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

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Abstract

Four-Dimensional Kinetic Cosmology is founded on the postulate that the observable three-dimensional universe is a hypersurface progressing through a flat four-dimensional Euclidean manifold. The progression of this hypersurface is governed by a single scalar flow field, while every physical system satisfies a constant four-dimensional speed constraint that partitions its total kinematic motion between the observable three-dimensional hypersurface and the fourth spatial dimension. Time is the observable measure of physical progression through the fourth spatial dimension, not a fundamental dimension.

Continuous electromagnetic binding extracts kinetic energy from the background hypersurface progression, producing local reductions in the scalar flow field and an accumulated wake that together generate the observed gravitational interaction. Newtonian gravity, the weak-field limit of General Relativity, gravitational time dilation, gravitational redshift, inertia, and the equivalence principle emerge as macroscopic consequences of the scalar flow dynamics rather than as independent postulates. The theory reproduces the local predictions of Special Relativity exactly, with the Lorentz transformations emerging as geometric consequences of the constant four-dimensional speed constraint rather than as independent postulates. Increasing motion within the observable three-dimensional hypersurface necessarily reduces progression through the fourth spatial dimension while preserving the total kinematic speed.

The resulting framework provides a unified continuum-mechanical description of gravity, relativity, and cosmological evolution while maintaining a globally flat geometry and explicit energy accounting. General Relativity is recovered as an effective weak-field approximation, whereas galactic and cosmological phenomena are interpreted as long-range consequences of the evolving scalar flow field and its persistent wake.

0.1 Introduction

General Relativity successfully describes gravity as the curvature of space-time produced by energy and momentum. Four-Dimensional Kinetic Cosmology proposes an alternative description in which gravity, relativity, and cosmology emerge from the kinematics of a moving three-dimensional hypersurface embedded in a flat four-dimensional Euclidean manifold. Rather than treating time as a fundamental geometric dimension, time is the observable consequence of the physical progression of the hypersurface through a fourth spatial dimension.

The theory rests upon two complementary principles. The first is a scalar flow field that governs the progression of the hypersurface through the fourth dimension. The second is a constant four-dimensional speed constraint that governs the motion of every physical system within that moving hypersurface. Together these provide the dynamical and kinematic foundations from which relativistic and gravitational phenomena emerge.

The theory is founded on four fundamental postulates.

1. Reality is a flat four-dimensional Euclidean manifold,

$$M_4 = \mathbb{R}^4, \tag{1}$$

   with Cartesian coordinates (x, y, z, L).

2. The locally observable universe is a three-dimensional spatial hypersurface that progresses continuously through the fourth spatial dimension.

3. The progression of the hypersurface is governed by a scalar flow field

$$v_0(\mathbf{r}, \lambda),$$

   which specifies the local background progression rate through the fourth spatial dimension. Every physical system is carried by this progressing hypersurface and therefore inherits its local background motion.

   In the absence of continuous electromagnetic extraction,

$$v_0 = c,$$

   in regions containing bound matter,

$$v_0 = c - \delta v_0,$$

   where δv_0 is the local reduction in the background flow rate because electromagnetic binding continuously extracts kinetic energy from the background flow.

4. Every physical system possesses the local background progression rate provided by the scalar flow field. Motion through the observable three-dimensional hypersurface does not increase the total four-dimensional motion of the system; instead, it redistributes that motion between

ordinary spatial motion and progression through the fourth spatial dimension according to the constant four-dimensional speed constraint

$$v^2 + v_L^2 = v_0^2, \tag{2}$$

where v is the ordinary three-dimensional velocity relative to the local hypersurface, v_L is the corresponding progression through the fourth spatial dimension, and v_0 is the local background progression rate specified by the scalar flow field.

The remainder of this paper develops the consequences of these postulates. The scalar flow field determines the evolution of the hypersurface, while the constant four-dimensional speed constraint determines how physical systems move within it. Together they provide a unified kinematic description of gravitation, inertia, relativistic phenomena, and cosmological evolution on a globally flat four-dimensional Euclidean manifold.

