4DKC (Four Dimensional Kinetic Cosmology) Electromagnetic Gravity in a Directly Perceptible Non-Compact Four-Dimensional Spatial Manifold

Dan Fragoules

May 2026

Abstract

General Relativity provides an extraordinarily accurate mathematical description of gravity but lacks a deeper physical mechanism for spacetime curvature. Four-Dimensional Kinetic Cosmology (4DKC) proposes a kinematic alternative: our locally observable three-dimensional space is a hypersurface moving uniformly through a flat, infinite, non-compact four-dimensional spatial manifold at speed c through a directly perceptible fourth spatial dimension L. Gravity, inertia, quantum behavior, nuclear forces, and cosmological phenomena all emerge from electromagnetic binding processes that continuously extract kinetic energy from this universal flow, creating local deceleration gradients. This framework eliminates the need for dark matter, dark energy, singularities, and a Big Bang while reproducing the successful predictions of GR and the Standard Model and offering numerous testable predictions.

Introduction

General Relativity gives an extraordinarily accurate mathematical description of what happens, but it offers no deeper mechanism or force that makes spacetime curvature occur. The curvature is simply the direct, instantaneous consequence of the stress-energy tensor. There is no cost, no conversion process, and no underlying “why.”

4DKC addresses this by replacing curved spacetime with a simple kinematic picture in a flat 4D spatial manifold. Our locally observable 3D space moves uniformly through the large fourth spatial dimension L at speed c. The electromagnetic nature of L allows binding processes to continuously extract kinetic energy from this flow and lock it into stable matter. This extraction creates local deceleration gradients that we experience as gravity.

The same mechanism unifies inertia, quantum behavior, nuclear forces, cosmological redshift, flat rotation curves, and the arrow of time, all without dark components, singularities, or a Big Bang.

Dimensional Structure:

The locally observable universe corresponds to a three-dimensional spatial hypersurface embedded in a flat 4D manifold with coordinates (x, y, z, L). Its progression is parameterized by an affine evolution parameter λ, which labels successive hypersurface states (not a coordinate of the manifold).

The flow law is:

$$v_L = \frac{dL}{d\lambda}. \tag{1}$$

In weak-field regions, the hypersurface advances at the baseline rate $v_L = c$. In regions containing bound electromagnetic structure, ongoing extraction reduces the local progression rate to

$$v_L = c - \delta v_L, \quad \delta v_L > 0. \tag{2}$$

All physical effects - gravity, inertia, redshift, quantum localization - arise from spatial variations in this local flow rate.

Global emergent cosmic time is defined as the cumulative displacement along L relative to the baseline rate:

$$t = \int \frac{v_L(\mathbf{r}, \lambda)}{c}\, d\lambda. \tag{3}$$

Physical clocks are bound systems regulated by the local flow rate. The proper time increment is

$$d\tau = \sqrt{1 - \frac{v^2}{c^2} - \frac{2\delta v_L}{c}}\, d\lambda, \tag{4}$$

where v is the 3D velocity relative to the local comoving frame.

Kinematics and Principles

When we observe a light source one million light-years distant, we see where 3D space was one million years ago, in the direction that 3D space is moving from. The forward direction along L, toward which the 3D hypersurface is moving at $v_L = c$, is causally inaccessible and unobservable, because no influence can ever reach a point ahead of the moving 3D hypersurface along L.

The moving 3D hypersurface can only interact with the portion of the manifold at or behind its current position. 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.

Inertia is the resistance to changing an object's velocity component along the fourth dimension relative to the universal flow. Gravity is the local deceleration gradient created by electromagnetic binding that extracts kinetic energy density $\rho_{\mathrm{k}} c^2$ of the moving hypersurface.

The source of the gravitational field is relativistic kinetic energy density, not rest mass. Gravity depends on both bound mass-energy density and electromagnetic coherence.

