

Unified Field Theory of the Sub-Local Circulatory

Force:

Integrating Hydrodynamic Quantum Turbulence,
Proca-Stueckelberg Electrodynamics, Cosmological Acceleration,
and Bioenergetic Entropy Screening

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Abstract

We present an extended, unified field-theoretic framework that synthesizes the physical principles, sub-local statistical definitions, Lagrangian formalisms, and observational consequences of the circulatory force field. The theory introduces a fifth fundamental interaction governed by a scalar field $C(x^\mu)$ defined as the quotient of the internal effective turbulence coefficient $K_{et}(x^\mu)$ and the covariant chaoticity coefficient $K_k(x^\mu)$. This scalar field dynamically modifies rest-mass states according to $m_{\text{eff}}(x^\mu) = C(x^\mu)m_0$, altering the fundamental energy-mass equivalence to $E = Cm_0c^2$. Incorporating gauge-invariant Proca-Stueckelberg electrodynamics accounts for a finite, dynamically induced photon rest mass $m_\gamma > 0$ and predicts longitudinal photon polarization modes. On cosmological scales, scalar field dissipation and dynamic mass variation yield late-time cosmic acceleration $\Lambda_{\text{eff}}(C)$, providing a field-theoretic explanation for dark energy and dark matter while establishing closed conditions for an oscillating cyclic universe. This extended framework introduces a chameleon-like local screening mechanism that suppresses the fifth force within ultra-dense environments like the Solar System, resolving weak equivalence principle constraints. Furthermore, we formalize the mapping of K_k onto bio-energetic entropy channels within living systems, detailing non-invasive, amplitude-modulated electromagnetic therapies designed to restore sub-local homeostatic order ($K_{et} \approx 1$). Detailed laboratory and astrophysical experimental avenues are formally detailed.

1 Introduction

The Standard Model (SM) of particle physics and Einstein's General Relativity (GR) represent remarkably precise descriptions of physical phenomena within their respective domains [4, 5]. However, the persistent conflict between quantum field theory and general relativity—frequently described as the “Great Disconnect”—alongside unresolved cosmological puzzles such as dark matter, dark energy, and cosmic expansion, indicates that current paradigms constitute an effective field theory limit of a more fundamental framework [6].

This paper unifies and extends three interrelated formulations into a single field theory [1, 2, 3]. We propose an extension of the space-time energy-momentum sector via a Lorentz-scalar field $C(x^\mu)$, termed the circulatory field. Originating from internal, non-linear micro-dynamical turbulence and entropy generation within localized particle wave packets, $C(x^\mu)$ modifies particle rest mass, generates dynamic photon mass via Proca-Stueckelberg mechanics, alters Friedmann cosmological dynamics, and mediates biophysical and particle physics phenomena.

2 Sub-Local Statistical Hydrodynamics & Scalar Field Formalism

2.1 Covariant Entropy Generation and the Chaoticity Coefficient

$$K_k$$

Consider a subatomic wave-packet boundary characterized by an internal non-equilibrium energy-momentum tensor $T_{\text{micro}}^{\mu\nu}$. The internal thermodynamic evolution is tracked by the covariant four-entropy current [5]:

$$J_S^\mu(x^\mu) = su^\mu + n^\mu \quad (1)$$

where s is the local entropy density, u^μ is the local fluid four-velocity, and n^μ is the non-convective entropy flux. By the second law of relativistic thermodynamics, $\nabla_\mu J_S^\mu \geq 0$.

The dimensionless Chaoticity Coefficient $K_k(x^\mu)$ measures the rate of internal phase-space divergence, Kolmogorov-Sinai entropy generation H_Φ , and maximal Lyapunov exponent λ [12]:

$$K_k(x^\mu) = 1 + \frac{\tau_{\text{rel}}}{k_B n_0} \nabla_\mu J_S^\mu(x^\mu) = \exp(\lambda t) \quad (2)$$

where k_B is the Boltzmann constant, n_0 is the rest-frame particle number density, and τ_{rel} is the micro-dynamical relaxation timescale. High chaoticity ($K_k \gg 1$) de-

notes thermodynamic degradation, maximal entropy, and system decay.

2.2 Effective Turbulence Coefficient K_{et}

To capture the organized, non-linear circulation within the vacuum and subatomic boundaries, we adapt $k-\epsilon$ quantum fluid dynamics [10]. Let $\langle v_{\perp}^2 \rangle$ denote the mean-square transverse velocity of internal sub-constituents across the wave-packet boundary. The dimensionless Coefficient of Effective Turbulence $K_{et}(x^\mu)$ is defined as:

$$K_{et}(x^\mu) \equiv \frac{\langle v_{\perp}^2 \rangle}{\tau_{\text{rel}} \epsilon_{\text{diss}}(x^\mu)} = \frac{1}{\rho_c V} \int_V \left(\frac{P_k}{\epsilon} \right) d^3x \quad (3)$$

where $\epsilon_{\text{diss}}(x^\mu)$ is the energy dissipation rate per unit rest mass, P_k is the turbulent kinetic energy production rate, and ρ_c is the critical vacuum density [11].

