

RBFL Research Project

Dark-Sector Accumulation and Gradient Harvesting from Time-Evolving Wave Domains

An established-mathematics theory with a separate RBFL correspondence layer

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RBFL Research Project | rbfl.link

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Accumulation = 3D wave transport integrated over time

In 3+1 spacetime: accumulation is the net conserved-current flux through the world-tube of a moving domain.

This is a speculative theory note, not an experimental discovery and not a claim that dark matter has been captured, created, or harvested. The main derivation deliberately uses established mathematics; the new content is the proposed physical synthesis, its RBFL correspondence test, and its falsification program.

Reference maps and explanatory figures begin on the following pages.

Visual thesis: the two RBFL reference maps that motivated the theory

3D field behavior: amplification and cancellation coexist inside the same volume

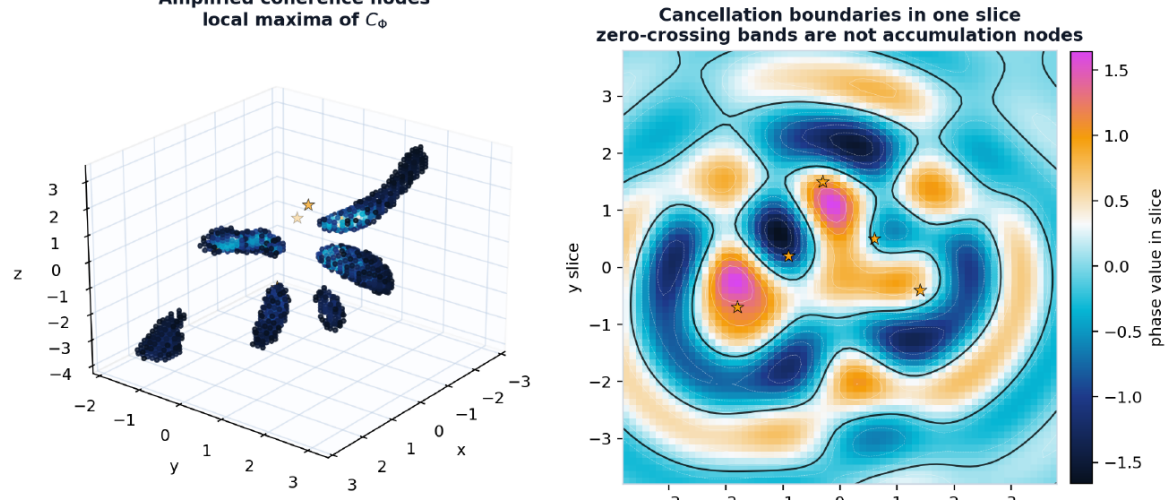


Figure 1. RBFL reference image: simultaneous amplification and cancellation in a three-dimensional field construction. This is a project-generated conceptual/sandbox figure, not an observed dark-matter map. The present paper replaces the informal idea of “boundaries” with standard level-set surfaces and transport across moving control volumes. Source: Haye, *RBFL 3D Sine-Intersection Field Mechanics White Paper* (2026).

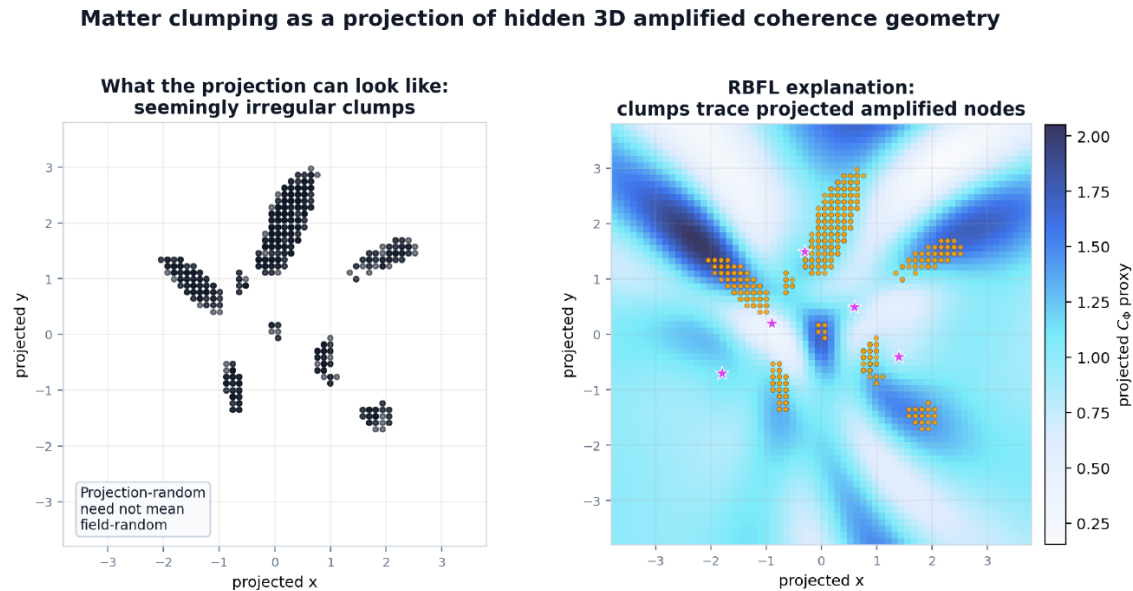
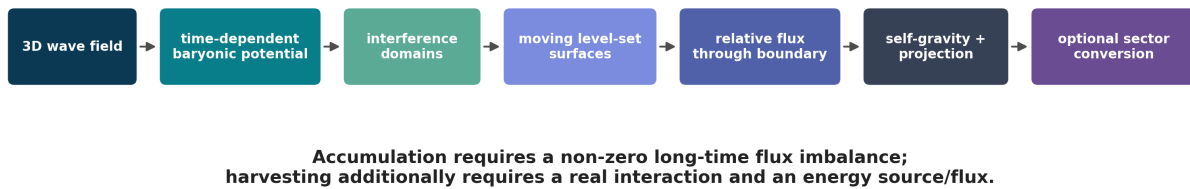


Figure 2. RBFL reference image: apparently irregular projected clumps overlaid on a projected amplified-node field. This is a hypothesis-generating project figure. It does not establish that astronomical dark-matter clumps are phase nodes. In the established-mathematics formulation developed here, the corresponding quantity is a three-dimensional wave density $\rho_X = m_X |\psi|^2$, which is then projected along the line of sight. Source: Haye (2026).



Established mathematics at every arrow; the new content is the physical synthesis and its falsifiable hypotheses.

Figure 3. The complete logical chain. Every arrow is implemented with standard mathematics. The speculative content is whether nature realizes the required dark field, whether the long-time transport bias is non-zero, and whether a usable coupling to the visible sector exists.

Executive statement

The theory asks a narrow question: if some dark matter is a coherent or partially coherent bosonic field, can galactic structure organize its three-dimensional wave dynamics into time-evolving domains whose relative flux produces secular accumulation, and, only if an independently allowed interaction exists, can energy carried by that field be converted without violating conservation laws?

The answer is not assumed. The paper turns that question into a sequence of ordinary equations and explicit failure gates.

A three-dimensional wave field can form interference structure; a time-dependent gravitational environment can move and reshape that structure; the Reynolds transport theorem decides whether a moving domain gains or loses field content; Poisson gravity decides whether the accumulated field becomes self-gravitating; line-of-sight projection determines what an observer infers; and stress-energy conservation decides whether any later conversion is harvesting or merely re-labelled conventional input power.

Accumulation map:

ambient wave field + 3D organization + time $\longrightarrow$ possible secular accumulation.

Accumulation can be true while harvesting is false.

Harvesting map:

dark-sector energy flux or stored-field depletion
+ real interaction $\longrightarrow$ possible visible-sector work.

Harvesting is forbidden as a claim unless the full energy ledger closes after all conventional inputs are subtracted.