Unified Gravitational Dynamics

The central field equation of 4DKC is

$$\mathbf{g} = -4\pi G \left(\rho_{\mathrm{bound}} + \frac{\rho_{\mathrm{kin}}}{c^2} \right) + \text{wake contributions from } \mathbf{\Phi}. \tag{5}$$

The deceleration-memory wake field $\mathbf{\Phi}$ obeys the advection-diffusion-relaxation equation (expressed with respect to λ):

$$\frac{\partial \Phi}{\partial \lambda} + \mathbf{v} \cdot \nabla \Phi = D \nabla^2 \Phi - \frac{\Phi}{\tau} + \kappa \, \rho_{\mathrm{bound}} \, f_{\mathrm{EM}}(\mathbf{r}, \lambda), \tag{6}$$

where D is the diffusion scale, τ the relaxation timescale, and κ the coupling constant.

In the low-acceleration regime this naturally reduces to the MOND-like interpolating function without ad-hoc parameters.

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.

Particles, Waves and Forces

Particles are localized, stable bound states that continuously extract kinetic energy. Waves are free-propagating disturbances with no net extraction. Quantum mechanics emerges as the 3D projection of deterministic 4D electromagnetic extraction modes.

Strong and weak nuclear forces are high-density and asymmetric electromagnetic extractions, respectively.

Inertia

Inertia arises as the resistance to acceleration along the **L** direction due to electromagnetic binding and extraction processes, amplified by the wake field $\mathbf{\Phi}$. This same mechanism also gives rise to gravitational mass, thereby explaining the observed equivalence between inertial and gravitational mass.

Apparent Expansion

Cosmic redshift is the cumulative loss of photon energy as light climbs successive deceleration gradients. Apparent cosmic expansion and acceleration emerge kinematically from these gradients and void replenishment, without actual metric expansion or dark energy.

Relativistic Effects

4DKC reproduces Lorentz transformations, time dilation, and length contraction kinematically. Both gravitational and kinematic time dilation arise from reductions in the local velocity component along L.

Black-hole analogs are regions of extreme deceleration ($v_L \to 0$) with no true event horizon or singularity.

The Invariance of the Speed of Light: Two-Way vs. One-Way Measurements

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.

Specific Phenomena

Distant Galaxy Light Frequency: Redshift arises from the cumulative deceleration gradient δv_L experienced by photons traveling along paths against the flow of 3D space and the wake field $\mathbf{\Phi}$ surrounding bound structures.

Bound structures (galaxies, clusters) obstruct the manifold flow along $\boldsymbol{L}$ and continuously extract kinetic energy density ρ_k. This creates a local slowdown (initial δv_L) and, simultaneously, launches a persistent wake $\mathbf{\Phi}$, a history-dependent scalar disturbance that propagates outward via diffusion $\mathcal{D}\Delta^2\mathbf{\Phi}$ that is carried by the background flow, and relaxes over timescale τ.

The extended deceleration gradient $\delta v_l \propto \Delta\Phi$. Over cosmological paths the integrated effect appears as a frequency shift:

$$z \approx \int_{\text{path}} \frac{\delta v_L(\Phi)}{c}\, ds \approx \int \frac{\Phi(r,\lambda)}{c}\, ds \tag{7}$$

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

The apparent acceleration (flattening or upward turn in the distance-redshift relation at $z < 1$ emerges from the same mechanism but in the opposite regime, void replenishment. In low-density voids (minimal bound structures, $\Gamma \approx 0$, the source term $\boldsymbol{S}$ 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 (less δv_L per distance) than paths to nearby objects (which pass through more galaxies/clusters).

This differential produces:

More redshift per distance at small scales (bound-dominated).
Less redshift per distance at large scales (void-dominated).

This differential redshift accumulation produces an apparent "acceleration" in the expansion rate: more redshift per unit distance at small scales (bound-dominated) and less redshift per unit distance at large scales (void-dominated), causing the distance-redshift relation to bend upward at low z when interpreted under the assumption of homogeneous expansion.

