From Neutrino Quantum Field to Atomic Structure: Microscopic Extension of Emergent Cosmology

Zhongyang Dong Independent Researcher

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ABSTRACT

Under the physical framework of a single neutral neutrino field Φ and a V_0 quantum vacuum fluid grid, this study establishes a geometric and topological mechanics picture of atomic structure. Traditional Standard Model [4] approaches rely on elementary particle hypotheses such as gauge bosons (gluons [5, 6], W/Z bosons [7], and photons [4]) to transmit interactions, leading to cumbersome corrections and ad hoc parameters. Here, the atomic nucleus is deconstructed into a condensation region of high-density baryon amplitude envelopes A_b. Meanwhile, electrons are identified as high-frequency phase-locked wave packets surrounding the nucleus. In this picture, the strong interaction is geometricized as topological flux tube tension resulting from envelope overlap at the femtometer scale. Asymptotic freedom naturally corresponds to the vanishing of phase gradients and tension unloading during extreme overlap. Furthermore, the weak interaction is expressed as local topological phase rearrangement accompanied by longitudinal spinor pulse emission, while the electromagnetic interaction is modeled as geometric polarization and transverse wave packet excitations of the parent fluid. Illustrative quantitative relations and energy transition integrals are provided, physical symbols are explicitly defined, future quantitative reproduction perspectives are outlined, and five prioritized experimental verification directions using existing and near-future precision instruments are proposed.

Keywords: Neutrino Field; Atomic Structure; Standard Model [4]; Elementary Particles [4-7]

1. Introduction

Conventional quantum chromodynamics and the Standard Model [4] rely on gauge bosons (such as gluons [5, 6], W/Z bosons [7], and photons [4]) as well as quarks [4-6] to mediate basic forces, causing microscopic physical models to incorporate numerous higher-order corrections and ad hoc parameters. Extending our previous work on the "neutrino quantum field background" and emergent cosmology [1-3], we apply Occam's razor to reduce the foundational reality of the universe to the dynamic response of a single neutral neutrino field Φ within a fundamental V_0 fluid grid.

The physical parameters in this model remain strictly aligned with our previous papers (fundamental grid spacing $\lambda_{v0} \approx 5.27$ mm, zero-point energy $E_{v0} \approx 2.35 \times 10^{-4}$ eV) [1, 3]. Microscopic particles and fundamental interactions are not independent entities, but rather localized stable amplitude and phase structures of the Φ field. This paper aims to unify the strong, weak, and electromagnetic interactions within the fluid geometry and topological dynamics of V_0. It should be noted that the present framework provides a qualitative geometric and topological unification; quantitative reproduction of high-precision quantum field theory calculations (such as exact nuclear binding energy values, detailed β-decay spectrum shapes, and atomic fine structure splittings) is reserved for dedicated future investigation. For detailed derivations of the background fluid grid parameterization (λ_{v0}, E_{v0}), dark phase transitions, and cosmic wave separation equations, readers are referred to Paper 1 [1, Sec. 2], Paper 2 [2, Sec. 3], and Paper 3 [3, Sec. 3–4].

2. Symbol and Variable Definitions

To ensure mathematical rigor, all physical symbols and variables appearing in this paper are defined with strict one-to-one correspondence in the table below:

Symbol / Variable	Physical Meaning and Definition	Standard Model Counterpart [4]
Φ	Single neutral neutrino field (Sole underlying entity field)	Unified parent field
V_0	Fundamental neutral fluid grid / Background vacuum (λ_{v0}, E_{v0})	Vacuum ground state
V_1	Dark energy state / Transverse phase flow field	Inflation / Dark energy field
V_2	Dark matter & gravity state / High-density degenerate fluid field	Dark matter / Gravitational medium
λ_{v0}	Vacuum fundamental grid spacing (Calibrated ~ 5.27 mm)	Spatial quantization scale
E_{v0}	Vacuum zero-point energy (Calibrated ~ 2.35×10^{-4} eV)	Vacuum zero-point energy
A_b	Baryon amplitude envelope (Proton/neutron localized structure)	Quark confinement state [4-6]
ρ_{core}	Energy density of the atomic nucleus core region	Nuclear matter density
ρ_{sat}	Saturation energy density plateau supported by V_2 state	Nuclear saturation density
$F_{tension}$	Topological flux tube tension (Strong nuclear force)	Strong force / Gluon field [5, 6]
κ_{top}	Topological stiffness coefficient of the vacuum fluid	String tension coefficient
$\Delta\varphi$	Local phase difference between adjacent envelopes	Color charge phase difference
d	Geometric distance between envelope centers	Inter-particle distance
d_{min}	Shortest distance limit during extreme envelope overlap	Asymptotic freedom scale [5, 6]
E_{bind}	Total binding energy of the atomic nucleus	Nuclear binding energy
$\nabla\varphi$	Local phase gradient vector	Field strength gradient
$\Delta E_{envelope}$	Energy difference during electron envelope transition	Atomic transition energy
$E_{initial}$	Initial state energy of the electron envelope before transition	Initial electron energy level
E_{final}	Final state energy of the electron envelope after transition	Final electron energy level
$\hbar$	Reduced Planck constant	Planck constant
$\omega_{transverse}$	Angular frequency of vacuum fluid transverse collective mode	Photon frequency [4]
ρ_{eff}	Effective mass density of the vacuum fluid	Vacuum effective density
$u_\perp$	Transverse displacement field vector of the vacuum fluid	Electromagnetic vector potential
P_{decay}	Probability of weak interaction process (e.g., β-decay)	Weak decay rate [7]
Θ	Heaviside step function	Critical step response
φ_{local}	Local accumulated phase value	Field accumulated phase
$\varphi_{critical}$	Critical phase threshold for unlocking and envelope reorganization	Weak critical phase angle [7]
ΔE_{weak}	Total energy released during weak decay process	Decay Q-value
E_ν	Energy carried by longitudinal spinor pulse (neutrino packet)	Neutrino energy [4]
E_e	Energy carried by newly generated electron envelope	Electron kinetic energy [4]
ΔE_{recoil}	Recoil energy absorbed by the daughter nucleus	Recoil energy