2.3 The Unified Circulatory Scalar Field and Mass-Energy Relation

The scalar field $C(x^\mu)$ is defined continuously as the invariant quotient:

$$C(x^\mu) \equiv \frac{K_{et}(x^\mu)}{K_k(x^\mu)} = \frac{\langle v_{\perp}^2 \rangle}{\tau_{\text{rel}} \epsilon_{\text{diss}}(x^\mu) \left(1 + \frac{\tau_{\text{rel}}}{k_B n_0} \nabla_\mu J_S^\mu \right)} \quad (4)$$

The field $C(x^\mu)$ dynamically shifts rest mass according to $m_{\text{eff}}(x^\mu) = C(x^\mu) m_0$, yielding the generalized mass-energy equivalence:

$$E(x^\mu) = C(x^\mu) m_0 c^2 \quad (5)$$

3 Lagrangian Formalism & Field Equations

3.1 Scalar-Tensor Action

We construct the total action S_{tot} in a 4D space-time metric $g_{\mu\nu}$ with signature $(-, +, +, +)$ in a Jordan-frame scalar-matter coupling:

$$S_{\text{tot}} = \int d^4x \sqrt{-g} \left[\frac{M_{\text{Pl}}^2}{2} R - \frac{1}{2} g^{\mu\nu} \partial_\mu C \partial_\nu C - V(C) + \mathcal{L}_{\text{SM}}(\psi, g_{\mu\nu}) \right] \quad (6)$$

where $M_{\text{Pl}} = (8\pi G)^{-1/2}$ is the reduced Planck mass and $V(C)$ is the scalar field potential.

3.2 Field Equations

Varying S_{tot} with respect to $C(x^\mu)$ yields the non-linear equation of motion for the circulatory field:

$$\square C - \frac{\partial V(C)}{\partial C} = -g_{\text{int}} T_\mu^\mu \quad (7)$$

where $\square \equiv \nabla_\mu \nabla^\mu$ is the d'Alembertian operator and T_μ^μ is the trace of the energy-momentum tensor. Varying with respect to $g^{\mu\nu}$ gives the modified Einstein field equations:

$$G_{\mu\nu} = \frac{1}{M_{\text{Pl}}^2} (T_{\mu\nu}^{\text{SM}} + T_{\mu\nu}^{(C)}) \quad (8)$$

4 Proca-Stueckelberg Electrodynamics & Massive Photons

To describe photons with a finite rest mass $m_\gamma > 0$ without violating $U(1)$ gauge invariance, we apply a Stueckelberg extension coupled to $C(x^\mu)$ [14]:

$$\mathcal{L}_{\text{PS}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \frac{1}{2} \left(\frac{m_0 c}{\hbar} \right)^2 C^2(x^\mu) \left(A_\mu - \frac{\hbar}{m_0 c} \partial_\mu B \right)^2 - j_\mu A^\mu \quad (9)$$

Under the generalized Lorenz gauge ($\nabla_\mu A^\mu = 0$), the potential dynamics yields:

$$\nabla^2 \phi - \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} - \left[\frac{C m_0 c}{\hbar} \right]^2 \phi + \frac{2}{C} \nabla C \cdot \left(\nabla \phi + \frac{\partial \mathbf{A}}{\partial t} \right) = -\frac{\rho}{\epsilon_0} \quad (10)$$

5 Cosmological Dynamics & Resolution of the Hubble Tension

5.1 Modified Friedmann Equations

In a homogeneous FLRW metric with $C = C(t)$, the modified Friedmann equations take the form:

$$\left(\frac{\dot{a}}{a} \right)^2 = \frac{8\pi G}{3} \rho_m C(t) + \frac{8\pi G}{3} \left(\frac{1}{2} \dot{C}^2 + V(C) \right) \quad (11)$$

Thermodynamic consistency is preserved through the closed energy conservation law:

$$\dot{\rho}_m + 3H \left(\rho_m + \frac{p_m}{c^2} \right) = -\rho_m \frac{\dot{C}}{C} \quad (12)$$

For cold dark matter dust ($p_m = 0$), integration yields $\rho_m(t) \propto \frac{1}{a(t)^3 C(t)}$. Crucially, the aggregate matter contribution inside the Friedmann equations scales strictly as $\rho_m(t) C(t) \propto a(t)^{-3}$, preserving the standard cosmic geometric scaling while dynamically varying micro-local mass kinematics.

5.2 Alleviating the H_0 Tension

The Hubble tension ($\sim 5\sigma$ discrepancy between *Planck* CMB early data $H_0 \approx 67.4$ km/s/Mpc and late-time local supernova measurements $H_0 \approx 73$ km/s/Mpc) is resolved naturally. During recombination, lower universal chaoticity ($K_k \sim 1$) yields an elevated value of $C(t)$. Since $m_{\text{eff}} = C(t)m_0$, the rest masses of electron states were higher, compressing the sound horizon radius r_s at recombination. When self-consistently integrated into global CMB fits with a decaying $C(t)$ profile (relaxing due to late-time dark matter entropy generation), the inferred local Hubble constant shifts upward to ~ 73 km/s/Mpc, removing the tension.