Authorship and priority scope

The conceptual synthesis, RBFL correspondence, and theory proposal in this document are attributed to **Levi S. Haye**. The dated priority claim is intentionally narrow. No priority is claimed for wave dark matter, fuzzy dark matter, the Schrödinger–Poisson equations, the dynamical Casimir effect, Reynolds transport, level-set methods, gravitational lensing, axion conversion, or generic dark-matter detection. Those bodies of work pre-exist this note. The priority record concerns the specific synthesis developed here: *time-evolving interference-domain transport $\longrightarrow$ a secular accumulation criterion $\longrightarrow$ a flux-limited harvesting gate $\longrightarrow$ an explicit RBFL correspondence test.*

A broad statement such as “first theory to harvest dark matter” would not be defensible without a dedicated prior-art search and would conflict with earlier work on dark-matter detection, conversion, capture, and wave interference. A defensible priority statement is the dated publication of the specific mathematical synthesis and falsification program in this note.

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1 Scope, assumptions, and architecture firewall

1.1 The minimum assumptions

The main theory uses the following conditional assumptions:

1. A dark-sector component admits a bosonic wave description on the scale of interest. Wave or fuzzy dark matter is an established research class in which this occurs [4, 7, 3, 6].
2. The field is gravitationally coupled, so its density contributes to the gravitational potential through Poisson gravity in the weak-field, non-relativistic galactic regime.
3. The baryonic galaxy may contain non-axisymmetric, time-dependent structures such as bars, spiral patterns, clumps, warps, or evolving gas distributions. Rotation by itself is not enough: a perfectly axisymmetric steady mass distribution produces a time-independent gravitational potential.
4. Any claimed energy harvesting requires a real dark-to-visible interaction permitted by a consistent field theory. The interaction is not invented by RBFL and is not assumed to be large.

1.2 What is deliberately excluded

The theory does not assume that every dark-matter candidate is wave-like, that an RBFL contour is a material wall, that visible and dark waves can simply be added as amplitudes, that interference creates net energy, or that a large dark-matter density automatically implies usable power.

The locked RBFL acceleration law is not modified by the harvesting branch. The standard-field derivation is performed independently. Only after it predicts a gravitational field is a correspondence test made against RBFL. No lensing factor, detector output, energy-conversion factor, or engineering quantity is inserted into the RBFL force law.

1.3 The locked RBFL law

The project-level RBFL statement carried into this note is

$$\mathbf{g}_{\text{RBFL}} = \mathbf{g}_b + C_\Phi \sqrt{a_\Phi |\mathbf{g}_b|} \hat{\mathbf{g}}_b \quad (1.1)$$

with

$$\mathbf{g}_b = -\nabla \Phi_b, \quad \nabla^2 \Phi_b = 4\pi G \rho_b. \quad (1.2)$$

Here C_Φ is dimensionless and a_Φ has dimensions of acceleration. The current RBFL architecture explicitly separates source, acceleration law, phase-response operator, projection channels, and falsification gates [20, 21].

2 Established physical scaffold

2.1 Why a wave-dark-matter scaffold is legitimate mathematics

Ultralight bosonic dark-matter candidates can have de Broglie wavelengths large enough that the field is well described by classical waves on astrophysical scales. Wave interference then creates real density fluctuations, vortices, and granulation in the wave-field density [7, 3]. This does not establish that nature chose such a candidate; it establishes that the mathematical scaffold is already part of mainstream theoretical physics.

The characteristic de Broglie wavelength is

$$\lambda_{\text{dB}} = \frac{h}{m_X v} \quad (2.1)$$

so the relevance of wave effects is set by the ratio of λ_{dB} to the structure size being studied. If λ_{dB} is microscopic compared with galactic scales, the moving-domain hypothesis described here cannot operate at galactic size through that field.

An order-of-magnitude coherence time follows from the non-relativistic frequency spread,

$$\tau_{\text{coh}} \sim \frac{\hbar}{m_X v^2}, \quad (2.2)$$

up to convention-dependent factors of order unity. Long-lived accumulation therefore cannot be assumed from a single instantaneous interference snapshot; it must survive or be continually regenerated over many relevant dynamical times.

2.2 Different wave sectors must not be added illegally

Earlier intuitive language about “all waves present in space” is replaced by a proper multi-field statement:

$$\mathcal{L}_{\text{total}} = \mathcal{L}_{\text{grav}} + \mathcal{L}_{\text{SM}} + \mathcal{L}_X + \sum_i \mathcal{L}_{\text{int}}^{(i)}. \quad (2.3)$$

Electromagnetic radiation, gravitational perturbations, plasma/MHD modes, baryonic density waves, and a hypothetical dark field are distinct physical degrees of freedom. Their amplitudes are not simply summed unless the theory says they are components of the same field. They influence one another through gravity, a material medium, or explicit interaction terms.

Table 1. Field inventory and the legal route by which each sector can influence the dark-field problem.

Sector	Mathematical object	Allowed route into the dark-field dynamics
Dark bosonic field	X relativistically, ψ non-relativistically	Own equation of motion; gravity; explicit portal interactions
Electromagnetic field	$F_{\mu\nu}$	Stress-energy/gravity or an explicit X -photon coupling
Gravity	metric $g_{\mu\nu}$ or weak-field potential Φ	Universal gravitational coupling
Plasma/MHD waves	fluid variables, $\mathbf{B}$, $\mathbf{E}$, currents	Medium-dependent stress-energy; possible portal only if specified
Baryonic density/spiral waves	ρ_b, Φ_b	Time-dependent gravitational potential and torque
Acoustic waves	pressure/density perturbations in matter	Require a material medium; not a vacuum field

2.3 Dynamical Casimir effect: a precedent, not the galactic mechanism

The dynamical Casimir effect demonstrates experimentally that rapidly changing effective boundary conditions can reorganize quantum-field modes and generate real photons when energy is supplied by the modulation [12]. The correspondence used

here is deliberately limited:

time-dependent environment $\longrightarrow$ mode evolution.

A galactic interference contour is not a conducting mirror, and a slowly rotating galaxy is not assumed to operate as a Casimir cavity. The DCE is cited only as an established precedent that time-dependent mode structure can matter physically. In the galactic theory, the actual driver is the gravitational Hamiltonian, not a mirror analogy.

3 Relativistic starting point and non-relativistic reduction

3.1 Scalar-field action

For a complex scalar field X in curved spacetime, a standard minimally coupled action is

$$S_X = \int d^4x \sqrt{-g} \left[-g^{\mu\nu} (\nabla_\mu X)^* (\nabla_\nu X) - m_X^2 |X|^2 - U(|X|) \right], \quad (3.1)$$

where natural units $c = \hbar = 1$ and metric signature $(-, +, +, +)$ are used in this subsection, with $\square = \nabla_\mu \nabla^\mu$. Variation with respect to X^* gives

$$\square X - m_X^2 X - \frac{\partial U}{\partial X^*} = 0. \quad (3.2)$$

A real scalar, including an axion-like field, has the corresponding real-field form. The complex field is convenient because an exact global $U(1)$ symmetry supplies a conserved number current. For a real oscillating scalar, the non-relativistic envelope can still obey an approximately number-conserving Schrödinger description over the regime where particle-number-changing processes are negligible.

3.2 Schrödinger–Poisson system in three spatial dimensions

In the weak-field, non-relativistic galactic regime, the baseline equations are

$$\boxed{i\hbar \frac{\partial \psi}{\partial t} = \left[-\frac{\hbar^2}{2m_X} \nabla^2 + m_X \Phi \right] \psi} \quad (3.3)$$

with

$$\boxed{\nabla^2 \Phi = 4\pi G (\rho_b + \rho_X), \quad \rho_X = m_X |\psi|^2.} \quad (3.4)$$

The three-dimensional Laplacian is

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}. \quad (3.5)$$

The normalization used throughout the paper is

$$n_X = |\psi|^2, \quad \rho_X = m_X n_X, \quad (3.6)$$

where n_X is number density and ρ_X is mass density. Schrödinger–Poisson methods have a long history in collisionless and wave-dark-matter modeling [2, 4, 5].