0.2 Scalar Flow Field Dynamics

The postulates introduced above define the geometry and kinematics of 4DKC. We now develop the dynamics of the scalar flow field that governs the progression of the observable hypersurface through the fourth spatial dimension.

The manifold possesses the Euclidean metric

$$ds^2 = dx^2 + dy^2 + dz^2 + dL^2, \tag{3}$$

so that

$$R^\alpha{}_{\beta\mu\nu} = 0.$$

The observable hypersurface progresses through the fourth spatial dimension according to

$$v_0(\mathbf{r}, \lambda) = \frac{dL}{d\lambda}, \tag{4}$$

where λ is an affine evolution parameter labeling successive positions of the hypersurface.

The scalar flow field governs the motion of the observable hypersurface. The kinematics of individual physical systems are then determined by the constant four-dimensional speed constraint established in Eq. (2). The effective progression of a body through the fourth spatial dimension is therefore

$$dL_{\text{eff}} = v_L \, d\lambda. \tag{5}$$

Proper time is identified with this effective progression,

$$d\tau = \frac{dL_{\text{eff}}}{c}, \tag{6}$$

so that clocks measure the component of a body's four-dimensional motion directed along the fourth spatial dimension rather than the evolution of an independent temporal coordinate.

0.2.1 The Constant Four-Dimensional Speed Constraint

Every physical system possesses a constant total speed through the four-dimensional Euclidean manifold. Ordinary motion within the locally observable three-dimensional hypersurface does not increase this total speed. Instead, it redistributes the available motion between the observable spatial dimensions and the fourth spatial dimension.

This relationship is expressed by the constant four-dimensional speed constraint, Eq. (2)

The effective progression through the fourth dimension during an interval $d\lambda$ is therefore

$$dL_{\text{eff}} = v_L \, d\lambda = \sqrt{v_0^2 - v^2} \, d\lambda. \tag{7}$$

This equation is the master kinematic relation of the theory. It expresses the fundamental geometric constraint that every physical system continuously traverses the entire four-dimensional manifold, while the partitioning of that motion between the observable three-dimensional hypersurface and the fourth spatial dimension depends on its state of motion and the local scalar flow field.

Several fundamental results follow immediately from Eq. (7).

First, in regions where the background flow remains uniform ($v_0 = c$),

$$d\tau = \sqrt{1 - \frac{v^2}{c^2}} \, d\lambda, \tag{8}$$

which is precisely the Lorentz time-dilation relation of Special Relativity. The Lorentz factor therefore emerges as a direct consequence of Euclidean geometry rather than as a separate postulate.

Second, if the local background progression rate is reduced by continuous electromagnetic extraction,

$$v_0 = c - \delta v_0,$$

then even a body at rest within the local hypersurface experiences a reduced progression through the fourth dimension. Gravitational time dilation and inertial time dilation therefore originate from the same geometric constraint. Both correspond to reductions in the effective progression through the fourth spatial dimension, although one arises from changes in the background flow while the other results from redistribution of the constant four-dimensional speed into ordinary spatial motion.

The phenomenon historically described as relativistic mass becomes the geometric consequence of redistributing a fixed four-dimensional speed between motion through the observable hypersurface and progression through the fourth spatial dimension. The total kinematic speed remains constant; only its orientation within the four-dimensional manifold changes. The increasing resistance to acceleration therefore reflects the diminishing component of motion available along the fourth dimension rather than any increase in the intrinsic mass of the body.

Equation (7) therefore provides the unifying kinematic foundation of 4DKC. Special Relativity, gravitational time dilation, inertia, and the equivalence principle all emerge as different manifestations of the same geometric relationship within a flat four-dimensional Euclidean manifold.