The result is an apparent "acceleration" in the expansion rate. The Hubble parameter $\boldsymbol{H}(z)$ increases at low z, mimicking ΛCDM's dark energy without any actual acceleration or negative-pressure fluid. Quantitatively, the effective cosmological constant

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

matches observations as an average replenishment rate.

Consistency and Distinctions:
This unified explanation fits supernova data (Pantheon+), BAO scales (~150 Mpc from plasma oscillations during creation), and CMB uniformity (eternal dissipation bath) without dark energy or fine-tuning. Unlike ΛCDM, 4DKC predicts slight deviations at very high z (less "acceleration" in denser early structures) and no future heat death. The eternal balance of creation in voids

and extraction in bounds maintains stability.

Spiral Galaxy Rotation Curve: Observations show that rotation speeds remain relatively constant (or "flat") at large radii, which has traditionally been explained by the presence of an unseen mass (dark matter) adding extra gravitational pull.

The Galaxy Rotation Curve Simulations in 4DKC encode gravity as a local deceleration of the 3D manifold driven by kinetic-energy extraction from the background space flow. Obstructions in the flow produce propagating deceleration wakes that extend beyond mass concentrations and source an extra field responsible for the observed rotation-curve behavior.

This approach yields flat or slowly rising rotation curves as a natural consequence of wake geometry and flow deceleration, unifying galaxy-scale dynamics with the broader 4DKC picture and dispensing with dark components as an explanatory crutch.
As with other 4DKC predictions, the emphasis is on the global flow dynamics and wake formation, offering concrete avenues for testing through detailed mapping of velocity fields and their correlation with the large-scale flow structure implied by the theory.

Bound electromagnetic structures decelerate the manifold at their location, creating a gradient in the flow of space. When the manifold flow encounters this slowed region, the obstruction causes the flow to pile up and launch a persistent wake $\mathbf{\Phi}$. In the halo the cumulative, history-dependent wake reaches $\mathbf{\Phi} \approx 5$–10. The wake $\mathbf{\Phi}$ then sustains and extends the deceleration gradient, giving the effective enclosed mass.

$$M_{\text{eff}}(r) = \int \Phi(r)\, \rho_b(r)\, dV' \tag{9}$$

In the low-acceleration regime this yields the asymptotic acceleration law above, giving flat rotation curves and the baryonic Tully–Fisher relation directly from wake dynamics.

The wake's memory $-\frac{\Phi}{\tau}$ keeps the halo persistent long after mergers, while advection carries the disturbance to large radii, eliminating the need for dark matter and preventing Keplerian decline.
The wake formulation also accounts for the radial acceleration relation and Renzo's rule, because the acceleration field remains locally anchored to the baryonic binding distribution while being extended non-locally by the propagating wake.

Cosmic Microwave Background: The CMB is the steady-state thermal bath generated by continuous electromagnetic dissipation of extracted ρ_k into

$\boldsymbol{L}$. Every bound structure creates a local extraction event that launches a wake ϕ. This wake thermalizes the dissipated energy at ~ 2.7 K because the diffusion scale $\boldsymbol{D}$ and relaxation time τ set a universal equilibrium.

Large-scale wake gradients (advection along $\boldsymbol{L}$) imprint the observed low-ℓ anomalies and hemispherical asymmetries directly onto the temperature field. The power spectrum matches observations at high ℓ because local physics is unchanged; deviations at low ℓ arise naturally from the propagating, non-instantaneous wake rather than primordial fluctuations.

Source of the Radiation: Continuous, low-level electromagnetic dissipation and re-emission from the manifold motion along $\boldsymbol{L}$.
In low-density regions (voids/intergalactic medium), kinetic energy density ρ_k is minimally extracted $\Gamma \approx 0$, allowing baseline manifold motion to persist. Small electromagnetic fluctuations/asymmetries in $\boldsymbol{L}$ (virtual charge separations or vector potential modes) convert tiny fractions of ρ_k into thermalized photons.