3.3 Optional self-interaction

If an allowed short-range bosonic self-interaction is physically motivated, the established Gross–Pitaevskii–Poisson generalization is

$$i\hbar\partial_t\psi = \left[-\frac{\hbar^2}{2m_X}\nabla^2 + m_X\Phi + g_X|\psi|^2 \right] \psi. \quad (3.7)$$

The minimal theory in this note sets $g_X = 0$ unless a specific dark-matter model requires otherwise. This prevents an unconstrained self-interaction from becoming a hidden tuning knob.

3.4 Cosmological-coordinate extension

For simulations spanning cosmological expansion, the local galactic form must be replaced by the standard comoving Schrödinger–Poisson equations with scale factor $a(t)$ and density contrast relative to the cosmic mean. The accumulation mechanism proposed here is local in the sense that it depends on relative flux through moving domains; it does not depend on choosing physical rather than comoving coordinates, provided the transport theorem and gravitational source terms are transformed consistently.

4 Madelung form: density, velocity, current, and quantum pressure

Write the wavefunction as

$$\psi(\mathbf{x}, t) = \sqrt{n_X(\mathbf{x}, t)} \exp \left[\frac{iS(\mathbf{x}, t)}{\hbar} \right]. \quad (4.1)$$

The phase defines the velocity field

$$\mathbf{v}_X = \frac{\nabla S}{m_X}. \quad (4.2)$$

The number current is

$$\mathbf{j}_N = \frac{\hbar}{m_X} \text{Im}(\psi^* \nabla \psi) = n_X \mathbf{v}_X, \quad (4.3)$$

and the mass current is

$$\mathbf{J}_X = m_X \mathbf{j}_N = \rho_X \mathbf{v}_X = \hbar \text{Im}(\psi^* \nabla \psi). \quad (4.4)$$

Taking the imaginary part of the Schrödinger equation yields the standard continuity equation

$$\frac{\partial \rho_X}{\partial t} + \nabla \cdot \mathbf{J}_X = 0. \quad (4.5)$$

The real part gives the quantum Hamilton–Jacobi equation, which can be differentiated to obtain

$$\frac{\partial \mathbf{v}_X}{\partial t} + (\mathbf{v}_X \cdot \nabla) \mathbf{v}_X = -\nabla \Phi + \frac{\hbar^2}{2m_X^2} \nabla \left(\frac{\nabla^2 \sqrt{n_X}}{\sqrt{n_X}} \right). \quad (4.6)$$

The final term is the quantum-pressure/quantum-potential contribution first exposed in hydrodynamic form by Madelung [1]. It is essential: wave accumulation cannot be treated as pressureless collapse on scales where this term is important.

The physically conserved transport quantity is not “coherence” by itself. It is the density/current pair $(\rho_X, \mathbf{J}_X)$ obeying equation (4.5). Any claim of deep-time accumulation must be expressible as a non-zero integral of this current relative to a moving domain boundary.

5 Interference: how a wave field produces real density structure

Let

$$\psi(\mathbf{x}, t) = \sum_{j=1}^N \psi_j(\mathbf{x}, t) = \sum_{j=1}^N a_j u_j(\mathbf{x}, t) \exp[-i\omega_j t + i\phi_j]. \quad (5.1)$$

Then

$$|\psi|^2 = \sum_j |\psi_j|^2 + \sum_{j \neq k} \psi_j \psi_k^* \quad (5.2)$$

$$= \sum_j |\psi_j|^2 + 2 \sum_{j < k} \text{Re}(\psi_j \psi_k^*). \quad (5.3)$$

The cross terms are ordinary wave interference. Because $\rho_X = m_X |\psi|^2$, constructive interference creates local density enhancement while destructive interference creates local depletion. Wave-dark-matter simulations already exhibit interference-generated granular halo structure [3, 7].

Constructive interference is **redistribution**, not energy creation. A local peak can exceed the incoherent sum because amplitudes interfere, while the global conserved quantities are determined by the Hamiltonian and boundary fluxes. Any harvesting claim that counts a constructive peak but ignores the energy that established the state is invalid.

5.1 A reproducible standard-wave illustration

Figure 4 uses a deterministic superposition of free Schrödinger plane-wave modes with the standard dispersion relation $\omega = \hbar k^2 / (2m_X)$ in dimensionless units. It demonstrates only one point: an isodensity/zero-contrast contour moves as phases evolve.

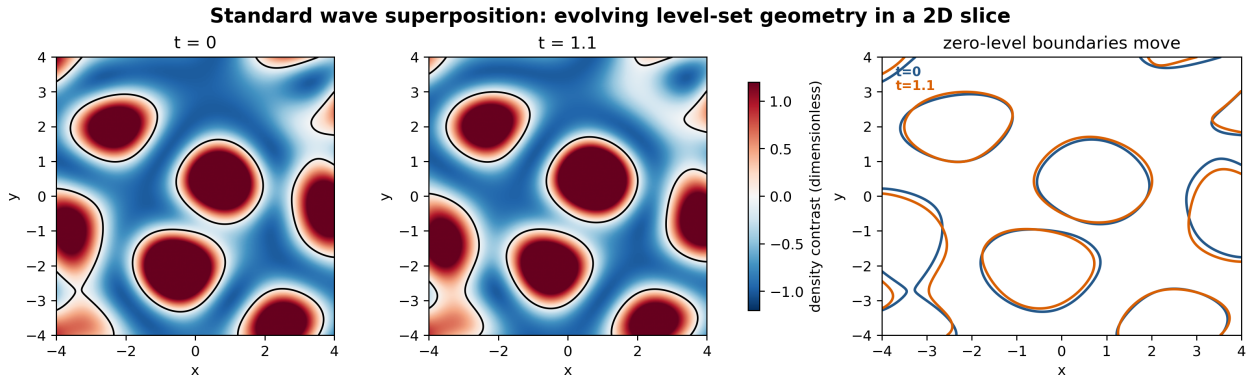


Figure 4. Illustrative standard wave superposition, not observational data and not an RBFL fit. The left and middle panels show a two-dimensional slice of a three-dimensional wave field at two times; black curves are zero-density-contrast level sets. The right panel overlays the level sets to show that the boundaries move under ordinary phase evolution.

6 From contours to genuine moving domains

6.1 Level sets

Define the dark-density contrast

$$\delta_X(\mathbf{x}, t) = \frac{\rho_X(\mathbf{x}, t) - \bar{\rho}_X(t)}{\bar{\rho}_X(t)}. \quad (6.1)$$

For any threshold c , define a surface

$$\Sigma_c(t) = \{\mathbf{x} : \delta_X(\mathbf{x}, t) = c\}. \quad (6.2)$$

A zero-crossing surface uses $c = 0$. In three spatial dimensions this is a two-dimensional surface, even though a plot usually shows only a line where that surface intersects a two-dimensional slice. Level-set methods are standard tools for evolving implicit surfaces [8, 9].

For a general level-set function $F(\mathbf{x}, t)$ with $F = 0$ on the interface, the unit normal is

$$\mathbf{n} = \frac{\nabla F}{|\nabla F|}, \quad (6.3)$$

and the normal interface speed is

$$v_{\Sigma, n} = -\frac{\partial_t F}{|\nabla F|}. \quad (6.4)$$

6.2 A contour is not automatically a wall

This distinction is central. A line or surface drawn at $\delta_X = c$ is a geometrical level set. It becomes a dynamically meaningful separatrix or trapping boundary only if the solved dynamics shows one or more of the following:

- suppressed normal current $\mathbf{J}_X \cdot \mathbf{n}$ across the surface;
- a persistent change in flow topology across the surface;
- a genuine potential barrier or turning surface in the Hamiltonian;
- a bound or long-lived quasi-bound eigenmode localized to the domain;
- a residence time substantially longer than the local crossing time.

Therefore the visual appearance of closed light/dark regions in [figure 1](#) is motivation, not proof of containment.