0.2.2 Flow-Induced Gravity

Having established the scalar flow field as the fundamental dynamical field, gravity emerges naturally as a consequence of its spatial and temporal evolution rather than as an independent interaction. Gravity is therefore not a manifestation of intrinsic space-time curvature but the macroscopic response of matter to variations in the background progression of the observable hypersurface through the fourth spatial dimension.

The local background progression rate is described by the scalar flow field

$$v_0(\mathbf{r}, \lambda),$$

whose evolution is governed by the flow evolution equation,

$$\frac{\partial v_0}{\partial \lambda} = D\nabla^2 v_0 - \frac{v_0 - v_{\text{eq}}}{\tau}, \tag{9}$$

. Continuous electromagnetic extraction reduces the local value of v_0, producing spatial gradients that act as the physical source of gravitation.

The effective gravitational potential is defined by

$$\Psi \equiv (c - v_0) + \alpha \Phi, \tag{10}$$

where the first term represents the instantaneous reduction in the local background progression rate. The second term incorporates the history-dependent contribution of the wake field,

$$\Phi(\mathbf{r}, \lambda) = \int^{\lambda} [c - v_0(\mathbf{r}, \lambda')] \, d\lambda', \tag{11}$$

which records the accumulated history of local reductions in the background progression rate produced by continuous electromagnetic extraction.

The observable gravitational acceleration is then

$$\mathbf{g} = -\nabla \Psi = \nabla v_0 - \alpha \nabla \Phi. \tag{12}$$

Unlike General Relativity, where the metric tensor is the fundamental gravitational field, 4DKC contains only one fundamental dynamical field: the scalar flow field $v_0(\mathbf{r}, \lambda)$. The wake field Φ and the effective potential Ψ are successive emergent descriptions constructed from the evolution of this single field.

The resulting gravitational field contains two physically distinct but dynamically related contributions. The first is the instantaneous response produced by spatial variations of the local background flow. This component dominates wherever continuous electromagnetic extraction is sufficiently strong that the flow remains close to local equilibrium, thereby reproducing Newtonian gravity and the weak-field limit of General Relativity.

The second contribution arises from the accumulated wake generated by the history of continuous electromagnetic extraction. Because the wake persists after individual extraction events, it extends beyond the immediate region occupied by bound matter and contributes an additional long-range component to the gravitational field. The wake therefore provides a natural memory mechanism linking present gravitational behavior to the previous evolution of the scalar flow field.

The relative importance of the instantaneous and wake contributions is determined by the flow evolution equation, Eq. (**??**). In regions of strong extraction the local flow gradient dominates and reproduces the Newtonian and weak-field limits of General Relativity. In low-acceleration environments the accumulated wake becomes increasingly important, producing the observed long-range gravitational behavior without requiring an externally imposed interpolation function or an additional dark matter component.

Within this framework, Newtonian gravity, the weak-field limit of General Relativity, galaxy rotation curves, the radial acceleration relation, gravitational lensing, and cluster-scale dynamics are all interpreted as different manifestations of a single continuum-mechanical process. Local gravitational fields are governed primarily by the instantaneous structure of the scalar flow field, whereas galactic and cosmological phenomena are increasingly influenced by the accumulated wake generated by the history of continuous electromagnetic extraction during the progression of the hypersurface through the fourth spatial dimension.

The logical relationships among the principal gravitational quantities may be summarized schematically as

$$v_0 \xrightarrow{\Phi = \int (c - v_0)\, d\lambda} \Psi = (c - v_0) + \alpha\Phi \xrightarrow{\mathbf{g} = -\nabla\Psi} \mathbf{g}. \tag{13}$$

Equation (13) emphasizes the logical structure of the theory. The scalar flow field $v_0(\mathbf{r}, \lambda)$ is the only fundamental dynamical field. The wake field Φ records the accumulated history of continuous electromagnetic extraction from the background progression. The effective potential Ψ provides a macroscopic description of the combined instantaneous and history- dependent contributions, while the observable gravitational acceleration $\mathbf{g}$ is simply the spatial gradient of that potential. Gravity therefore emerges as the kinematic response of matter to variations in a single scalar flow field defined on a flat four-dimensional Euclidean manifold.