These photons are repeatedly scattered/absorbed/re-emitted by sparse plasma (intergalactic hydrogen/helium, dust, magnetic fields), driving the spectrum toward a near-perfect blackbody via eternal thermalization (a single early decoupling event is not needed).
The matter creation term $S \approx k(\rho_{\text{th}} - \rho_{\text{em}})$ feeds back in voids: created pairs partially annihilate or radiate, contributing to the photon bath.

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.

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.

Anisotropies and Power Spectrum: Small-scale acoustic-like peaks emerge from local plasma oscillations in regions of ongoing matter creation and binding (around proto-galaxies or filaments), where coherent ρ_{em}^b induces sound waves in the ionized medium before full binding.

The first acoustic peak occurs at multipole $\ell \approx 220$, consistent with observed CMB anisotropies and corresponds to the characteristic scale of these oscillations set by the Jeans-like length in the 4D extraction framework (related to binding amplification ξ and Γ thresholds).

Power spectrum shape is not from primordial quantum fluctuations but from a hierarchy of extraction/binding events across cosmic scales: high- ℓ from small, dense bindings (galaxy/cluster scales); low- ℓ from large-scale gradients.
Low- ℓ suppression and anomalies (cold spot, asymmetry) arise naturally from cumulative extraction along sightlines through large bound structures (local voids or superclusters "shadowing" the background). (ℓ corresponds roughly to angular size on the sky).

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.

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.

Gravitational Waves: Gravitational waves are ripples propagating in the wake field $\boldsymbol{\Phi}$. A rapid change in binding/extraction (merger) injects a source pulse into the $\boldsymbol{\Phi}$ equation. The wake disturbance then travels at effective speed ($\approx c$) in vacuum), advected by the background manifold flow. The observed strain $\boldsymbol{h}$ is the propagating gradient of this wake.

Because ϕ carries memory (relaxation term), ringdown tails persist slightly longer than in vacuum GR, and small arrival-time delays relative to light appear in dense-wake regions. This reproduces LIGO/Virgo waveforms while offering testable distinctions (wake-modified polarization and tails).

Cosmic Background: Stochastic GW background from eternal hierarchical mergers, modulated by cumulative extraction, similar to, but not identical to inflationary predictions.

Baryon Acoustic Density Waves BAO are the frozen imprint of early-plasma sound waves in the wake field ϕ. At recombination the pressure waves created characteristic source modulations in $\eta\rho_{\mathrm{b}}$. The resulting wake Φ diffused and advected over cosmic time, freezing the ~ 150 Mpc scale into the present-day deceleration-gradient pattern.

The observed BAO peak position and broadening arise from the wake's finite propagation length D and relaxation time τ. The apparent acceleration of the scale with redshift is simply the integrated growth of wake gradients along the line of sight. No dark energy is required.

Imprints in LSS: As plasma condenses into bound structures (galaxies/clusters), oscillations "freeze" at the scale where extraction stabilizes bindings (~ Jeans length in 4D, calibrated to ~ 150 Mpc observed). This leaves overdensities at that separation, visible in galaxy surveys as the BAO peak.

There is no single "decoupling", oscillations occur eternally in creation zones, with cumulative effects over cosmic scales mimicking a "standard ruler." Electromagnetic binding ties BAO directly to gravity's source: Oscillations enhance local Γ, feeding back to stronger bindings and deceleration gradients. In high-ξ regions (coherent plasma), waves propagate farther, explaining sharp BAO signals.

BAO are "macroscopic" versions of microscopic nuclear/atomic vibrations, all driven by electromagnetic extraction hierarchies.

In ΛCDM, BAO scale dilates with expansion; in 4DKC, apparent "expansion" is cumulative redshift from extraction gradients, so the scale is fixed kinematically but appears z-dependent via path-integrated $\delta\nu_L$.

BAO "ruler" measures extraction gradients, not acceleration, consistent with tensions (Hubble constant) as local binding variations.