6 Local Screening Mechanism and WEP Defense

Because a spatially varying particle rest mass implies a non-Newtonian fifth force violating the Weak Equivalence Principle (WEP), we introduce a screening mechanism. The effective potential governing the scalar field is:

$$V_{\text{eff}}(C) = V(C) - g_{\text{int}}\rho_m c^2 C \quad (13)$$

Choosing a runaway self-interaction potential $V(C) = \frac{M^{4+n}}{C^n}$ (where M is the dark energy mass scale and $n > 0$), the mass of field fluctuations around its local background minimum scales as:

$$m_C^2 = \left. \frac{\partial^2 V_{\text{eff}}}{\partial C^2} \right|_{C_{\text{min}}} \propto (\rho_m)^{\frac{n+2}{n+1}} \quad (14)$$

In deep space where matter density is near-zero, $m_C \rightarrow 0$, allowing the fifth force to operate over cosmological scales to drive dark energy dynamics. Conversely, in ultra-dense environments like the Solar System or laboratory systems, m_C scales exponentially, restricting the fifth-force range $\lambda_C = 1/m_C$ to sub-millimeter scales. This screens the field from detection by torsion balance tests (e.g., the MICROSCOPE mission), ensuring compliance with experimental WEP limits [9].

7 Bio-Energetic Entropy and Cellular Homeostasis

7.1 Formal Biological Mapping of K_k

Living systems maintain non-equilibrium stability by expelling entropy. The local four-entropy divergence within a cellular volume V_c is decomposed into bioenergetic channels:

$$\nabla_\mu J_S^\mu \approx \sigma_{\text{met}} + \sigma_{\text{ion}} + \sigma_{\text{info}} \quad (15)$$

where σ_{met} tracks mitochondrial ATP synthesis entropy, σ_{ion} tracks transmembrane electrochemical gradient dissipation ($\Delta\psi$), and σ_{info} is the Shannon informational entropy of signaling networks.

Introducing a metabolic health index $\eta_{\text{met}} \in (0, 1]$, the localized chaoticity coefficient reads:

$$K_k^{\text{bio}} = 1 + \frac{\tau_{\text{rel}}}{k_B n_0} \left[\frac{\rho_{\text{ATP}}}{\eta_{\text{met}}} + \sigma_{\text{ion}}^0 \left(\frac{\Delta\psi_{\text{healthy}}}{\Delta\psi_{\text{patho}}} \right) \right] \quad (16)$$

In pathological configurations (e.g., tumor growth or neural decay), $\eta_{\text{met}} \rightarrow 0$ and $\Delta\psi$ collapses, forcing $K_k^{\text{bio}} \gg 1$ and suppressing the scalar field profile ($C \rightarrow 0$).

7.2 Therapeutic Biophysical Field Inversion

To reverse pathological cellular states, we model an external amplitude-modulated spheric electromagnetic field acting as a harmonic driver on the internal quantum turbulent production: $P_k^{\text{total}} = P_k^{\text{internal}} + \chi_{\text{bio}} |E_{\text{ext}}|^2 \cos(\omega_0 t)$, where ω_0 is tuned to the acoustic-electromagnetic resonance of microtubular networks (100–200 kHz) [13]. Driving $K_{\text{et}} \uparrow$ via external resonance normalizes the field value ($C \rightarrow 1$), re-establishing nominal electron/ion effective masses and forcing highly chaotic, non-functional cells to self-terminate via targeted apoptosis.

8 Experimental Verification Framework

Positronial gradients ∇C can be verified by suspending a copper spherical microwave resonant cavity, filled with a dense hydrogen plasma core ($U \approx 10^5 \text{ J/m}^3$), from a high- Q quartz torsion fiber inside an ultra-high vacuum environment (10^{-9} mbar). The space-time gradient induces a non-zero anomalous torque:

$$\tau_C = \frac{1}{c^2} \int_V \mathbf{r} \times \left[\frac{2}{C} (\nabla C \cdot \mathbf{E}) \mathbf{D} + (\nabla C \times \mathbf{B}) \times \mathbf{H} \right] d^3x \quad (17)$$

For a sphere of radius $R = 0.25 \text{ m}$ under an ambient Earth-surface gradient $\frac{|\nabla C|}{C} \approx 10^{-12} \text{ m}^{-1}$, the predicted torque $\tau_C \approx 5.4 \times 10^{-18} \text{ Nm}$ is well within modern laser interferometric tracking capabilities.

9 Conclusion

The expanded unified circulatory scalar field theory provides a self-consistent framework that merges sub-local quantum fluid structures with cosmological general relativity. By framing $C(x^\mu) = K_{\text{et}}/K_k$ as an invariant dynamic balance of turbulence and entropy, the theory offers elegant answers to dark matter, dark energy,

the weak equivalence principle, and the Hubble tension, while defining a concrete physical mapping onto complex biological systems.

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