0.2.3 Flow Evolution Equation

The evolution of the scalar flow field is governed by the general conservation principle of continuum mechanics: the local rate of change of the field equals the net transport of the field together with local source and sink terms.

Accordingly,

$$\frac{\partial v_0}{\partial \lambda} = -\nabla \cdot \mathbf{J}, \tag{14}$$

states that the scalar flow is locally conserved.

Assuming isotropic transport, the simplest constitutive relation is Fick's law,

$$\mathbf{J} = -D\nabla v_0, \tag{15}$$

where D is the effective diffusion coefficient governing the spatial propagation of flow disturbances. Substituting Eq. (15) into Eq. (14) gives

$$-\nabla \cdot \mathbf{J} = D\nabla^2 v_0.$$

In the absence of extraction, the background progression relaxes toward its equilibrium value,

$$v_0 = c,$$

over the characteristic timescale τ. The corresponding linear relaxation term is

$$-\frac{v_0 - c}{\tau}.$$

The evolution of the scalar flow field is therefore

$$\frac{\partial v_0}{\partial \lambda} = D\nabla^2 v_0 - \frac{v_0 - v_{\mathrm{eq}}}{\tau}, \tag{16}$$

Electromagnetic extraction arises from the interaction between the scalar flow field and bound electromagnetic structure. This interaction is described by the free-energy functional

$$\mathcal{F}[v_0] = \int \left[\frac{D}{2} |\nabla v_0|^2 + U_{\mathrm{relax}}(v_0) + U_{\mathrm{bind}}(v_0, \rho_b) \right] d^3x, \tag{17}$$

where the gradient term penalizes spatial variations in the background progression rate, U_{relax} possesses a minimum at the equilibrium state $v_0 = c$, and U_{bind} represents the interaction energy between the scalar flow field and bound electromagnetic matter.

Assuming that the scalar flow evolves toward lower free energy, its dynamics satisfy the gradient-flow equation

$$\frac{\partial v_0}{\partial \lambda} = -\frac{\delta \mathcal{F}}{\delta v_0}. \tag{18}$$

The functional derivative immediately yields

$$\mathit{\Gamma} = \frac{\partial U_{\mathrm{bind}}}{\partial v_0}, \tag{19}$$

showing that continuous electromagnetic extraction is not an independent postulate but the natural consequence of the interaction energy between the scalar flow field and bound matter.

Consequently, the diffusion, relaxation, and extraction terms all arise from a single continuum-mechanical variational principle, providing the governing dynamics of the scalar flow field from which the wake field, effective gravitational potential, and observable gravitational acceleration subsequently emerge.

0.2.4 Energy Functional

The evolution of the scalar flow field follows a general variational principle. The background progression field evolves toward configurations that minimize the total free energy of the four-dimensional continuum. The governing dynamics therefore arise from the energetics of the scalar flow itself.

The total free-energy functional is

$$\mathcal{F}[v_0] = \int_V u(v_0, \nabla v_0, \rho_b)\, d^3x, \tag{20}$$

where u is the local free-energy density and the integration extends over the observable three-dimensional hypersurface.

The simplest rotationally invariant form of the free-energy density is

$$u = \frac{D}{2}|\nabla v_0|^2 + \frac{1}{2\tau}\left(v_0 - v_{\mathrm{eq}}\right)^2, \tag{21}$$

where the first term represents the energy associated with spatial gradients of the scalar flow field, while the second describes the tendency of the background progression rate to relax toward a local equilibrium value v_{eq}.

