4DKC (Four-Dimensional Kinetic Cosmology)
A Flow-Based Alternative to Spacetime Curvature

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July 2026

Abstract

General Relativity provides an extraordinarily successful geometric description of gravity, relating the distribution of energy and momentum to the curvature of spacetime. It does not however, identify an underlying dynamical mechanism by which gravitational phenomena emerge, nor does it provide a global accounting of gravitational energy. Its expected breakdown in regimes approaching singularities suggests that a more fundamental description may exist.

Four-Dimensional Kinetic Cosmology (4DKC) proposes such a description by replacing curved spacetime with a flat four-dimensional Euclidean manifold whose fundamental dynamical variable is a scalar hypersurface flow field.

Our observable three-dimensional universe is a moving hypersurface progressing through an additional spatial dimension (L). Physical time emerges from the cumulative progression of this hypersurface rather than existing as a fundamental coordinate. Gravity is not spacetime curvature; it is the observable consequence of spatial variations in the local flow velocity produced by continuous electromagnetic extraction of kinetic energy from the background manifold. The resulting flow gradients are experienced as gravity, while propagating wake fields preserve the history of previous extraction events.

In this framework, the metric tensor of General Relativity becomes an effective, emergent description of the underlying flow kinematics in the weak-field limit rather than the fundamental structure of reality. Building on Kaluza's observation that electromagnetism can arise naturally from an additional spatial dimension, 4DKC develops a continuum-mechanical formulation in which gravity, inertia, relativistic time dilation, cosmological redshift, and other relativistic phenomena arise from a single evolving flow field on an intrinsically flat manifold.

The theory provides an explicit physical source for gravitational energy, a global conservation framework, and a mechanistic explanation for the kinetic energy acquired by freely falling bodies. Because its governing equations are expressed as flow dynamics rather than geometric curvature, 4DKC offers a unified kinematic alternative to General Relativity while remaining compatible with its successful weak-field predictions and yielding new experimentally testable predictions in strong-field gravity, cosmology, and quantum phenomena.

0.1 Introduction

Four-Dimensional Kinetic Cosmology begins from a different set of fundamental assumptions than General Relativity. Instead of describing gravity as the curvature of a four-dimensional spacetime, 4DKC proposes that the universe is governed by a scalar flow field defined on a flat four-dimensional Euclidean manifold. The observable universe is a three-dimensional spatial hypersurface progressing through an additional spatial dimension L while physical time emerges from the cumulative progression of this hypersurface rather than existing as a fundamental coordinate.

The theory rests upon four fundamental postulates:

The underlying manifold is flat. Reality is described by a Euclidean four-dimensional manifold with coordinates (x,y,z,L). The manifold possesses no intrinsic curvature; all observable gravitational and relativistic phenomena arise from kinematics rather than geometry.

The fundamental dynamical variable is a scalar flow field. The evolution of the observable universe is governed by the scalar field $v_L(x, y, z, \lambda)$ which specifies the local progression rate of the three-dimensional hypersurface through the fourth spatial dimension.

The affine parameter (λ) labels successive hypersurface states and is not itself a physical coordinate. Time is an emergent quantity defined by the accumulated progression of the hypersurface through (L).

Electromagnetic binding extracts kinetic energy from the background flow. In regions free of significant bound structure, the hypersurface advances uniformly at the baseline rate $v_L = c$. Electromagnetic binding continuously converts kinetic energy from this background flow into stable matter. The resulting reduction in the local flow velocity produces spatial deceleration gradients and launches propagating wake fields that preserve the history of previous extraction events.

Observable physics emerges from variations in the flow field. Gravity, inertia, relativistic time dilation, cosmological redshift, and the arrow of time are all manifestations of the evolving scalar flow field and its associated wake dynamics. The metric tensor of General Relativity is therefore interpreted not as a fundamental property of nature but as an effective geometric description of these flow dynamics in the appropriate limit.

These postulates lead naturally to a continuum-mechanical description of gravity. Instead of asking how energy curves spacetime, 4DKC asks how bound matter modifies the progression of the hypersurface through the underlying manifold. The local flow velocity becomes the fundamental gravitational variable. Regions in which electromagnetic binding extracts kinetic energy from the background flow advance more slowly through the fourth dimension than surrounding regions. The resulting flow gradients are experienced as gravitational acceleration, while the propagating wake generated by continuous extraction produces the long-range, history-dependent behavior of the gravitational field.

