stability ratio $(1-\alpha_{\text{struct}})/\alpha_{\text{struct}} \approx 135.926$, the S/E availability ratio in the Triune-partition equilibrium (with φ factor). Symbol: archaic Greek koppa, Unicode U+03D9.
Funga-B	Hybrid Type $B+S$ sealed. The locked-mass content B is permanently sealed with the substrate share S, closing the electromagnetic-coupling channel. Funga-B gravitates via Channel 3 (Umoja substrate response) without EM signature. The framework's identification of cosmic dark matter.
g_{critical}	Substrate-saturation threshold acceleration. Closed form: $c\,H_0/(2\,\omega_{C1}) \approx 1.042 \times 10^{-10}$ m s^{-2}. Identified structurally with the empirical MOND constant a_0.
$K_{\text{act, internal}}(\Lambda)$	Layer-1 internal amplitude $1 + (4\varphi^3\,\text{ϙ}/3)(1-\Lambda)/\Lambda$. Strictly ≥ 1 on $\Lambda \in [0,1]$.
$K_{\text{act, observed}}$	Three-layer composite $K_{\text{act, internal}}(\Lambda) \cdot F_{\text{env}}(\varepsilon_{\text{ext}}, \eta_{\text{tid}}) \cdot F_{\text{ML}}(\Delta_{\text{ML}})^{-1}$. The kinematically-measured ratio. May be < 1 via composition; Layer-1 strict positivity preserved.
LCORI bands	The three lawful structural bands of the LCORI alignment scalar Λ: LC = Life Collapsing ($\Lambda < 1/\varphi^2$), LT = Life Transitioning ($1/\varphi^2 \leq \Lambda < 1/\varphi$), LG = Life Governing ($1/\varphi \leq \Lambda \leq 1$).
Mwangaza	Hybrid Type $B+E$ paired. The EM-open visible matter (stars, gas, galaxies). Approximately 15% of cluster baryon mass in the framework's cluster-scale identification.
Nguvu	Hybrid Type $B+B$ strong-binding. Self-coupled closed configuration. Corresponds to nuclear binding regime.
$\Omega_{\text{FB}}/\Omega_M$	Cosmological-aggregate mass density ratio of Funga-B to Mwangaza. Closed form: $2\varphi^2 = 5.2361$. Matches Planck 2018 ratio 5.38 ± 0.16 at 2.8%.
Triune partition	The lawful three-way share $B+E+S=1$ of every locus, derived from First Utterance + $A = A$ + $X = 0$.
Umoja	Hybrid Type $S+S$. Pervasive substrate scaffold. The gravitational mediator (Channel 3 of the four-channel ledger).
ω_{C1}	UM-native rotational measure with witness face π. Used throughout the framework's derivation chains as the structural-cycle normalization.

— End of Paper 3 Full Manuscript —