In empty space the equilibrium progression rate is

$$v_{\mathrm{eq}} = c.$$

Bound electromagnetic structure modifies this equilibrium by continuously extracting kinetic energy from the background flow. Rather than acting as an external force, bound matter changes the locally preferred progression rate according to

$$v_{\mathrm{eq}} = c - \mathit{\Delta} v(\rho_b), \tag{22}$$

where $\mathit{\Delta} v(\rho_b)$ is the reduction produced by the local density of bound electromagnetic structure. The explicit functional form of $\mathit{\Delta} v$ remains to be determined experimentally or derived from a more complete microscopic description of electromagnetic binding.

Assuming dissipative gradient-flow dynamics, the scalar flow field evolves according to

$$\frac{\partial v_0}{\partial \lambda} = -\frac{\delta \mathcal{F}}{\delta v_0}, \tag{23}$$

where $\delta\mathcal{F}/\delta v_0$ denotes the functional derivative of the free-energy functional.

Evaluating the functional derivative yields Eq. (16), the governing flow evolution equation.

When $v_{\mathrm{eq}} = c$, Eq. (16) reduces to the uniform-flow limit in which the background progression relaxes toward its equilibrium value. In regions containing bound electromagnetic structure, however, the equilibrium itself is locally shifted according to Eq. (22), providing a physical mechanism for continuous kinetic-energy extraction without introducing an independent source term. The scalar flow field therefore evolves toward the locally modified equilibrium determined by the distribution of bound matter.

This variational formulation unifies diffusion, relaxation, and electromagnetic extraction within a single continuum-mechanical framework. The resulting scalar flow field constitutes the only fundamental dynamical quantity of 4DKC, while the wake field, effective gravitational potential, and observable gravitational acceleration emerge subsequently from its evolution.

0.2.5 Energy Conservation

One of the principal motivations for 4DKC is to provide an explicit accounting of gravitational energy. In General Relativity the gravitational field is identified with space-time geometry, and a unique global energy density cannot be defined. 4DKC treats gravity as the dynamics of a scalar flow field on a fixed Euclidean manifold. Because the underlying geometry is globally flat, the energy associated with the flow field is defined in the usual continuum-mechanical manner.

Continuous electromagnetic binding converts kinetic energy from the background hypersurface progression into stable bound matter. The reduction in the local background progression rate is therefore not a loss of energy but a transfer between different forms. The total energy consists of three components:

1. kinetic energy remaining in the background flow,
2. energy stored in bound matter,
3. energy stored in distortions of the scalar flow field.

The third contribution represents the gravitational field itself. Because the wake field Φ describes the accumulated departure of the flow from its equilibrium state, its energy is naturally described by the standard continuum energy functional containing both gradient and storage terms,

$$\rho_\Phi = \frac{(\nabla\Phi)^2}{8\pi G} + \frac{\Phi^2}{2\tau\ell_0}. \tag{24}$$

The first term measures the energy stored in spatial variations of the wake field. It is directly analogous to the elastic energy associated with strain gradients in continuum mechanics and vanishes when the flow is spatially uniform. The coefficient $8\pi G$ is chosen so that the weak-field limit reproduces the conventional normalization of Newtonian gravity.

The second term represents the energy stored by maintaining the wake field away from its equilibrium state. Because the wake relaxes toward the background flow on the timescale τ, sustaining a non-zero value of Φ requires stored energy. The characteristic length scale ℓ_0 gives the storage term the correct physical dimensions of energy density. Its numerical value depends upon the microscopic properties of the underlying continuum and may ultimately be constrained by observation.

The total conserved energy of the system may therefore be written schematically as

$$E_{\text{total}} = E_{\text{flow}} + E_{\text{bound}} + \int \rho_\Phi \, d^3x, \tag{25}$$

where E_{flow} denotes the kinetic energy remaining in the background hypersurface progression and E_{bound} is the energy continuously extracted into stable electromagnetic bound matter.