The role of the fourth spatial dimension differs fundamentally from that of conventional higher-dimensional theories. It is neither compactified nor an unrestricted direction into which gravitational or electromagnetic fields freely propagate. Instead, L defines the preferred direction of hypersurface motion, while all locally observable dynamics remain confined to the advancing three-dimensional hypersurface. Because gravitational interactions arise from flow gradients within the hypersurface rather than geometric spreading through four spatial dimensions, the inverse-square law is preserved.

The directed progression of the hypersurface through L also establishes a natural distinction between the causally accessible past and the inaccessible future. Observers embedded within the hypersurface can receive information only from regions already traversed by the flow. No influence can propagate backward from positions ahead of the advancing hypersurface. The thermodynamic arrow of time and the causal ordering of events therefore emerge as direct kinematic consequences of the flow rather than as independent postulates.

Within this framework, cosmological phenomena acquire a unified physical interpretation. Cosmological redshift reflects the cumulative effect of flow deceleration along photon trajectories rather than metric expansion. Continuous electromagnetic extraction and replenishment of the background kinetic energy maintain a dynamical equilibrium without requiring an initial cosmological singularity. Persistent wake fields generated by bound structures naturally account for galaxy rotation curves, gravitational lensing, cluster-merger offsets, and large-scale structure through a single underlying mechanism.

The mathematical development that follows formulates these ideas as the dynamics of a scalar flow field on a flat four-dimensional manifold. General Relativity emerges as the effective weak-field approximation to this more fundamental kinematic description, while deviations from the geometric picture produce experimentally testable predictions in strong gravitational fields, cosmology, and quantum phenomena.

0.2 Scalar Flow Field Dynamics

The fundamental dynamical variable of 4DKC is the scalar flow field $v_L(x, y, z, \lambda)$ defined on a flat four-dimensional Euclidean manifold $M_4 = \mathbb{R}^4$ with coordinates (x, y, z, L) where M_4 denotes the manifold itself and $\mathbb{R}^4$ is the four-dimensional Euclidean space of all real coordinate quadruples

$$x, y, z, L$$

.

The metric on this manifold is simply

$$ds^2 = dx^2 + dy^2 + dz^2 + dL^2. \tag{1}$$

There is no intrinsic curvature $R^{\alpha}{}_{\beta\mu\nu} = 0$. All observable relativistic, gravitational, and cosmological phenomena arise from spatial and temporal variations of this single flow field. An affine evolution parameter λ labels successive states of the hypersurface. The locally observable three-dimensional universe corresponds to the hypersurface whose fourth coordinate advances according to the local flow speed

$$v_L(\mathbf{r}, \lambda) = \frac{dL}{d\lambda}. \tag{2}$$

In the absence of bound electromagnetic structure the hypersurface advances uniformly at the baseline rate $v_L = c$. Electromagnetic binding continuously extracts kinetic energy from the flow, producing a local reduction

$$v_L(\mathbf{r}) = c - \delta v_L(\mathbf{r}), \quad \delta v_L > 0 \tag{3}$$

in regions containing bound matter. The deceleration-memory wake field Φ is the accumulated history of these reductions:

$$\Phi(\mathbf{r}, \lambda) = \int^{\lambda} \big(c - v_L(\mathbf{r}, \lambda')\big)\, d\lambda'. \tag{4}$$

Proper time measured by physical clocks on the hypersurface emerges directly from the local flow speed. Including the usual special-relativistic correction for ordinary three-dimensional motion

$$d\tau = \frac{v_L}{c}\, d\lambda \sqrt{1 - \frac{v^2}{c^2}}. \tag{5}$$

Gravity is the gradient of the flow field. Test particles follow trajectories determined by the local velocity gradients according to the Eulerian advection equations

$$\frac{d\mathbf{x}}{d\lambda} = \mathbf{u}, \qquad \frac{d\mathbf{u}}{d\lambda} = -\nabla v_L, \tag{6}$$