6.3 Bound-state gate

For a time-independent effective potential, a true stationary bound mode satisfies

$$\hat{H}u_n = E_n u_n, \quad \hat{H} = -\frac{\hbar^2}{2m_X} \nabla^2 + m_X \Phi, \quad (6.5)$$

with a normalizable eigenfunction and energy below the continuum threshold appropriate to the chosen asymptotic convention. A quasi-bound state is a resonance with finite lifetime. This spectral test is more rigorous than declaring a visually closed contour to be a container.

7 Accumulation = 3D wave transport integrated over time

7.1 The exact moving-domain equation

Let $D(t)$ be a three-dimensional domain whose boundary $\partial D(t)$ moves with velocity $\mathbf{v}_\Sigma$. The field mass inside is

$$M_D(t) = \int_{D(t)} \rho_X dV. \quad (7.1)$$

The Reynolds transport theorem gives

$$\frac{d}{dt} \int_{D(t)} \rho_X dV = \int_{D(t)} \frac{\partial \rho_X}{\partial t} dV + \oint_{\partial D(t)} \rho_X \mathbf{v}_\Sigma \cdot \mathbf{n} dA. \quad (7.2)$$

Using continuity, [equation \(4.5\)](#), and the divergence theorem,

$$\boxed{\frac{dM_D}{dt} = - \oint_{\partial D(t)} (\mathbf{J}_X - \rho_X \mathbf{v}_\Sigma) \cdot \mathbf{n} dA.} \quad (7.3)$$

This is the central accumulation equation of the theory. It is not a new law; it is the Reynolds transport theorem applied to a conserved wave-field density [\[10\]](#).

Integrating from t_0 to t_1 ,

$$\boxed{\Delta M_D = - \int_{t_0}^{t_1} dt \oint_{\partial D(t)} (\mathbf{J}_X - \rho_X \mathbf{v}_\Sigma) \cdot \mathbf{n} dA.} \quad (7.4)$$

ACCUMULATION = 3D WAVE MECHANICS OVER TIME

More precisely: accumulation is the time integral of the net field current relative to a moving three-dimensional domain boundary, as given by [equation \(7.4\)](#).

7.2 What counts as secular accumulation

For outward normal $\mathbf{n}$, a domain gains mass when the time-averaged relative outward flux is negative:

$$\boxed{\left\langle \oint_{\partial D(t)} (\mathbf{J}_X - \rho_X \mathbf{v}_\Sigma) \cdot \mathbf{n} dA \right\rangle_T < 0.} \quad (7.5)$$

A visually oscillating domain for which the positive and negative fluxes cancel over each cycle has

$$\Delta M_D(T) = 0 \quad (7.6)$$

and therefore does *not* accumulate despite continuous wave activity.

7.3 The relabeling trap

If $D(t)$ is defined only by a density threshold, its mass can change partly because the threshold surface moves through a pre-existing density field. [Equation \(7.3\)](#) handles this correctly through the $\rho_X \mathbf{v}_\Sigma$ term. A valid claim of physical accumulation should

therefore report both the Eulerian current $\mathbf{J}_X$ and the boundary velocity $\mathbf{v}_\Sigma$, not merely the mass enclosed by an isocontour.

7.4 4D spacetime statement

The phrase “3D or 4D over time” is made precise as follows. Three spatial dimensions plus time form a 3+1 dimensional spacetime. For any conserved four-current J^μ satisfying

$$\nabla_\mu J^\mu = 0, \quad (7.7)$$

the four-dimensional divergence theorem applied to the spacetime world-tube Ω_4 swept out by $D(t)$ gives

$$\int_{\partial\Omega_4} J^\mu d\Sigma_\mu = 0. \quad (7.8)$$

The difference between the content on the initial and final spacelike slices is balanced by the current through the timelike side wall. Thus the slogan has an exact covariant analogue:

Accumulation = net conserved-current flux
through a 4D moving-domain world-tube.

For a real scalar without an exact $U(1)$ number symmetry, [equation \(7.8\)](#) should be applied to an actually conserved current or to stress-energy rather than interpreted as exact particle-number conservation.

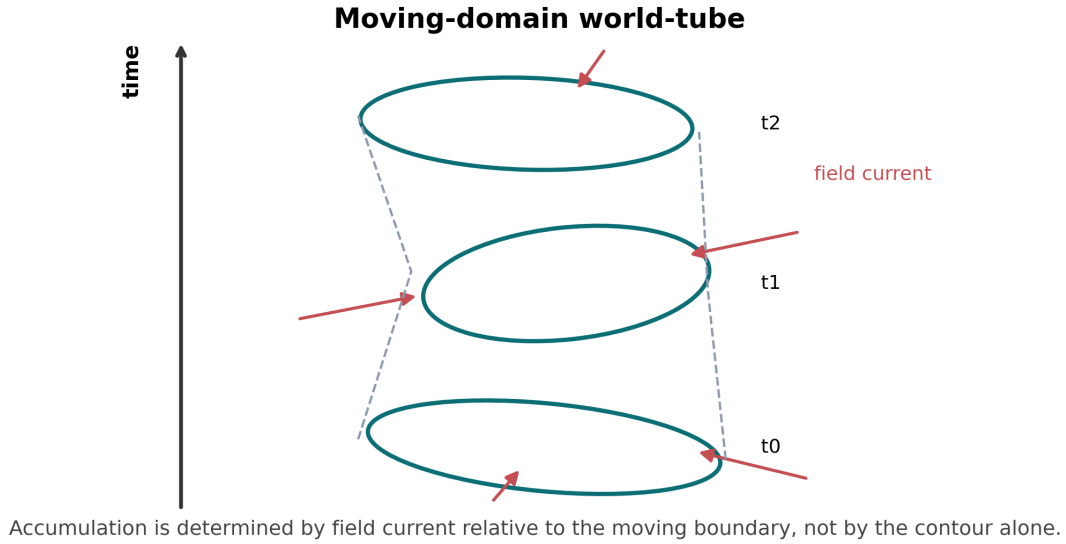


Figure 5. World-tube interpretation of a moving three-dimensional domain. The domain shape changes with time. The quantity that controls accumulation is field current relative to the moving boundary, not the existence of a closed contour.

8 How a galaxy can organize the field without inventing new physics

8.1 Baryonic potential

Split the potential into visible and dark contributions,

$$\Phi(\mathbf{x}, t) = \Phi_b(\mathbf{x}, t) + \Phi_X(\mathbf{x}, t), \quad (8.1)$$

with

$$\nabla^2 \Phi_b = 4\pi G \rho_b, \quad \nabla^2 \Phi_X = 4\pi G \rho_X. \quad (8.2)$$

The dark wave evolves in the total potential through equation (3.3).

8.2 Rotation is not enough; time-dependent structure is required

A perfectly axisymmetric disk can rotate while its gravitational potential remains stationary. In that limit

$$\partial_t \Phi_b = 0, \quad (8.3)$$

so rotation does not by itself “shake” the dark field. The theory requires actual non-axisymmetric or evolving mass structure.

A conventional Fourier representation is

$$\Phi_b(R, \phi, z, t) = \Phi_0(R, z) + \sum_{m \geq 1} \Phi_m(R, z) \cos[m(\phi - \Omega_{p,m}t) + \delta_m]. \quad (8.4)$$

Here $\Omega_{p,m}$ is the pattern speed of the m th non-axisymmetric component. The material angular frequency is

$$\Omega(R) = \frac{v_\phi(R)}{R}, \quad (8.5)$$

and a standard dimensionless shear parameter is

$$q(R) = -\frac{d \ln \Omega}{d \ln R}. \quad (8.6)$$

The dimensional shear rate may equivalently be written $S = R d\Omega/dR$.

8.3 Rotating frame

For a single rigidly rotating pattern with angular speed Ω_p , transformation to the rotating frame gives the standard Hamiltonian

$$\hat{H}_{\text{rot}} = \hat{H} - \Omega_p \hat{L}_z. \quad (8.7)$$

Multiple pattern speeds or differential evolution generally prevent one global rotating frame from removing the time dependence.