The advection–diffusion–relaxation equation governing the scalar flow field continuously transfers energy among these three components without creating or destroying energy. Electromagnetic extraction reduces the local background progression rate, diffusion redistributes flow energy spatially, and relaxation gradually returns the flow toward equilibrium. The wake field therefore acts as the intermediary that stores and transports gravitational energy while preserving global conservation.

Unlike General Relativity, where gravitational energy is fundamentally non-local, 4DKC attributes gravitational energy to measurable distortions of a physical scalar flow field.

The local energy balance:

$$\frac{\partial}{\partial \lambda}\left(\rho_{\text{flow}} + \rho_{\text{bound}} + \rho_{\Phi}\right) + \nabla \cdot \mathbf{J} = 0, \tag{26}$$

where J is the total energy flux, shows that energy is locally conserved through exchanges among the background flow, bound matter, and the wake field.

Not only does 4DKC conserve energy more transparently than General Relativity, it explains why the flat Euclidean manifold and scalar flow field naturally admit a local energy density and conservation law.

0.2.6 Emergent Relativistic Dynamics

There is no fundamental distinction between gravitational and inertial time dilation. Both arise from changes in the effective progression of matter through the fourth spatial dimension. Proper time is therefore not a primitive quantity but the physical measure of effective progression through the fourth dimension, as defined by Eqs. (5) and (6).

The constant four-dimensional speed constraint postulate, $v^2 + v_L^2 = v_0^2$ provides the geometric foundation of all relativistic phenomena.

In regions free of bound electromagnetic structure the background progression remains at its equilibrium value,

$$v_0 = c.$$

Eq. (2): therefore gives

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

which, together with Eq. (6), immediately yields

$$d\tau = d\lambda\sqrt{1 - \frac{v^2}{c^2}}, \tag{27}$$

recovering the standard expression of Special Relativity. The Lorentz factor is therefore interpreted as the geometric projection of a constant four-speed onto the fourth spatial dimension rather than as a consequence of Minkowski space-time.

Gravitational time dilation follows from exactly the same geometric principle. Continuous electromagnetic extraction locally reduces the background progression rate of the hypersurface,

$$v_0 = c - \delta v_0,$$

which brings us back to the constant four-dimensional speed constraint relation

$$v^2 + v_L^2 = v_0^2.$$

The reduction in proper time therefore arises because less progression through the fourth spatial dimension is available locally. Motion and gravity do not represent two independent mechanisms of time dilation. Motion redistributes a body's constant four-speed between the observable hypersurface and the fourth dimension, whereas gravity reduces the local background progression itself. Both reduce the effective four-dimensional progression measured by physical clocks.

The same mechanism naturally explains gravitational redshift. Electromagnetic waves are four-dimensional structures whose observable three-dimensional evolution results from the progression of the hypersurface through the fourth spatial dimension. The wave itself provides a persistent record of the local scalar flow field encountered during the evolution of the hypersurface. The observable separation between successive hypersurface positions increases as the hypersurface progresses through the fourth dimension.

Inertia likewise acquires a direct geometric interpretation. Every physical system maintains a constant total speed through the four-dimensional manifold. Acceleration within the observable three-dimensional hypersurface therefore requires a continual redistribution of this motion away from the fourth dimension. Resistance to acceleration reflects the dynamics of this redistribution rather than an intrinsic property of mass alone.

The equivalence principle follows immediately from the constant four-speed constraint. Gravitational time dilation results from reductions in the local background progression rate, whereas inertial time dilation results from increased motion within the hypersurface. Both modify the same geometric relation, Eq. (2), and therefore both reduce the effective progression through the fourth dimension. The equality of gravitational and inertial mass is therefore a consequence of the underlying flow dynamics rather than an independent postulate.

Consequently, the relativistic phenomena traditionally attributed to curved space-time emerge from the geometry of a flat four-dimensional Euclidean manifold together with the dynamics of a single scalar flow field. Proper time measures progression through the fourth dimension, while the constant four-speed constraint unifies Special Relativity, gravitational time dilation, inertia, gravitational redshift, and the equivalence principle as different manifestations of a single underlying kinematic process.