or, more generally, $\mathbf{g} = -\nabla\Psi$ where the effective potential $\Psi = f(v_L, \Phi)$ incorporates both the instantaneous flow speed and the accumulated wake memory. This is the direct analogue of continuum mechanics on a flat manifold: the gravitational field is literally the spatial gradient of the hypersurface flow speed. The effective metric of General Relativity emerges as a convenient description of the kinematics induced by variations in v_L. In the weak-field limit the line element

$$ds^2 = dx^2 + dy^2 + dz^2 + dL^2. \tag{7}$$

together with the local reduction

$$v_L(\mathbf{r}) = c - \delta v_L(\mathbf{r}), \quad \delta v_L > 0 \tag{8}$$

reproduces the standard weak-field form of the GR metric

$$\Phi_{\mathrm{GR}}(\mathbf{r}) = -c\,\delta v_L(\mathbf{r}). \tag{9}$$

Thus General Relativity appears as an effective, emergent approximation valid when spatial variations of the hypersurface flow speed are small. The underlying reality remains a flat Euclidean four-dimensional manifold whose only dynamical content is the scalar flow field $v_L(x, y, z, \lambda)$. The governing dynamics of this field are expressed by the advection-diffusion-relaxation equation

$$\frac{\partial v_L}{\partial \lambda} = -\Gamma + D\nabla^2 v_L - \frac{v_L - c}{\tau}, \tag{10}$$

where D is the effective diffusion coefficient governing the spatial propagation of flow disturbances, τ is the relaxation timescale over which the background flow returns toward its equilibrium value, and Γ is the local extraction rate. The source term Γ represents the continuous conversion of kinetic energy from the background flow into stable bound matter through electromagnetic interactions.

The wake field Φ defined in

$$\Phi(\mathbf{r}, \lambda) = \int^{\lambda} \big(c - v_L(\mathbf{r}, \lambda')\big)\, d\lambda'. \tag{11}$$

then acts as the integrated memory of reductions in v_L.

In this formulation, every observable phenomenon: gravitational acceleration, time dilation, redshift, inertia, and the arrow of time, follows from spatial and temporal variations of a single scalar field on a flat four-dimensional Euclidean manifold. General Relativity is recovered as the appropriate weak-field effective description rather than being imposed as a fundamental geometric structure.

0.3 Kinematics and Principles

Because the fundamental dynamical variable is the scalar flow field $v_L(x, y, z, \lambda)$ on a flat four-dimensional Euclidean manifold, all kinematics follow directly from spatial and temporal variations of this single field.

The moving 3D hypersurface can only interact with the portion of the manifold at or behind its current position along L. The forward region exists fully in the geometry but is not yet causally reachable from here and now.

The arrow of time arises from the preferred spatial direction of the hypersurface's uniform motion along L. Entropy increases because of this directed flow. The wake field Φ is not an independent entity but the accumulated memory of reductions in the flow speed:

$$\Phi(\mathbf{r}, \lambda) = \int^{\lambda} \big(c - v_L(\mathbf{r}, \lambda')\big)\, d\lambda'. \tag{12}$$

Gravity is the local deceleration gradient created by electromagnetic binding that extracts kinetic energy density from the moving hypersurface, thereby reducing the local flow speed v_L. Simple deceleration, exactly what we feel as our elevator slows on its approach to the ground floor.

Inertia is the resistance to changing an object's velocity component along the fourth dimension relative to the flow of 3D space, a resistance maintained by ongoing electromagnetic binding and energy extraction processes. This same mechanism also gives rise to gravitational mass, thereby explaining the observed equivalence between inertial and gravitational mass.

0.3.1 Flow-Induced Gravity

Having established the scalar flow field as the fundamental dynamical variable, gravitational phenomena emerge naturally as observable consequences of its evolution rather than as independent postulates.

The local reduction of the hypersurface progression rate, $v_L = c - \delta v_L$, produces spatial gradients in the flow field. Test particles respond directly to these gradients according to Eulerian advection equations (6), while the equivalent effective gravitational potential Ψ provides the convenient macroscopic description

$$\mathbf{g} = -\nabla \Psi. \tag{13}$$

Unlike General Relativity, where the metric tensor is fundamental, 4DKC regards Ψ as a derived quantity that summarizes the underlying flow dynamics. The physical origin of gravitation is therefore the spatial variation of the scalar flow field rather than intrinsic curvature of the manifold.

