Field Coupling in Emergent Geometry: Neutrino Mass and Photon Behavior under τ_2/τ_3 Curvature Dynamics

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Abstract

This paper extends the Residual Curvature as Emergent Memory (RCEM) framework by introducing explicit coupling mechanisms between Standard Model particles and the coherence/emergence fields τ_2 and τ_3. We define Lagrangian-level interactions for neutrinos and photons within RCEM's six-dimensional geometric model, showing how coherence memory can modulate effective mass, propagation speed, and phase behavior. These additions open new testable predictions and bridge the model further into particle phenomenology.

1. Background: The RCEM Framework

The RCEM model operates on a six-dimensional spacetime geometry:

$$\mathcal{M}_6 = \mathbb{R}^3 \times \mathbb{R}^1 \times S^2$$

Where:

- $\mathbb{R}^3$: Observable space
- $\mathbb{R}^1$: Coordinate time ($\tau_1 \equiv t$)
- S^2: Compactified curvature-memory geometry

Key fields:

- $\tau_2(x, \theta, \phi, t)$: Internal coherence field
- $\tau_3(x)$: Emergence field (activates when $E_{\tau_2} > P_{\text{Planck}}$)
- $\kappa(t)$: Readiness function triggering transitions

2. Neutrino Coupling

To couple curvature-memory to neutrinos, we introduce a Yukawa-type term where the coupling constant depends on the local coherence field:

$$\mathcal{L}_\nu = i\,\bar{\nu}\,\gamma^\mu \partial_\mu \nu - y(\tau_2)\,\bar{\nu}_L H \nu_R + \text{h.c.}$$

Where:

- $y(\tau_2) = y_0(1 + \lambda\tau_2^2)$ modulates effective mass
- h.c. ensures a real-valued Lagrangian

τ_2's spatial/temporal variation creates the possibility of neutrino mass variation in high-coherence zones, which may explain oscillation anomalies or dark sector mixing.

3. Photon Coupling

For photons, we propose a modified electromagnetic Lagrangian:

$$\mathcal{L}_\gamma = -\frac{1}{4}(1 + \alpha\tau_2^2) F_{\mu\nu} F^{\mu\nu}$$

This introduces an effective, curvature-modulated refractive index. Predictions include:

- Phase shifts in light propagation
- Birefringence-like effects in curved voids
- Local time dilation and redshift variations

4. Emergence-Gated Coupling

The emergence field $\tau_3(x)$ can act as an interaction envelope:

$$\mathcal{L}_{\text{eff}} = \tau_3(x) \cdot (\mathcal{L}_\nu + \mathcal{L}_\gamma)$$

Only in active emergence zones do these particle-level effects become significant, maintaining GR compatibility in standard environments.

5. Implications and Future Work

This coupling framework enhances RCEM's explanatory power, linking cosmological geometry with particle-scale effects.

Next steps:

- Simulate phase shifts near compact τ_3 zones
- Extend to fermionic generations and charged leptons
- Investigate τ_2 influence on polarization rotation and light cone shifts
- Derive constraints using neutrino observatories and radio wave dispersion data

References

1. Fortes, W. (2025). *Curvature Resonance and the τ_3 Field*. Zenodo. DOI: 10.5281/zenodo.15598257

2. Fortes, W. (2025). *Curvature Coupling and the $\kappa_4(x)$ Function*. Zenodo. DOI: 10.5281/zenodo.15660713