8.4 Energy and angular-momentum exchange identity

For a quantum system with an explicitly time-dependent Hamiltonian,

$$\frac{d}{dt} \langle H \rangle = \left\langle \frac{\partial H}{\partial t} \right\rangle. \quad (8.8)$$

For the external baryonic potential term, the power transferred into the wave field is therefore

$$P_{b \rightarrow X} = \int \rho_X(\mathbf{x}, t) \frac{\partial \Phi_b}{\partial t} dV. \quad (8.9)$$

For a rigid pattern $\Phi_b(R, \phi - \Omega_p t, z)$,

$$\partial_t \Phi_b = -\Omega_p \partial_\phi \Phi_b. \quad (8.10)$$

Define the torque on the dark field as

$$\tau_z = - \int \rho_X \partial_\phi \Phi_b dV. \quad (8.11)$$

Then

$$\boxed{P_{b \rightarrow X} = \Omega_p \tau_z.} \quad (8.12)$$

This is a crucial accounting result: if a rotating baryonic pattern pumps energy into the dark field, that energy came from the pattern’s mechanical/gravitational energy budget. A later converter cannot count it as dark-sector energy harvested from nowhere.

The publishable hypothesis is not “rotation creates dark matter.” It is: a time-dependent baryonic gravitational potential can mix and redistribute the modes of an already-existing wave-like dark component. Whether that produces a persistent, non-zero accumulation bias is determined by [equation \(7.3\)](#), not by analogy.

9 Self-gravity, trapping, and visible matter response

9.1 Self-consistent feedback

The minimal self-gravitating loop is

$$\psi \longrightarrow \rho_X = m_X |\psi|^2 \longrightarrow \Phi_X \longrightarrow \psi.$$

The field therefore need not be a passive tracer. If a density enhancement becomes sufficiently self-gravitating, it modifies the potential that governs subsequent evolution. Wave-dark-matter simulations already contain this feedback through Schrödinger–Poisson [3, 4].

9.2 Virial and bound-state checks

A persistent clump should be tested using the established energy and virial diagnostics of the chosen model. For an isolated non-relativistic self-gravitating wave system, define kinetic/gradient energy

$$K = \int \frac{\hbar^2}{2m_X} |\nabla \psi|^2 dV, \quad (9.1)$$

and gravitational self-energy

$$W = \frac{1}{2} \int \rho_X \Phi_X dV. \quad (9.2)$$

For a relaxed isolated state without extra interactions, a virial relation of the familiar $2K + W \simeq 0$ form provides a consistency check, subject to surface terms and the exact conventions of the simulation. A transient interference maximum that fails every bound-state/virial/residence test should not be called accumulated matter.

9.3 Ordinary baryons need no new drift force

Visible stars can be described by the collisionless Boltzmann equation

$$\boxed{\frac{\partial f_b}{\partial t} + \mathbf{v} \cdot \nabla_{\mathbf{x}} f_b - \nabla \Phi \cdot \nabla_{\mathbf{v}} f_b = 0,} \quad (9.3)$$

with

$$\rho_b(\mathbf{x}, t) = \int f_b(\mathbf{x}, \mathbf{v}, t) d^3v. \quad (9.4)$$

Gas can be treated with the Euler or MHD equations. Thus if a dark-wave concentration changes Φ , ordinary matter responds through standard dynamics. The earlier RBFL drift-diffusion expression can remain an interpretive sandbox, but it is unnecessary in the established-mathematics version of the theory.

10 Projection into halo and lensing observables

10.1 Three-dimensional density to two-dimensional surface density

The dark field is three-dimensional. An observer usually receives a projected quantity. The projected surface density is

$$\boxed{\Sigma_X(X, Y) = \int_{-\infty}^{+\infty} \rho_X(X, Y, z) dz.} \quad (10.1)$$

This is the mathematically disciplined version of the project insight that an apparently irregular two-dimensional map may be the projection of a structured three-dimensional field.

10.2 Weak-lensing convergence

For a thin lens, the standard convergence is

$$\kappa(X, Y) = \frac{\Sigma_b(X, Y) + \Sigma_X(X, Y)}{\Sigma_{\text{crit}}}, \quad (10.2)$$

where

$$\Sigma_{\text{crit}} = \frac{c^2}{4\pi G} \frac{D_s}{D_l D_{ls}}. \quad (10.3)$$

The rest of the lensing pipeline – potential, deflection, shear, and source-plane mapping – follows standard gravitational-lensing theory [11].

10.3 Halo dominance is not an edge-creation claim

Define

$$\mathcal{R}_X(r) = \frac{|\mathbf{g}_X(r)|}{|\mathbf{g}_b(r)|}, \quad \mathbf{g}_X = -\nabla\Phi_X. \quad (10.4)$$

The outer galaxy can become “dark dominated” because $|\mathbf{g}_b|$ declines while $|\mathbf{g}_X|$ declines differently. No special physical wall at the visible edge is required. The theory therefore predicts a radial change in relative contribution, not the creation of dark matter at an edge.

10.4 What the RBFL clump figure can and cannot mean

Figure 2 becomes scientifically meaningful only if an independently evolved three-dimensional ρ_X field, projected through equation (10.1), predicts clump/filament/void statistics or lensing structure without placing peaks after seeing the target map. The figure itself is not evidence. It is a target morphology that the field equations must either reproduce or fail to reproduce.

11 RBFL correspondence: a test, not a replacement for the field equations

The standard wave-field calculation predicts

$$\mathbf{g}_X = -\nabla\Phi_X. \quad (11.1)$$

The locked RBFL law, [equation \(1.1\)](#), predicts an additional aligned response

$$\mathbf{g}_\Phi^{\text{RBFL}} = C_\Phi \sqrt{a_\Phi |\mathbf{g}_b|} \hat{\mathbf{g}}_b. \quad (11.2)$$

Therefore the field solution can be mapped into an RBFL-implied coefficient

$$C_\Phi^{\text{field}}(\mathbf{x}, t) = \frac{\mathbf{g}_X \cdot \hat{\mathbf{g}}_b}{\sqrt{a_\Phi |\mathbf{g}_b|}}, \quad (11.3)$$

where $|\mathbf{g}_b| > 0$. Near baryonic-field nulls this diagnostic becomes ill-conditioned and should be excluded or regularized by a predeclared rule.

11.1 Transverse falsification test

RBFL's compact form carries the extra response along $\hat{\mathbf{g}}_b$. Define

$$\mathbf{g}_{X,\perp} = \mathbf{g}_X - (\mathbf{g}_X \cdot \hat{\mathbf{g}}_b) \hat{\mathbf{g}}_b \quad (11.4)$$

and

$$\epsilon_\perp = \frac{|\mathbf{g}_{X,\perp}|}{|\mathbf{g}_X|}. \quad (11.5)$$

If $\epsilon_\perp$ is generically large in the regime where the compact RBFL law is supposed to apply, the proposed correspondence fails. This is a stronger test than simply fitting a radial amplitude.

11.2 No feedback from the detector into the law

The project architecture requires that rotation, lensing, detector residuals, and harvesting terms not be inserted as hidden force multipliers [20]. In this paper, standard field theory generates ρ_X , Φ_X , and $\mathbf{g}_X$ first. RBFL is then evaluated as a separate correspondence layer.

12 Harvesting branch: conservation before conversion

12.1 Accumulation does not imply harvestability

A static bound halo can have large mass and energy density while supplying no usable cyclic power. Harvestability requires an energy-transfer channel and either incoming flux, depletion of stored field energy, or an external source doing work.

Let $T_X^{\mu\nu}$ be the dark-sector stress-energy tensor and $T_{\text{vis}}^{\mu\nu}$ the visible-sector tensor. If the sectors interact, write

$$\boxed{\nabla_\mu T_X^{\mu\nu} = -Q^\nu, \quad \nabla_\mu T_{\text{vis}}^{\mu\nu} = +Q^\nu.} \quad (12.1)$$

Total stress-energy remains conserved.