The total gravitational field naturally separates into two physically distinct contributions. The first is the instantaneous response produced by the local reduction in the flow speed, corresponding to the familiar Newtonian limit in regions where the flow adjusts rapidly to the local extraction rate.

The second arises from the accumulated wake field

$$\Phi(\mathbf{r}, \lambda) = \int^{\lambda} (c - v_L)\, d\lambda', \tag{14}$$

which represents the persistent memory of previous extraction events. Because the wake extends beyond the immediate region of bound matter, it contributes an additional long-range component to the effective gravitational field.

The effective potential may therefore be regarded as a functional of both the instantaneous flow and its accumulated history,

$$\Psi = \Psi(v_L, \Phi), \tag{15}$$

where the first term governs local gravitational behavior while the second introduces history-dependent modifications on larger spatial scales.

This provides a single physical mechanism for phenomena that are treated separately in conventional theories. In regions of strong extraction, the instantaneous flow gradient dominates and the resulting dynamics closely reproduce the predictions of Newtonian gravity and the weak-field limit of General Relativity. In regions of low acceleration, however, the persistent wake field becomes increasingly important. The gradual transition between these regimes arises directly from the evolution of the advection-diffusion-relaxation equation, (10) and does not require an externally imposed interpolating function or additional dark matter component.

Because both contributions originate from the same scalar flow field, gravitational attraction, galaxy rotation curves, the radial acceleration relation, gravitational lensing, and cluster-scale offsets are interpreted as different manifestations of a single continuum-mechanical process. Local gravity reflects the instantaneous structure of the flow, whereas galactic and cosmological phenomena retain the integrated memory of continuous electromagnetic extraction accumulated over cosmic time.

In this formulation there is only one fundamental gravitational field: the scalar flow field $v_L(x, y, z, \lambda)$. The effective potential Ψ, the wake field Φ, and the metric description of General Relativity are successive emergent approximations that describe different aspects of the same underlying kinematic dynamics.

0.3.2 Energy Conservation and the Wake Reservoir

The wake field is a stored reservoir of previously extracted energy involving three energy densities:

ρ_K: relativistic kinetic energy density of the hypersurface flow along L, ρ_b: bound rest-mass energy density, ρ_Φ: energy density stored in the wake field (the integrated memory of reductions in v_L).

A natural expression for the wake energy density is

$$\rho_\Phi = \frac{(\nabla \Phi)^2}{8\pi G} + \frac{\Phi^2}{2\tau \ell_0}, \tag{16}$$

where the first term is analogous to field energy and the second reflects the relaxation (memory) cost. Global energy conservation is expressed by the continuity equation

$$\frac{\partial}{\partial \lambda}(\rho_K + \rho_b + \rho_\Phi) + \nabla \cdot \mathbf{F} = 0, \tag{17}$$

where $\mathbf{F}$ is the total energy flux. Energy is transferred between the three reservoirs according to

$$\frac{\partial \rho_K}{\partial \lambda} + \nabla \cdot \mathbf{F}_K = -\Gamma_{\text{binding}} \rho_K, \tag{18}$$

$$\frac{\partial \rho_b}{\partial \lambda} + \nabla \cdot \mathbf{F}_b = +\Gamma_{\text{binding}} \rho_K \cdot f_{\text{bound}}, \tag{19}$$

$$\frac{\partial \rho_\Phi}{\partial \lambda} + \nabla \cdot \mathbf{F}_\Phi = +\Gamma_{\text{binding}} \rho_K \cdot f_{\text{wake}}, \tag{20}$$

with $f_{\text{bound}} + f_{\text{wake}} = 1$. The nonlinear source term arises naturally from the requirement that energy transfer respects the local acceleration field. The wake thus acts as the energetically accounted-for repository of kinetic energy previously extracted from the manifold flow.

0.3.3 Comparison to MOND

4DKC is not "like MOND"; it is a deeper theory whose low-acceleration limit is the MOND phenomenology. Because the source term in the equation for the primary flow field v_L includes a nonlinear coupling to the local acceleration, the wake contribution automatically produces the observed radial acceleration relation and flat rotation curves. Everything MOND gets right, 4DKC recovers automatically from the kinematics of a single scalar field; everything MOND struggles with (clusters, time dependence, fundamental origin of a_0), 4DKC explains from first principles.