BAO dynamics follow from the extraction-augmented continuity equation, perturbed for waves:

$$\partial_t \delta + \nabla \cdot (\mathbf{v}\delta) = -\nabla \cdot \mathbf{v} + \delta\mathcal{E}(\rho_b) + S_{\mathrm{creation}} \tag{10}$$

where δ denotes density/velocity perturbations (acoustic modes), $\mathcal{E}(\rho_b)$ is the perturbative extraction modulated by binding fluctuations, and S_{creation} represents creation source variations driving initial compressions. Damping from extraction limits the oscillation lifetime, freezing the characteristic scale at binding lengths.

Black Holes

Black-hole analogs form where continuous extraction drives the wake field ϕ to saturation: $\delta v_L \to c$ inside the core, so local $v_L \to 0$. The surface is defined by the wake's relaxation term dominating, but matter and light can still cross (no true event horizon). The finite "horizon" radius is $r_s \approx \frac{2G}{c^2} \int \phi(r)\, \rho_b \, dV$.
Inside the core, matter dissipates electromagnetically into $\boldsymbol{L}$. The surrounding wake ϕ retains angular momentum and charge as a persistent gradient shell, allowing gradual radiation without information loss.

Singularities

Singularities cannot form. The wake field ϕ obeys an advection-diffusion-relaxation equation that forbids divergence: diffusion $D\Delta^2\phi$ smooths any attempted collapse, advection carries excess extraction outward, and the relaxation term $\frac{\phi}{\tau}$ caps δv_L at $\frac{\phi}{\tau}$. The result is a finite-density core surrounded by a stable, static wake "memory shell." All extracted energy is radiated into $\boldsymbol{L}$ over finite time. There is therefore no curvature singularity, no information paradox, and no need for Planck-scale quantum gravity. The kinematic wake mechanism prevents infinite density by construction.

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.

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.

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 $\boldsymbol{\Phi}$ greater than 20 or negative values to fit data.

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.

Implications and Ramifications

Galaxy Rotation Curves Without Dark Matter

Phenomenon: In standard cosmology, the flat rotation curves of galaxies, where orbital velocities remain constant at large radii, require dark matter to account for the additional gravitational pull beyond visible mass.
4DKC's kinematics naturally explain rotation curves.

Apparent Accelerated Expansion of the Universe and Dark Matter

Phenomenon: The apparent accelerated expansion of the universe, typically attributed to dark energy in the ΛCDM model, drives cosmic evolution based on supernova and CMB data.
4DKC Explanation: Photons traveling from distant sources to observers must climb cumulative deceleration gradients (and the associated wakes). This energy loss produces a progressive redshift that increases with distance, giving the appearance of cosmic expansion without any actual stretching or recession of space itself.

Cosmic Microwave Background (CMB) Isotropy and Temperature

Phenomenon: The CMB's remarkable uniformity and temperature (2.7 K) require a mechanism like cosmic inflation in the Big Bang model to explain its isotropy and fluctuation patterns.

4DKC Explanation: The CMB are photons from hydrogen formation and stellar fusion across an infinite past, redshifted into microwaves by accumulated deceleration along **L** The isotropy arises naturally from the uniform geometry of the 4D manifold, without needing a singular origin or inflation.

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).

Quantum Entanglement Without Non-Locality
Phenomenon: Quantum entanglement, where particles exhibit correlated behaviors instantaneously over distances, challenges locality and is often described as "spooky action" in standard quantum mechanics.

4DKC Explanation: Entanglement results from connections through the fourth dimension $\boldsymbol{L}$ What appears non-local in 3D are local interactions in 4D, akin to how folding a 2D sheet connects distant points in 3D. Viability Improvement: Explaining entanglement as a geometric effect in 4D space eliminates the need for non-locality, aligning quantum mechanics with classical intuitions and strengthening 4DKC's unification of forces.

Wave-Particle Duality and the Double-Slit Experiment
Phenomenon: The double-slit experiment demonstrates particles exhibiting wave-like interference patterns, a cornerstone of quantum weirdness unexplained by classical physics.