12.2 Interaction Lagrangian

The general statement is

$$\boxed{\mathcal{L} = \mathcal{L}_X + \mathcal{L}_{\text{SM}} + \mathcal{L}_{\text{int}}.} \quad (12.2)$$

The interaction must come from a specific dark-matter model. For example, axion-like theories contain the established operator

$$\mathcal{L}_{a\gamma} = -\frac{1}{4}g_{a\gamma\gamma}aF_{\mu\nu}\tilde{F}^{\mu\nu}, \quad (12.3)$$

which underlies real axion-conversion searches [13, 14, 15]. A scalar field could instead possess scalar portal operators, subject to laboratory and astrophysical constraints. These examples demonstrate that conversion mathematics exists; they do not establish that the field postulated here has a useful coupling.

12.3 Energy-flux gate

In a local inertial frame, let u_X denote dark-sector energy density and S_X the associated energy flux. The integrated energy ledger for a control volume is schematically

$$\frac{dE_X}{dt} = - \oint_{\partial V} \mathbf{S}_X \cdot \mathbf{n} dA - P_{X \rightarrow \text{vis}} + P_{\text{source}}. \quad (12.4)$$

For a cyclic converter whose own stored energy returns to its initial value,

$$\boxed{W_{\text{load}} = W_{\text{drive}} + E_{X,\text{in}} - E_{X,\text{out}} - E_{\text{loss}}.} \quad (12.5)$$

Therefore

$$\boxed{W_{\text{load}} - W_{\text{drive}} > 0 \quad \Rightarrow \quad E_{X,\text{in}} - E_{X,\text{out}} > E_{\text{loss}},} \quad (12.6)$$

provided every conventional heat, electromagnetic, mechanical, chemical, gravitational, and rotational input has been included.

12.4 Flux ceiling

If an ambient component with energy density u_X streams through an effective area A_{eff} at characteristic speed v_X , a purely kinematic upper scale is

$$P_{\text{flux}} \sim u_X v_X A_{\text{eff}}. \quad (12.7)$$

A converter with efficiency $0 \leq \eta \leq 1$ must satisfy

$$P_{\text{out}} \leq \eta P_{\text{flux}} \quad (12.8)$$

unless it also depletes energy already stored in the volume. Taking $u_X = \rho_X c^2$ gives only an absolute rest-energy ceiling; it does *not* imply that rest mass is actually convertible by the interaction under consideration. For many couplings only a much smaller portion of the field energy is accessible.

12.5 The baryonic-drive subtraction

The energy exchange in equation (8.9) is a conventional input. If a time-dependent galaxy or laboratory potential supplies power $P_{b \rightarrow X}$ and the output later returns that same energy, the system is a transducer of baryonic/drive power, not a dark-sector harvester. A credible dark-sector claim requires the residual after subtracting this term and all other conventional sources.

Level 1 – Field-state transducer: output is fully accounted for by drive energy and ordinary field storage.

Level 2 – External-background dependence: after drive subtraction, an output or state variable depends reproducibly on an external background not controlled by the apparatus.

Level 3 – Dark-sector attribution: the residual tracks a predeclared dark-sector observable or field prediction, survives conventional nulls, and obeys the stress-energy ledger.

Until Level 3, the responsible label is **Dark-Sector Gradient Harvesting Hypothesis**, not demonstrated dark-matter harvesting.

13 Specific predictions that distinguish the theory from a slogan

The theory is useful only if it produces statements that can fail.

13.1 Prediction P1: interference domains move in full 3D

A solved wave field should contain time-dependent level-set surfaces $\Sigma_c(t)$ whose motion is predicted by the field equations, not drawn post hoc. The two-dimensional contour patterns should change when viewed at different z slices and different times.

13.2 Prediction P2: accumulation requires a non-zero relative-flux integral

Any domain claimed to accumulate must satisfy equation (7.4). A closed contour with $\Delta M_D = 0$ is not an accumulator.

13.3 Prediction P3: true containment requires dynamics beyond a contour

Long-lived clumps must exhibit bound/quasi-bound spectra, suppressed normal current, long residence time, self-gravitating support, or equivalent dynamical evidence. A threshold contour alone is insufficient.

13.4 Prediction P4: a steady axisymmetric galaxy does not provide the proposed time-dependent drive

With $\partial_t \Phi_b = 0$, the explicit external-drive power in equation (8.9) vanishes. If the claimed effect requires rotational forcing, it must arise from non-axisymmetric/evolving structure or from initial/self-consistent wave dynamics.

13.5 Prediction P5: projection must be multi-observable

The same three-dimensional solution should predict rotation/dynamics and projected lensing quantities without placing a separate free halo for each observable. A projection that fits only after independent target-specific tuning fails the theory's intended economy.

13.6 Prediction P6: RBFL correspondence is optional and falsifiable

The standard field solution must either satisfy the RBFL amplitude/alignment tests equations (11.3) and (11.5) in the claimed regime or it does not. The standard wave theory remains mathematically valid even if RBFL fails.

13.7 Prediction P7: harvesting requires an independent energy flux or depletion term

If a closed cycle has no dark-sector energy flux, no stored dark-field depletion, and no unaccounted external source, then net output above drive and losses is forbidden by conservation.

14 Engineer-ready proof and falsification program

In experimental science one does not “prove” a physical theory by algebra. One first proves internal mathematical consistency, then attempts to falsify the physical hypotheses with simulation, observation, and experiment. The following program is designed so a computational physicist or engineer can begin without accepting RBFL.

14.1 WP0 – Reproduce the standard equations

Implement the 3D Schrödinger–Poisson system equations (3.3) and (3.4). Before any rotating potential is introduced, verify:

- convergence under spatial and temporal refinement;
- conservation of $N_X = \int |\psi|^2 dV$ for closed/periodic boundaries;
- conservation of the appropriate total energy for a time-independent isolated problem;
- Poisson residuals and boundary-condition convergence;
- known test solutions such as free-wave propagation and stationary self-gravitating states.

14.2 WP1 – Static-potential null

Choose a static $\Phi_b(\mathbf{x})$. Evolve multiple phase realizations. Extract the same predeclared level-set thresholds c . Measure $M_D(t)$ and the two terms in [equation \(7.3\)](#). The default expectation is no systematic secular growth attributable solely to a periodically relabelled contour.

14.3 WP2 – Time-dependent non-axisymmetric potential

Introduce a controlled potential of the form [equation \(8.4\)](#). Sweep pattern speed, amplitude, and geometry using predeclared ranges. Record

$$P_{b \rightarrow X}(t) = \int \rho_X \partial_t \Phi_b dV \quad (14.1)$$

and torque simultaneously. This prevents energy transferred from the baryonic pattern from being misidentified as dark-field energy creation.

14.4 WP3 – Moving-domain transport

For every candidate domain:

1. construct $F(\mathbf{x}, t) = \delta_X - c$ on the 3D grid;
2. reconstruct $\partial D(t)$ with a standard isosurface algorithm;
3. compute $\mathbf{n} = \nabla F / |\nabla F|$;
4. compute $v_{\Sigma, n}$ from [equation \(6.4\)](#);
5. compute $\mathbf{J}_X$ from [equation \(4.4\)](#);
6. surface-integrate the relative flux in [equation \(7.3\)](#);
7. independently compute $M_D(t)$ by volume integration;
8. verify that the differential and integral forms agree to numerical tolerance.

This agreement is a stringent code-level conservation check.

14.5 WP4 – Persistence and trapping

For any domain with $\Delta M_D > 0$, test whether the growth represents actual retention rather than transient threshold motion. Compute current topology, residence time,

bound/quasi-bound spectra when applicable, and response to turning off the time-dependent forcing. A domain that instantly disperses when forcing stops is a driven concentration, not a self-sustaining clump.

14.6 WP5 – Add self-gravity

Turn on Φ_X in Poisson’s equation. Repeat WP1–WP4. Determine whether self-gravity stabilizes, erases, merges, or fragments the wave domains. Track the energy terms and virial diagnostics.

14.7 WP6 – Baryonic tracers

Evolve collisionless tracers with equation (9.3) or gas with standard hydrodynamics in the same $\Phi_b + \Phi_X$. Test whether visible matter statistically traces the predicted potential wells without an extra phenomenological attraction term.