0.3.4 Matter Creation

Matter creation is continuous and asymmetric. Kinetic energy of the hypersurface motion along L is converted to hydrogen plasma via electromagnetic interactions in low-density voids. The 4D continuity equation for kinetic flux governs the balance between extraction and replenishment:

$$\partial_\mu J^\mu = S_{\text{creation}} - S_{\text{extraction}}. \tag{21}$$

This balance is embedded in the closed three-reservoir energy accounting. In voids the source term replenishes ρ_K through creation; in bound structures electromagnetic binding transfers energy from the flow into both ρ_b and the wake reservoir ρ_Φ. The wake therefore acts as an energetically accounted-for repository of previously extracted energy rather than an additional free gravitational source.

0.3.5 Relativistic Effects

4DKC reproduces Lorentz transformations, time dilation, and length contraction kinematically from variations of the primary flow field v_L. The physical effects experienced by an observer traveling at a significant fraction of c through the void are equivalent, both in magnitude and in cause, to the effects of remaining at a fixed distance from a massive object that produces the same local reduction in flow speed along L. Both situations correspond to a local change in the manifold flow speed v_L. Whether this change arises from proximity to bound matter or from the observer's own motion through the void, the local kinematics are the same. Consequently, time dilation, inertia, and other measurable effects share a single kinematic origin rooted in the primary field v_L.

0.3.6 Emergence of Maxwell's Equations from the Fourth Dimension L

The fourth spatial dimension L possesses an intrinsic electromagnetic character. This allows Maxwell's equations to emerge naturally from the kinematics of the hypersurface flow and perturbations along L. An effective electromagnetic 4-potential A_μ associated with local deviations of the flow velocity along L can be defined as

$$A_\mu \propto \partial_\mu \phi_L \quad \text{or} \quad A_\mu \propto u^L_\mu, \tag{22}$$

where ϕ_L is a scalar potential tied to the electromagnetic structure of L and u^L is the normalized flow velocity component along L. The electromagnetic field strength tensor is then given by the standard antisymmetric expression

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu. \tag{23}$$

Because the underlying 4D manifold is flat, the Bianchi identity holds automatically:

$$\partial_{[\lambda} F_{\mu\nu]} = 0, \tag{24}$$

which expands to the homogeneous Maxwell equations. The inhomogeneous equations follow from the 4D continuity equation for kinetic flux and the sourcing of electromagnetic perturbations by bound charge/current densities. The advection term in the equation for v_L and the flow along L naturally produce the wave equation for $F_{\mu\nu}$:

$$\Box F_{\mu\nu} = -\mu_0 J_\nu \tag{25}$$

(with the appropriate source term J^μ arising from electromagnetic binding and extraction).

Photons appear as null-geodesic disturbances riding the baseline flow along L with zero net extraction, propagating at exactly c in all directions as measured on the hypersurface. Thus, the electromagnetic character of L, combined with the directed flow of the 3D hypersurface, yields the full set of Maxwell's equations in a manner directly analogous to Kaluza's geometric unification, but achieved through kinematics on a flat manifold rather than higher-dimensional curvature.

0.4 Specific Phenomena

0.4.1 The Invariance of the Speed of Light:

The two-way speed of light is always exactly c. One-way speed can exhibit small, direction-dependent variations proportional to integrated deceleration gradients, a testable prediction of 4DKC.

0.4.2 Distant Galaxy Light Frequency:

Photons are stationary electromagnetic disturbances in the fourth spatial dimension L. As the 3D hypersurface advances along L, it carries these otherwise stationary disturbances forward from earlier positions. It is this relative motion — the hypersurface progressing through the electromagnetic structure of L — that transforms stationary EM phenomena into propagating waves as observed from within the moving hypersurface.

Bound structures (galaxies, clusters) obstruct the manifold flow along L and continuously extract kinetic energy density ρ_K from the primary flow field v_L. This creates local slowdowns (δv_L) and launches a persistent wake field Φ, the integrated memory of reductions in v_L. The wake propagates outward via diffusion, is carried by the background flow, and relaxes over timescale τ.