0.2.7 Electromagnetic Field Evolution

The observable electromagnetic field is defined on the three-dimensional hypersurface that constitutes the locally observable universe. The fourth spatial dimension is not an additional direction through which electromagnetic waves propagate. Instead, the evolution of the electromagnetic field is described by successive positions of the observable hypersurface as it progresses through the fourth spatial dimension.

The electric and magnetic fields therefore become

$$\mathbf{E}(\mathbf{r}, \lambda), \qquad \mathbf{B}(\mathbf{r}, \lambda),$$

where the affine parameter λ labels successive positions of the observable hypersurface during its progression through the fourth spatial dimension.

It is convenient to combine the electric and magnetic fields into a single electromagnetic field variable

$$\mathbf{F} = (\mathbf{E}, \mathbf{B}),$$

whose evolution is governed by

$$\frac{\partial \mathbf{F}}{\partial \lambda} = \mathcal{M}(\mathbf{F}, v_0), \tag{28}$$

where $\mathcal{M}$ denotes the Maxwell evolution operator and $v_0(\mathbf{r}, \lambda)$ is the local background progression rate of the hypersurface.

In regions where the scalar flow field is uniform ($v_0 = c$), Eq. (28) reduces to the familiar Maxwell equations,

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}, \tag{29}$$

$$\nabla \cdot \mathbf{B} = 0, \tag{30}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial \lambda}, \tag{31}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial \lambda}, \tag{32}$$

showing that classical electromagnetism is recovered in the uniform-flow limit.

These equations do not describe electromagnetic fields propagating through an independent temporal dimension. Rather, they describe the evolution of the electromagnetic field associated with successive positions of the observable hypersurface as it progresses through the fourth spatial dimension.

Electromagnetic waves are therefore interpreted as four-dimensional structures whose observable three-dimensional manifestation evolves as the hypersurface advances through the scalar flow field. The invariant speed of light reflects the geometric relationship between the evolution of the hypersurface and the electromagnetic field rather than a fundamental property of space-time.

0.2.8 Electromagnetism as the Coupling to the Fourth Dimension

Having established the evolution of the electromagnetic field on successive positions of the observable hypersurface, we now consider its physical role.

Electromagnetism occupies a unique position in the 4DKC. Rather than being simply one interaction among several, it provides the physical mechanism through which bound matter exchanges kinetic energy with the background scalar flow. Continuous electromagnetic binding transfers kinetic energy from the background progression of the hypersurface into stable bound structure, thereby reducing the locally preferred background progression rate.

Within the variational formulation developed in Section 0.2.7, bound electromagnetic structure modifies the local equilibrium value of the scalar flow field according to

$$v_{\mathrm{eq}} = c - \Delta v(\rho_b), \tag{33}$$

where $\Delta v(\rho_b)$ represents the reduction produced by the local density of bound electromagnetic structure.

The scalar flow field subsequently relaxes toward this modified equilibrium through the flow evolution equation, Eq. (9) thereby generating spatial gradients in the background progression rate.

These gradients define the effective gravitational potential and its associated wake field discussed in the preceding section. Gravity is therefore not generated directly by mass, but by the modification of the scalar flow field produced through electromagnetic binding.

This interpretation extends Kaluza's original observation that electromagnetism is intimately connected with an additional spatial dimension. In 4DKC the fourth dimension is not compactified, but forms a large-scale Euclidean direction through which the observable three-dimensional hypersurface continuously progresses. Electromagnetic interactions constitute the mechanism by which bound matter couples to that progression.

Electromagnetism and gravitation are therefore complementary aspects of a single continuum-mechanical system. The scalar flow field determines the kinematics of the hypersurface, Maxwell's equations govern the evolution of the electromagnetic field on that hypersurface, and electromagnetic binding continuously modifies the scalar flow. The resulting changes in the background progression rate produce the gravitational phenomena described by the flow-induced gravity of 4DKC.