3. Strong Interaction & Nucleus: High-Density Envelopes & Flux Tube Tension

Protons and neutrons are not rigid spheres composed of point quarks [4-6], but high-density condensations of baryon amplitude envelopes A_b at the femtometer scale. The core energy density is supported by localized V_2 degenerate states, reaching a saturation plateau:

$$\rho_{core} \to \rho_{sat} \tag{3.1}$$

When multiple baryon envelopes approach within close proximity, the V_0 parent field undergoes geometric entanglement between envelopes, forming topological flux tubes. The strong force is essentially the tensile tension exerted by V_0 fluid resisting deformation, replacing gluon [5, 6] exchange:

$$F_{tension} = \kappa_{top} \cdot (\Delta\varphi / d) \tag{3.2}$$

Because $\Delta\varphi$ builds up rapidly at short distances and d is on the order of femtometers, this naturally explains the short-range and immense strength of the nuclear force. Multiplying tension by distance d_{ij} cancels the inverse-distance dependence, yielding the total nuclear binding energy as a direct sum of net topological phase potential energy across all adjacent envelope pairs:

$$E_{bind} \approx \sum_{i<j} \kappa_{top} \cdot \Delta\varphi_{ij} = \sum_{i<j} F_{tension}^{(ij)} \cdot d_{ij} \tag{3.3}$$

4. Fluid Mechanics Mechanism of Quark Confinement & Asymptotic Freedom

- **Quark Confinement:** When attempting to separate baryon envelopes, the V_0 fluid exhibits a non-zero effective shear modulus. Stretching the topological flux tube causes the geometric deformation energy to grow linearly or super-linearly with distance d:

  $$\lim_{d \to \infty} F_{tension} \to \infty \tag{4.1}$$

  This topologically forbids isolated single envelopes (referred to as free quarks [5, 6] in the Standard Model [4]).
- **Asymptotic Freedom:** When baryon envelopes are squeezed extremely close under high energy or high pressure ($d \to d_{min}$), the local phase gradient in the overlapping region vanishes:

  $$\nabla\varphi \to 0 \tag{4.2}$$

  The flux tube length contracts to zero and topological tension is unloaded:

  $$F_{tension} \to 0 \quad (\text{when } d \to d_{min}) \tag{4.3}$$

  Inside the deep core, envelopes experience zero deformation resistance, manifesting as asymptotic freedom [5, 6].

5. Electron Envelope, Energy Levels, & Electromagnetic Polarization

The electron is a high-frequency lepton amplitude envelope excited by the Φ field around the nucleus [4]. Discrete atomic orbits correspond to phase-locking and topological equilibrium radii established between the electron envelope and the fundamental grid spacing λ_{v0}.

Electromagnetic interactions manifest as longitudinal polarization and transverse vortices in the V_0 medium without virtual photon exchange [4]. When an electron transitions between energy levels, phase structure reorganizes, converting energy into kinetic energy of transverse collective wave modes in V_0 (aligned in three lines):

$$\begin{aligned} \Delta E_{envelope} &= E_{initial} - E_{final} \\ &= \hbar\,\omega_{transverse} \\ &= \int (\rho_{eff}/2)\,(\partial_t\,\mathbf{u}_\perp)^2\,dV \end{aligned} \tag{5.1}$$

where the volume integral in the third line represents the collective energy of the outward propagating transverse wave packet.

6. Weak Interaction: Phase Rearrangement & Spinor Release

Weak interactions correspond to unlocking and restructuring of high-frequency topological phases at the femtometer scale. When local phase accumulation reaches a critical threshold, envelope geometric reorganization occurs (e.g., neutron envelope restructuring into a proton envelope). The decay probability is governed by local phase conditions:

$$P_{decay} \sim \Theta(\varphi_{local} - \varphi_{critical}) \tag{6.1}$$

During phase reorganization, excess topological entanglement energy and angular momentum are instantly emitted as a longitudinal spinor pulse (neutrino wave packet) and a newly generated electron envelope (i.e., β-decay [4]). Total energy conservation satisfies:

$$\Delta E_{weak} = E_\nu + E_e + \Delta E_{recoil} \tag{6.2}$$

This demonstrates that weak interactions are not exchange processes mediated by W/Z bosons [7], but phase unlocking and pulse emission.