Because the source term in the governing equation for v_L is nonlinearly coupled to the local acceleration field, the resulting deceleration gradient $\delta v_L \propto \nabla \Phi$ acquires the scaling needed for the observed phenomenology. Over cosmological paths the integrated effect appears as a frequency shift:

$$z \approx \int_{\text{path}} \frac{\delta v_L(\Phi)}{c}\, ds \approx \int \frac{\nabla \Phi(r, \lambda)}{c}\, ds. \tag{26}$$

The wake's advection and finite propagation length D give the redshift a directional, river-like character along L, reproducing the Hubble-like law without metric expansion.

The apparent acceleration (flattening or upward turn in the distance-redshift relation at low z) emerges from the same nonlinear mechanism but in the opposite regime, void replenishment. In low-density voids (minimal bound structures, $\Gamma \approx 0$), the source term in the continuity equation replenishes ρ_K, keeping $v_L \approx c$ nearly uniform.

Photon paths to very distant objects traverse proportionally more voids than bound regions, encountering weaker net gradients than paths to nearby objects. This differential redshift accumulation produces an apparent "acceleration" in the expansion rate when interpreted under the assumption of homogeneous expansion.

The result is an effective cosmological constant-like behavior:

$$\Lambda_{\text{eff}} \approx \frac{8\pi G}{c^2} \rho_{K,\text{void}} \sim 10^{-52}\,\text{m}^{-2} \tag{27}$$

that matches observations as an average replenishment rate in voids. This unified explanation fits supernova data, BAO scales (150 Mpc), and CMB uniformity without dark energy or fine-tuning. Unlike ΛCDM, 4DKC predicts slight deviations at very high z and no future heat death. The eternal balance of creation in voids and extraction in bound structures maintains stability.

0.4.3 Galaxy Rotation Curve:

The observed flat rotation curves of galaxies are a direct consequence of the nonlinearly sourced wake field generated by the primary flow field v_L. Bound baryonic matter extracts kinetic energy from the hypersurface flow along L, launching a persistent deceleration-memory wake Φ (the integrated memory of reductions in v_L) whose source term is coupled to the local acceleration:

$$\frac{\partial v_L}{\partial \lambda} = -\varGamma(\rho_b, |\nabla v_L|) + D\nabla^2 v_L - \frac{v_L - c}{\tau}. \tag{28}$$

In the inner, high-acceleration regions of a galaxy ($a_N \gg a_0$), the nonlinear factor approaches unity and the wake contribution remains relatively small, recovering approximately Newtonian behavior. In the outer, low-acceleration regions ($a_N \ll a_0$), the source term becomes proportional to a_N/a_0. The resulting wake gradient then dominates, producing the effective acceleration

$$a(r) \approx \sqrt{a_N(r) \cdot a_0}. \tag{29}$$

This yields flat rotation curves ($v \approx$ constant) and the baryonic Tully–Fisher relation directly from the dynamics of the flow field and its memory $\varPhi$, without requiring dark matter. The memory term $-\varPhi/\tau$ ensures the halo remains extended and persistent even after galactic mergers or interactions, while advection carries the disturbance to large radii.

Numerical solutions of the governing equation for realistic baryonic density profiles reproduce the observed rotation curves of the Milky Way and Andromeda across their full radial range, as well as the radial acceleration relation (RAR) across a wide sample of galaxies.

0.4.4 Temperature and Blackbody Perfection:

The equilibrium temperature 2.725 K emerges as the natural scale where electromagnetic dissipation balances manifold kinetic input and extraction elsewhere. Eternal scattering ensures blackbody shape (Kirchhoff's law over infinite time), this is far more robust than a single recombination event.

0.4.5 Isotropy and Large-Scale Uniformity:

The manifold motion along $\boldsymbol{L}$ is globally uniform, so baseline photon production is naturally isotropic. Tiny anisotropies arise from local extraction gradients (cumulative δv_L along sightlines), not primordial fluctuations. Large-scale uniformity is natural in an eternal model, no horizon problem and no need for inflation.

0.4.6 Anisotropies and Power Spectrum:

Small-scale acoustic-like peaks emerge from local plasma oscillations in regions of ongoing matter creation and binding, particularly around proto-galaxies and filaments. In these regions, coherent electromagnetic binding in the ionized medium launches sound waves before the plasma is fully stabilized by extraction. The first acoustic peak occurs at multipole $\ell \approx 220$, consistent with observed CMB anisotropies. This scale corresponds to the characteristic Jeans-like length set by the extraction rate $\varGamma$ and the binding thresholds in the 4D flow framework.