4DKC Explanation: The wave function in 4DKC is a 4D entity projected into 3D. Interference patterns arise from the wave's extension into $\boldsymbol{L}$, with particle-like behavior triggered by deceleration-induced collapse during measurement. Viability Improvement: If 4DKC can model interference fringe shifts (as predicted in its testable quantum interference section) and the transition to particle states, it would unify wave-particle duality under a physical mechanism, reducing quantum postulates.

Resolution of Black Hole Singularities
Phenomenon: General Relativity predicts singularities inside black holes, where physical laws break down, posing a theoretical challenge.

4DKC Explanation: By reinterpreting gravity as deceleration, 4DKC replaces singularities with regions of extreme deceleration along $\boldsymbol{L}$ maintaining physical consistency without infinite densities.

Viability Improvement: Eliminating singularities and predicting observable effects (modified gravitational wave signatures) would address a key flaw in General Relativity, making 4DKC a more robust gravitational theory.

In these extreme regions, the deceleration scalar $\delta \propto \rho_m$ dominates the unified equation, reducing $v_L = c$ while ρ^b_{em} dissipation feedback ensures finite physical consistency, preventing true singularities through maximal electromagnetic binding that recycles matter kinematically.

Large-Scale Structure Formation

Phenomenon: The distribution of galaxies and clusters, including features like baryon acoustic oscillations (BAO), is typically explained by initial fluctuations and dark matter in the Big Bang model.

4DKC Explanation: 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.

Viability Improvement: In 4DKC, the characteristic ~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.

Entropy and the Arrow of Time

Phenomenon: The second law of thermodynamics states that entropy increases over time, giving processes a preferred direction from past to future. In the Big Bang model, this thermodynamic arrow is linked to an unexplained low-entropy initial state at $t = 0$, with the universe evolving from that special beginning toward higher entropy.

4DKC Explanation: The observed arrow of time, the unidirectional flow from past to future, emerges entirely from the preferred spatial direction of the 3D manifold's uniform motion through the large spatial dimension $\boldsymbol{L}$ at $v_L \approx c$. Entropy increases as a direct consequence of this irreversibility. Continuous matter creation in low-density voids introduces new low-entropy plasma, while extraction and dissipation in bound regions drive local entropy production. The dynamic balance between creation and dissipation maintains an overall stable average entropy density across the infinite universe, with no need for a singular low-entropy origin.

Viability Improvement: 4DKC provides a physical, kinematic basis for the arrow of time and entropy increase without invoking a special initial state, a Big Bang singularity, or fine-tuned boundary conditions. The directionality is rooted in the large-scale spatial structure (the coherent flow along $\boldsymbol{L}$), not in any intrinsic property of time itself. This resolves a fundamental thermodynamic puzzle, why time has a robust arrow while space does not.

Fine-Tuning Problems (Cosmological Constant and Hierarchy)

Phenomenon: The cosmological constant's tiny observed value and the vast disparity between gravity and the weak force (hierarchy problem) suggest fine-tuning in current models.

4DKC Explanation: The 4D framework and deceleration dynamics naturally set scales for fundamental constants, avoiding arbitrary adjustments. The cosmological constant emerges directly from the manifold's kinematics.

Nuclear Forces (Strong and Weak Interactions)

Phenomenon: The strong and weak nuclear forces govern particle interactions but are distinct from gravity and electromagnetism in the Standard Model.

4DKC Explanation: The strong force arises from high-frequency oscillations in confining quarks, while the weak force emerges from symmetry breaking in $\boldsymbol{L}$'s field, producing massive bosons. These unify with gravity and electromagnetism under the 4D framework.

Viability Improvement: If 4DKC can derive the properties of nuclear forces (strong force range $\approx 10^{-15}$ mweak force mass $\approx$ 80-90 GeV) from $\boldsymbol{L}$'s dynamics, it would achieve a grand unification, a long-standing goal in physics.

Comparison to MOND

4DKC is not "like MOND", it is a deeper theory that recovers MOND phenomenology exactly as the low-acceleration limit of a propagating, history-dependent wake field. Everything MOND gets right, 4DKC gets right automatically; everything MOND struggles with (clusters, time dependence, fundamental origin of a_0, 4DKC explains from first principles.