14.8 WP7 – Projection and independent observable tests

Compute Σ_X , κ , shear, rotation curves, and any other predeclared observable. Blind the 3D field solution before comparing it with target maps wherever possible. Use wrong-depth, wrong-centre, phase-scrambled, and mass-shuffled nulls.

14.9 WP8 – RBFL correspondence

Only after WP0–WP7, compute C_Φ^{field} and $\epsilon_\perp$. No parameter in the Schrödinger–Poisson simulation may be retroactively changed to improve the RBFL handshake unless that change belongs to a separately declared model comparison.

14.10 WP9 – Harvesting mathematics, only if a coupling is specified

Choose a physically motivated $\mathcal{L}_{\text{int}}$ already consistent with particle-physics constraints. Derive Q^ν from the action, compute the energy exchange, and close equation (12.5). No hardware claim is needed. The theoretical branch succeeds only if it identifies a non-zero allowed conversion channel and a replenishing energy source/flux without double counting the baryonic drive.

14.11 Recommended numerical formulations

The mathematics does not force one solver. Established options include split-step Fourier/pseudospectral Schrödinger evolution for periodic domains, Crank–Nicolson or finite-difference schemes for isolated geometries, FFT or multigrid Poisson solvers, and marching-cubes/level-set methods for surfaces. Whichever method is used, the conservation and convergence gates take precedence over visual similarity.

14.12 Dimensionless form for numerical work

Choose a characteristic length L_0 , speed v_0 , time $t_0 = L_0/v_0$, and potential scale $\Phi_0 = v_0^2$. Define

$$\epsilon = \frac{\hbar}{m_X L_0 v_0} = \frac{\lambda_{\text{dB}}}{2\pi L_0} \quad (14.2)$$

for a representative v_0 . With suitable density scaling, the dimensionless Schrödinger equation takes the familiar form

$$i\epsilon \partial_{\tilde{t}} \tilde{\psi} = \left[-\frac{\epsilon^2}{2} \tilde{\nabla}^2 + \tilde{\Phi} \right] \tilde{\psi}. \quad (14.3)$$

Resolving the wave physics requires grid spacing and timestep sufficient to resolve the relevant de Broglie wavelength and phase evolution; otherwise apparent smoothing or accumulation can be a numerical artifact.

15 Null tests and failure modes

Table 2. Predeclared nulls and what each one protects against.

Null/control	Operation	Failure protected against
Static potential	Set $\partial_t \Phi_b = 0$ while keeping mass distribution fixed	Mistaking ordinary interference or numerical drift for driven accumulation
Axisymmetric control	Remove bar/spiral/non-axisymmetric terms	Claiming that mere rotation of an axisymmetric disk changes the potential
Phase-scramble	Randomize initial mode phases at fixed power spectrum	Post-hoc phase selection

Null/control	Operation	Failure protected against
Pattern reversal	Reverse pattern rotation where symmetry permits	Tests sign/torque dependence and coding errors
No self-gravity	Set $\Phi_X = 0$	Distinguishes imposed-field focusing from self-gravitating stabilization
Wrong centre/depth	Shift source geometry before projection	Projection coincidence and target leakage
Resolution sweep	Increase spatial/time resolution and domain size	Grid pinning, aliasing, boundary reflections, under-resolution
Flux identity	Compare surface-flux integral with dM_D/dt	Moving-boundary bookkeeping errors
Energy ledger	Track all drive, boundary, and interaction work	Free-energy misclassification
Holdout observables	Predict data not used in calibration	Overfitting of morphology or RBFL response

The accumulation hypothesis fails for a tested model if the long-time relative-flux integral converges to zero, changes sign arbitrarily with resolution, or is entirely attributable to boundary relabeling. The harvesting hypothesis fails if no allowed coupling exists or if every positive output is accounted for by baryonic drive, heat, electromagnetic input, stored energy, numerical non-conservation, or other conventional sources.

16 Definition and symbol dictionary

Table 3. Primary symbols. SI dimensions are shown for the non-relativistic sections.

Symbol	Definition	Typical SI dimension
$\mathbf{x} = (x, y, z)$	Three-dimensional spatial position	m
t	Time	s
X	Relativistic dark scalar field	convention dependent

Symbol	Definition	Typical SI dimension
ψ	Non-relativistic field envelope normalized so $ \psi ^2 = n_X$	$\text{m}^{-3/2}$
m_X	Dark-sector boson mass	kg (or eV/c^2)
n_X	Number density $ \psi ^2$	m^{-3}
ρ_X	Dark-sector mass density $m_X \psi ^2$	kg m^{-3}
ρ_b	Baryonic mass density	kg m^{-3}
Φ_b	Baryonic gravitational potential	$\text{m}^2 \text{s}^{-2}$
Φ_X	Dark-field gravitational potential	$\text{m}^2 \text{s}^{-2}$
Φ	Total weak-field potential $\Phi_b + \Phi_X$	$\text{m}^2 \text{s}^{-2}$
$\mathbf{g}_b$	Baryonic acceleration $-\nabla\Phi_b$	m s^{-2}
$\mathbf{g}_X$	Dark-field acceleration $-\nabla\Phi_X$	m s^{-2}
S	Madelung phase action in $\psi = \sqrt{n_X}e^{iS/\hbar}$	J s
$\mathbf{v}_X$	Wave-fluid velocity $\nabla S/m_X$	m s^{-1}
$\mathbf{j}_N$	Number current	$\text{m}^{-2} \text{s}^{-1}$
$\mathbf{J}_X$	Mass current $\rho_X \mathbf{v}_X$	$\text{kg m}^{-2} \text{s}^{-1}$
δ_X	Density contrast	dimensionless
$\Sigma_c(t)$	Level-set surface $\delta_X = c$	2D surface embedded in 3D space
$\mathbf{v}_\Sigma$	Velocity of moving level-set surface	m s^{-1}
$D(t)$	Moving three-dimensional domain	m^3 region
M_D	Dark-field mass contained in $D(t)$	kg
$\Omega(R)$	Material angular frequency	s^{-1}
Ω_p	Pattern speed of a non-axisymmetric structure	s^{-1}
q	Dimensionless shear parameter $-\text{d} \ln \Omega / \text{d} \ln R$	dimensionless
τ_z	z -component of gravitational torque	N m
Σ_X	Projected dark surface density	kg m^{-2}
Σ_{crit}	Critical lensing surface density	kg m^{-2}
κ	Lensing convergence	dimensionless
$T_X^{\mu\nu}$	Dark-sector stress-energy tensor	J m^{-3} in energy-density components
Q^ν	Four-density of energy-momentum exchange between sectors	convention dependent; Q^0 maps to power density in local frame

Symbol	Definition	Typical SI dimension
S_X	Dark-sector energy flux	W m^{-2}
C_Φ	RBFL dimensionless coherence/response coefficient	dimensionless
a_Φ	RBFL acceleration scale	m s^{-2}
$\mathcal{R}_X$	Dark-to-baryonic acceleration ratio	dimensionless
$\epsilon_\perp$	Transverse-field fraction in RBFL correspondence test	dimensionless

17 Novelty boundary and publication language

17.1 What the literature already contains

Wave-dark-matter interference, solitonic structure, and granular halo fluctuations are established theoretical topics [3, 4, 7, 6]. Moving-interface kinematics and the Reynolds transport theorem are standard mathematics [8, 10]. Time-dependent boundaries can reorganize quantum modes, as demonstrated by the dynamical Casimir experiment [12]. Axion-to-photon conversion is a mature detection concept [13, 14, 15]. None of those results should be presented as an RBFL discovery.

17.2 The specific synthesis proposed here

The proposed contribution is the combined chain

3D wave field $\rightarrow$ evolving interference domains $\rightarrow$ moving-boundary transport
 $\rightarrow$ secular accumulation test $\rightarrow$ self-gravity/projection
 $\rightarrow$ RBFL correspondence test $\rightarrow$ flux-limited conversion gate.