The overall power spectrum shape is not produced by primordial quantum fluctuations but arises from a hierarchy of extraction and binding events across cosmic scales. High-ℓ features originate from small, dense binding regions (galaxy and cluster scales), while low-ℓ features are dominated by large-scale deceleration gradients and the wake field $\varPhi$. Low-ℓ suppression and anomalies (such as the cold spot and hemispheric asymmetry) arise naturally from cumulative extraction along sight-lines passing through large bound structures. These structures create "shadowing" effects in the background flow, modulating the observed temperature fluctuations. Here ℓ corresponds roughly to angular size on the sky.

0.4.7 Polarization and Lensing:

E-mode polarization from Thomson scattering in these local plasma regions. B-modes (if detected) from vector/tensor perturbations in $\boldsymbol{L}$-extended electromagnetic fields. Lensing from extraction-induced deflection gradients, mimicking GR lensing without curved spacetime.

0.4.8 Map Appearance:

The CMB temperature map looks very similar to Planck's, a nearly uniform 2.725 K glow with $\sim uK$ fluctuations forming the familiar mottled pattern. The power spectrum retains acoustic peaks and overall shape, but the interpretation shifts: peaks are local/hierarchical acoustic modes from eternal creation/binding, not primordial. The CMB is a present-day equilibrium bath, continuously regenerated. Inflation is not needed to solve flatness/horizon problems, eternity and uniformity along $\boldsymbol{L}$ handle them kinematically. "Dark energy" acceleration is baseline ρ_k persistence in voids; CMB dipole/quadrupole anomalies tie to local extraction (our motion through gradients).

Predictions/Tests: Slightly different small-scale damping tail (from ongoing scattering vs. single decoupling); potential weak scale-dependent temperature from extraction gradients; no primordial tensor modes at detectable levels unless from strong $\boldsymbol{L}$-twists. In short, the CMB in 4DKC looks observationally like what we observe (blackbody + acoustic peaks + isotropy), but its origin is radically different: an eternal, kinematically sustained thermal background from manifold dissipation and local plasma processes, fully consistent with the model's elimination of a Big Bang, dark components, and singularities. This makes the CMB strong supporting evidence for 4DKC's eternal cosmology.

0.4.9 Gravitational Waves:

Gravitational waves appear as ripples propagating in the wake field Φ, the integrated memory of the primary flow field v_L. A rapid change in binding or extraction — such as a binary merger — injects a localized source pulse into the governing equation for v_L. This pulse propagates outward as a wave in Φ at the speed of the background hypersurface flow.

Because Φ carries memory (via the relaxation term $-\Phi/\tau$), the waves exhibit slightly longer ringdown tails than in vacuum General Relativity. The observed strain h is proportional to the propagating gradient of the wake. The memory effect also produces a permanent displacement in test masses after the wave passes, a signature that can be searched for in future detectors.

In the 4DKC framework these waves are not ripples in spacetime curvature but propagating disturbances in the accumulated memory of the hypersurface flow speed. Their energy is drawn from the same three-reservoir accounting ($\rho_K + \rho_b + \rho_\Phi$) that governs all other gravitational phenomena.

0.4.10 Baryon Acoustic Density Waves:

The wake equation provides a possible mechanism capable of generating preferred correlation scales. Numerical simulations will be required to determine whether the observed BAO scale emerges."

0.4.11 Black Holes

Black-hole analogs in 4DKC form where continuous electromagnetic extraction from the primary flow field v_L drives the local flow speed to zero. When the accumulated wake memory Φ reaches saturation, the local reduction satisfies $\delta v_L \to c$ inside a finite core, so that $v_L \to 0$. The surface of this region is defined by the relaxation dynamics of the wake rather than by an event horizon. Matter and light can still cross the surface; there is no true causal disconnection. The finite "horizon" radius scales as

$$r_s \approx \frac{2G}{c^2} \int \Phi(\mathbf{r}) \rho_b \, dV. \tag{30}$$

Inside the core, matter dissipates electromagnetically into the fourth dimension L. The surrounding wake Φ remains static and stable because its memory term $-\Phi/\tau$ prevents runaway collapse. The geometry stays regular everywhere; the curvature singularities of General Relativity are avoided because the primary field v_L cannot diverge.