Summary of Symbols

L Fourth spatial dimension

v_L Velocity along L (baseline c)

λ Affine evolution parameter

$\mathbf{\Phi}$ 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 in the observable 3D space

j_u 4D Current Density

References

[1] Kaluza, T. (1921). Zum Unitätsproblem in der Physik. Sitzungsberichte der Preußischen Akademie der Wissenschaften, 966–972. (Original 5D unification of gravity and electromagnetism.)

[2] Klein, O. (1926). Quantum theory and five-dimensional relativity. Zeitschrift für Physik, 37(12), 895–906. (Early development of compactified extra dimensions; foundational for later KK theories.)

[3] Bondi, H., Gold, T., Hoyle, F. (1948). A new model for an expanding universe. Monthly Notices of the Royal Astronomical Society, 108(3), 252–270. (Classic steady-state cosmology with continuous matter creation.)

[4] Hoyle, F. (1948). A new model for the expanding universe. Monthly Notices of the Royal Astronomical Society, 108(5), 372–382. (Independent formulation of steady-state creation.)

[5] Milgrom, M. (1983). A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis. The Astrophysical Journal, 270, 365–370. (MOND as a reference for emergent modified gravity effects; 4DKC shares some phenomenological similarities via amplification.)

[6] Planck Collaboration. (2020). Planck 2018 results. VI. Cosmological parameters. Astronomy Astrophysics, 641, A6. (Standard CDM parameters; used for contrast with 4DKC predictions.)

[7] Riess, A. G., et al. (2022). A comprehensive measurement of the local value of the Hubble constant with 1 km s^{1} Mpc^{1} uncertainty from the Hubble Space Telescope and the SH0ES team. The Astrophysical Journal Letters, 934(1), L7. (Hubble tension; 4DKC offers a kinematic resolution via extraction gradients.)

[8] Boylan-Kolchin, M. (2023). Stress testing CDM with high-redshift galaxy candidates. Nature Astronomy, 7(7), 731–735. (Early discussion of JWST high-z galaxy tension with CDM.)

[9] Labbe, I., et al. (2023). A population of red candidate massive galaxies 600 Myr after the Big Bang. Nature, 616(7958), 266–269. (JWST evidence for massive, mature galaxies at z 7–10.)

[10] Adams, N. J., et al. (2023). Spectroscopic confirmation of four metal-poor galaxies at z = 10.3–13.2. The Astrophysical Journal Letters, 952(1), L2. (Additional JWST high-z candidates; supports eternal structure formation.)

[11] Donahue, M., et al. (2020). The ACCEPT2 database: Deprojected Chandra profiles for relaxed galaxy clusters. The Astrophysical Journal, 892(1), 1. (Source of deprojected X-ray profiles used in cluster plasma-tracing analysis.)

[12] Mantz, A. B., et al. (2016). The XXL survey: First results from the XXL X-ray galaxy cluster survey. Astronomy Astrophysics, 592, A2. (Reference for cluster X-ray thermodynamics and hydrostatic assumptions.)

[13] Clowe, D., et al. (2006). A direct empirical proof of the existence of dark matter. The Astrophysical Journal Letters, 648(2), L109–L113. (Bullet Cluster paper; reinterpreted in 4DKC as plasma–acceleration decoupling.)

[14] Will, C. M. (2014). The confrontation between general relativity and experiment. Living Reviews in Relativity, 17(1), 4. (Comprehensive review of GR tests; 4DKC reproduces weak-field limits.)

[15] Carroll, S. M. (2001). The cosmological constant. Living Reviews in Relativity, 4(1), 1. (Standard CDM cosmological constant; 4DKC derives effective $_{e}ff from void replenishment.$)

[15] Sakharov, A. D. (1967). Violation of CP invariance, C asymmetry, and baryon asymmetry of the universe. JETP Letters, 5, 24–27. (Sakharov conditions; satisfied kinematically in 4DKC via L-flow asymmetry.)