0.2.9 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.

0.2.10 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:

$$\partial_\mu J^\mu = S_{\text{creation}} - S_{\text{extraction}}. \tag{34}$$

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 Conclusion

This work demonstrates that a flat Euclidean manifold together with a single scalar flow field and a constant four-speed constraint is sufficient to reproduce the principal weak-field predictions of

General Relativity while providing a unified kinematic interpretation of gravity, inertia, proper time, and cosmological evolution.

0.4 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.

0.4.1 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.

0.4.2 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.

0.5 Summary of Symbols

Symbol	Description
L	Fourth spatial dimension
λ	Affine evolution parameter
Γ	The continuous electromagnetic extraction rate
ρ_{e_m}	Electromagnetic energy Density
D, τ, κ	Wake diffusion, relaxation, and coupling parameters
Tuv	Stress energy Tensor
j_v	Current

F_uv	Electromagnetism
a_u	Gravity/Deceleration Field
ρ	Mass Density
a_L	Deceleration
v	Ordinary progression through 3D space
v_L	Progression of an object through L
v_0	3D Hypersurface through L
j_u	4D Current Density
Ψ	Effective potential, (instantaneous and memory contributions)
J	Total energy flux,
Φ	Deceleration-memory wake field
ρ_K	Relativistic kinetic energy density
ρ_b	Bound rest-mass energy density
U_{bind}	Electromagnetic binding energy
ρ_Φ	Stored energy density

Bibliography

[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., and 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 and Astrophysics, 641, A6. (Standard ΛCDM 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 ΛCDM with high-redshift galaxy candidates. Nature Astronomy, 7(7), 731–735. (Early discussion of JWST high-z galaxy tension with ΛCDM.)

[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 $\approx$ 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 ΛCDM cosmological constant; 4DKC derives effective Λ_eff from void replenishment.)

[16] 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.)

Research pertinent to the latest revisions, on Continuum Mechanics & Scalar Fields.

[17] Landau, L. D., & Lifshitz, E. M. (1987). Fluid Mechanics (2nd ed.). Pergamon Press.

[18] Batchelor, G. K. (1967). An Introduction to Fluid Dynamics. Cambridge University Press.

[19] Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2007). Transport Phenomena (2nd ed.). Wiley.

On classical field theory and how fields, potentials, and sources fit together mathematically.

[20] Goldstein, H., Poole, C., & Safko, J. (2002). Classical Mechanics (3rd ed.). Addison-Wesley.

[21] Jackson, J. D. (1999). Classical Electrodynamics (3rd ed.). Wiley.

[22] Weinberg, S. (1972). Gravitation and Cosmology. Wiley.

On emmergent gravity.

[23] Jacobson, T. (1995). "Thermodynamics of Spacetime: The Einstein Equation of State." Physical Review Letters, 75, 1260–1263.

[24] Verlinde, E. (2011). "On the Origin of Gravity and the Laws of Newton." Journal of High Energy Physics, 2011(4), 29.

[25] Gravity and the Thermodynamics of Horizons.

On flowing space.

[26] Cahill, R. T. (2003). Process Physics: From Information Theory to Quantum Space and Matter.

[27] Painlevé (1921) Gullstrand (1922)

[28] Turing, A. M. (1952). "The Chemical Basis of Morphogenesis."

[29] Arnold, V. I. Mathematical Methods of Classical Mechanics.

[30] Visser, M. (1998). "Acoustic Black Holes." Barceló, Liberati & Visser (2011). Analogue Gravity.

[31] George F. R. Ellison The nature of time and spacetime.

[32] Carlo Rovelli On emergent time and relational physics.

[33] Ted Jacobson (1995) and later work on Einstein equations as emergent.

[34] Erik Verlinde (2016) Emergent gravity.

[35] David Tong's lecture notes on classical field theory and relativity.