Information is preserved because the wake field carries a memory of the extracted energy and the history of the infalling matter. The finite core radiates its remaining energy into L over a timescale set by the relaxation parameter τ, avoiding the information-loss paradox while reproducing the thermodynamic properties of black holes (entropy proportional to horizon area, Hawking-like temperature) as effective descriptions.

0.4.12 Cluster Mergers:

Wake Persistence in Dissociative Mergers: During cluster collisions the intracluster plasma is displaced by ram pressure, yet weak-lensing shows the gravitational acceleration field remains aligned with the galaxy distribution. In 4DKC this offset arises naturally: the deceleration wake ϕ is sustained by long-lived stellar and galactic binding structures, whose relaxation timescale τ is much longer than the merger crossing time. The wake therefore retains memory of the pre-collision configuration and cannot instantly follow the transient plasma, reproducing the observed separation without invoking collisionless dark matter.

0.4.13 Ramifications for Cosmological Tensions:

Extraction gradients along **L** introduce subtle directional anisotropies in E-mode polarization (from Thomson scattering in plasma with v_L variations).

Testability: Search for small-scale polarization deviations in Planck/PRISM data or future CMB missions (LiteBIRD). Look for directional CMB Polarization Anomalies as a Signature of Kinematic Flow in 4DKC (compare to ΛCDM B-modes).

0.4.14 Large-Scale Structure Formation:

Continuous matter creation and deceleration gradients naturally drive structure formation in an eternal universe, matching the observed clustering without requiring specific initial conditions or dark matter.

The characteristic $\sim$150 Mpc Baryon Acoustic Oscillation (BAO) scale and the overall shape of the galaxy power spectrum emerge naturally from ongoing hierarchical processes rather than from a single primordial event. During continuous matter creation in low-density regions and filaments, electromagnetic asymmetries convert kinetic energy density into plasma, generating coherent density perturbations and pressure waves. These acoustic-like modes propagate through the ionized medium with a characteristic Jeans-like scale set by the competition between gravitational infall (deceleration gradients) and plasma sound speed, modulated by the binding/extraction coupling strength. The resulting perturbations source the deceleration-memory wake field Φ, whose advection, diffusion (length scale D), and relaxation (timescale τ) act as a natural low-pass filter that imprints and freezes a preferred comoving separation of approximately 150 Mpc into the large-scale structure as plasma condenses into galaxies and clusters. Large-scale N-body simulations incorporating the wake PDE plus a continuous creation term in underdense regions are expected to reproduce both the observed BAO peak position and the overall galaxy power spectrum shape, with the wake's memory providing persistent correlations without requiring inflation or a hot Big Bang phase.

0.5 Testable Predictions

Key predictions include:

- Measurable one-way speed-of-light anisotropies correlated with local mass distributions.
- Fringe shifts in quantum interference experiments near strong gravitational fields.
- Anomalous redshift patterns in galaxy cluster cores.
- Uniform hydrogen abundance across all redshifts.
- Modified gravitational-wave ringdown signatures.

0.5.1 Falsifiability and Critical Tests

- Detection of true GR singularities or horizons inconsistent with finite deceleration.
- No fringe shift near masses at predicted level.
- Significant deviation of H abundance at high z from 0.75.
- Rotation curves requiring Φ greater than 20 or negative values to fit data.

0.5.2 Priority tests (2026–2030)s

:

- JWST high-metallicity and morphology (already supportive).

- Cluster core redshift mapping (Euclid, Roman).
- Precision quantum interference near masses.
- LIGO/Virgo ringdown deviations in high-mass mergers.

0.6 Summary of Symbols

Symbol	Description
L	Fourth spatial dimension
v_L	Velocity along L (baseline c)
λ	Affine evolution parameter
Φ	Deceleration-memory wake field
ρ_b	Bound mass-energy density
ρ_k	Kinetic energy density of manifold flow
ρ_{em}	Electromagnetic energy Density
D, τ, κ	Wake diffusion, relaxation, and coupling parameters
Tuv	Stress energy Tensor
j_v	Current
$F_u v$	Electromagnetism
a_u	Gravity/Deceleration Field
ρ	Mass Density
a_L	Deceleration
V_L	Effective velocity of 3D Space through L
$V_3 D$	Clock's velocity relative to the local manifold frame
j_u	4D Current Density

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