(17.1)

The physical content is deliberately conditional and therefore falsifiable.

17.3 Suggested citation

Haye, L. S. (2026). *Dark-Sector Accumulation and Gradient Harvesting from Time-Evolving Wave Domains: An Established-Mathematics Theory with RBFL Correspondence*, version 1.0, RBFL Research Project, 24 September 2026. <https://rbfl.link>

17.4 Recommended abstract-level priority wording

A defensible wording for public release is:

“This note presents a dated synthesis in which a wave-like dark component is evolved with standard three-dimensional field dynamics; time-evolving interference domains are treated as moving control volumes; secular accumulation is defined by the relative-flux form of the Reynolds transport theorem; and any later energy-conversion claim is gated by stress-energy conservation. A separate correspondence test asks whether the standard-field gravitational response can reproduce the locked RBFL phenomenology.”

18 Conclusions

The theory can be reduced to four equations and one firewall.

First, the field evolves in three spatial dimensions:

$$i\hbar\partial_t\psi = \left[-\frac{\hbar^2}{2m_X}\nabla^2 + m_X(\Phi_b + \Phi_X) \right] \psi.$$

Second, its density gravitates:

$$\nabla^2\Phi_X = 4\pi Gm_X|\psi|^2.$$

Third, accumulation inside an evolving domain is exactly the relative-flux statement

$$\boxed{\frac{dM_D}{dt} = - \oint_{\partial D(t)} (\mathbf{J}_X - \rho_X \mathbf{v}_\Sigma) \cdot \mathbf{n} \, dA.}$$

Fourth, any interaction with an observable sector must conserve total stress-energy:

$$\nabla_\mu (T_X^{\mu\nu} + T_{\text{vis}}^{\mu\nu}) = 0.$$

The firewall is that none of these equations authorizes a free-energy claim. Constructive interference can concentrate density; a moving gravitational pattern can do work; self-gravity can stabilize a field configuration; projection can make three-dimensional structure appear as a two-dimensional halo; and an allowed portal can convert energy. But each energy source remains explicitly identifiable.

The shortest physically accurate version of the thesis is therefore:

Accumulation = 3D wave transport integrated over time.

In 4D: accumulation = net conserved-current flux through a moving-domain world-tube.

Harvesting = conversion of independently supplied dark-sector energy flux or stored-field depletion, never organization alone.

If the long-time relative-flux integral is zero, the accumulation mechanism fails for that model. If no allowed coupling exists, the harvesting branch fails even if accumulation is real. If all output energy traces back to the time-dependent baryonic potential, the system is a conventional gravitational/rotational transducer rather than a dark-sector harvester. These are strengths, not weaknesses: the proposal makes itself vulnerable to decisive tests.

A Derivation of the continuity equation from Schrödinger dynamics

Start from equation (3.3) and its complex conjugate,

$$i\hbar\partial_t\psi = -\frac{\hbar^2}{2m_X}\nabla^2\psi + m_X\Phi\psi, \quad (\text{A.1})$$

$$-i\hbar\partial_t\psi^* = -\frac{\hbar^2}{2m_X}\nabla^2\psi^* + m_X\Phi\psi^*. \quad (\text{A.2})$$

Multiply the first by ψ^* , the second by ψ , subtract, and use

$$\psi^*\nabla^2\psi - \psi\nabla^2\psi^* = \nabla \cdot (\psi^*\nabla\psi - \psi\nabla\psi^*). \quad (\text{A.3})$$

The real potential terms cancel, yielding

$$\partial_t|\psi|^2 + \nabla \cdot \left[\frac{\hbar}{m_X} \text{Im}(\psi^*\nabla\psi) \right] = 0. \quad (\text{A.4})$$

Multiplication by m_X produces equations (4.4) and (4.5).

B Derivation of the moving-domain accumulation identity

The Reynolds transport theorem for a scalar density ρ_X over a moving volume $D(t)$ is equation (7.2). Substitute $\partial_t \rho_X = -\nabla \cdot \mathbf{J}_X$ from continuity:

$$\frac{dM_D}{dt} = - \int_{D(t)} \nabla \cdot \mathbf{J}_X dV + \oint_{\partial D(t)} \rho_X \mathbf{v}_\Sigma \cdot \mathbf{n} dA \quad (\text{B.1})$$

$$= - \oint_{\partial D(t)} \mathbf{J}_X \cdot \mathbf{n} dA + \oint_{\partial D(t)} \rho_X \mathbf{v}_\Sigma \cdot \mathbf{n} dA, \quad (\text{B.2})$$

which gives equation (7.3). This derivation makes clear why a moving threshold boundary cannot be treated as stationary.

C Energy functional and the time-dependent potential identity

For the baseline non-relativistic field, a convenient energy functional is

$$E_X = \int \left[\frac{\hbar^2}{2m_X} |\nabla \psi|^2 + \rho_X \Phi_b + \frac{1}{2} \rho_X \Phi_X \right] dV, \quad (\text{C.1})$$

subject to the chosen boundary convention. The factor 1/2 avoids double-counting gravitational self-energy. For a closed numerical domain and an explicitly time-dependent external baryonic potential, differentiating the expectation value yields the external work term

$$\left. \frac{dE_X}{dt} \right|_{\text{external}} = \int \rho_X \partial_t \Phi_b dV, \quad (\text{C.2})$$

which is equation (8.9). The full energy budget must also include boundary fluxes and any interaction terms. This identity provides a direct numerical audit for simulations with rotating patterns.

D Minimal pseudocode for a reproducible 3D numerical test

The following is algorithmic pseudocode, not a prescribed software implementation.

1. Define m_X , L_0 , the 3D grid, boundary conditions, and an initial $\psi(\mathbf{x}, 0)$ indepen-

dent of the target output map.

2. Define a baryonic density $\rho_b(\mathbf{x}, t)$ and solve $\nabla^2 \Phi_b = 4\pi G \rho_b$.
3. Solve $\nabla^2 \Phi_X = 4\pi G m_X |\psi|^2$.
4. Advance ψ one timestep under [equation \(3.3\)](#) with a convergent norm-preserving method.
5. Recompute ρ_X , Φ_X , $\mathbf{J}_X$, and total energy diagnostics.
6. Construct $F = \delta_X - c$ for predeclared thresholds c and reconstruct the 3D isosurfaces.
7. Compute $\mathbf{n}$ and $v_{\Sigma, n}$; evaluate the relative-flux surface integral.
8. Independently integrate $M_D = \int_D \rho_X dV$ and verify the transport identity.
9. Repeat long enough to distinguish bounded oscillation from secular growth.
10. Repeat the entire run for static, axisymmetric, phase-scrambled, no-self-gravity, wrong-centre, and resolution controls.
11. Only after the 3D dynamics is frozen, compute Σ_X , lensing observables, and the RBFL correspondence diagnostics.
12. If and only if a concrete $\mathcal{L}_{\text{int}}$ is specified, derive Q^ν and evaluate the full energy ledger.

E Checklist for a publishable positive result

A future positive paper should report, at minimum:

- the exact field model and parameter values;
- the full 3D initial and boundary conditions;
- convergence with grid, timestep, and box size;
- norm/mass conservation and energy accounting;
- direct verification of [equation \(7.3\)](#) from both sides;
- long-time behavior over many coherence and orbital times;
- null controls defined before target inspection;

- independent evidence of trapping or self-gravitating persistence;
- projected observables predicted from the same 3D field;
- explicit separation of standard-field results from RBFL interpretation;
- if harvesting is claimed, a derived interaction term and stress-energy exchange ledger that closes quantitatively.

Authorship and provenance statement

The theory proposal, conceptual synthesis, RBFL correspondence, and dated priority record in this document are attributed to **Levi S. Haye** and the RBFL Research Project. Standard mathematical frameworks and prior physical results are explicitly cited and are not claimed as original contributions. Figures 1 and 2 are derived from prior RBFL project work by the same author; all additional schematics in this note are explanatory visualizations of the equations stated here. The priority claim is limited to the specific synthesis and falsification program defined in this versioned record.

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