7. Geometric Unification Comparison of the Three Interactions

Interaction	Scale	Local Geometric & Topological Manifestation	Illustrative Relation	Standard Model [4]
Strong Force	Femtometer (10^{-15} m)	Topological flux tube tension & geometric locking at envelope overlap	$F_{tension} = \kappa_{top} \cdot (\Delta\varphi/d)$	Gluon [5, 6] / Confinement
Weak Force	Femtometer (10^{-18} m)	Critical phase unlocking, envelope restructuring & spinor pulse emission	$P_{decay} \sim \Theta(\varphi - \varphi_c)$	$W^{\pm}$, Z^0 Bosons [7]
EM Force	Atomic (10^{-10} m)	Longitudinal polarization & transverse collective wave excitation in V_0	$\Delta E = \hbar\omega = \int (\rho/2)(\partial_t \mathbf{u}_\perp)^2 dV$	Photons [4]

8. Experimental Verification Directions (Ordered by Priority)

To test the geometric and topological predictions of this framework, five concrete experimental testing schemes ordered by priority, feasibility, and decisive impact are proposed below:

1. **Gravitational Potential & Local V_0 Density Dependence of Isotope Decay Rates (Priority 1: Low-Cost, Long-Term Feasibility):** If weak interactions are topological phase unlocking processes at the femtometer scale, external gravitational potential wells or local V_0 vacuum density variations will perturb the critical phase threshold $\varphi_{critical}$. We propose long-term precision monitoring of radioactive isotope β-decay rates [4] at different altitudes, deep underground mines, and along Earth's orbit (perihelion vs. aphelion). This theory predicts periodic relative half-life variations on the order of $\Delta T_{1/2} / T_{1/2} \sim 10^{-6}$ to 10^{-8} (Note: these orders of magnitude are illustrative estimates within the theoretical framework).
2. **λ_{v0} Grid Modulation in Ultra-Cold / Microgravity Atomic Spectroscopy (Priority 2: Precision Spectroscopy Test):** If electronic energy levels are phase-locked standing waves with the background grid, ultra-high-precision optical frequency comb spectroscopy of simple atoms (H, He) in microgravity (e.g., ISS Cold Atom Lab) or cryogenic environments should reveal faint periodic frequency shifts or extra sub-structure splittings associated with $\lambda_{v0} \approx 5.27$ mm spatial harmonics, with predicted relative frequency shifts of $\Delta\nu / \nu \sim 10^{-12}$ to 10^{-15} (Note: these orders of magnitude are illustrative estimates within the theoretical framework).
3. **Phase Memory & Polarization Residuals in Electron-Positron (e^-e^+) Collisions (Priority 3: Secondary Data Mining):** Analyzing scattering events in e^-e^+ colliders can test whether collision products retain small asymmetries tied to incident phase. If electromagnetic force is geometric polarization of the V_0 medium rather than virtual photon exchange [4], phase-dependent residual deviations unexplainable by QED should appear in historical collider datasets.
4. **Fluid Tension Tearing Features in Heavy-Ion Collisions (Priority 4: Large Accelerator Data Analysis):** In heavy-ion collision data (RHIC/LHC), beyond the confirmed low-viscosity "perfect fluid" behavior, event-by-event analyses should track non-linear energy dissipation and abnormal particle correlation residuals during flux tube snapping, providing collateral evidence for topological flux tube tearing rather than gluon jet models [5, 6].
5. **Strong V_2 Geometric Spectral Shifts on Compact Astronomical Objects (Priority 5: Extreme Astrophysics Test):** Using space telescopes (JWST, X-ray observatories) to observe atomic absorption lines on neutron stars or white dwarfs. Under extreme density and strong V_2 gradient environments, atomic energy levels are predicted to exhibit extra geometric shifts beyond conventional relativistic corrections.

9. Conclusion: Ontology of a Single Field

This hypothesis demonstrates that the universe contains no independent elementary particles as postulated by the Standard Model [4]. Under a single field ontology, reality consists solely of a **single neutral neutrino field Φ** and its quantum manifestations (three-phase transitions, amplitude envelopes, orthogonal phases, and collective excitations). All observed physical phenomena emerge from this single field across different scales:

- **Vacuum & Space:** V_0 fundamental fluid grid
- **Dark Energy:** V_1 transverse phase flow
- **Dark Matter & Gravity:** V_2 high-density degenerate state & density gradient
- **Matter (Baryons & Leptons):** Local amplitude envelopes A_b [4]
- **Light & EM Radiation:** Transverse vortex wave packets & collective wave modes
- **Fundamental Forces (Strong, Weak, EM):** Manifestations of geometric phase & topological deformation

No other fundamental entity exists. From cosmic evolution to atomic structure, nature obeys a unified fluid geometry and topological evolution law. While the present qualitative picture achieves geometric unification, numerical simulations will further realize quantitative reproduction of quantum field theory precision calculations in future work.

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