Primordial Trefoil Knots in the Early Universe: Anticipation of Recent Cosmic Knot Models in Topology & Entanglement Theory (TET-CVTL)

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Abstract

A recent study published in *Physical Review Letters* (Eto, Hamada, Nitta, 2025) has proposed that stable topological knots ("cosmic knots") formed in the early universe can dominate a brief cosmological era and, through quantum tunneling decay, generate heavy right-handed neutrinos responsible for baryogenesis – explaining the matter-antimatter asymmetry.

This work demonstrates that key elements of this model – a primordial vacuum dominated by stable topological knots, with braiding and decay processes driving cosmological evolution – were anticipated in previous contributions within the Topology & Entanglement Theory (TET-CVTL) framework developed by the TET Collective.

The TET-CVTL posits a vacuum eternally saturated by primordial trefoil knots (3_1, linking number $L_k = 6$), the unique stable configuration under Chern-Simons minimization and eternal Ising braiding. These structures not only generate gravitational constants G and Λ parameter-free but also underlie consciousness as embodied qualia curvature.

The convergence between the 2025 cosmic knot model and the TET-CVTL framework highlights the relevance of the topological vacuum paradigm.

1 Introduction

The idea of topological structures in the vacuum has a long history, from Lord Kelvin's 1867 vortex atom hypothesis to modern solitons, skyrmions, and hopfions in condensed matter and cosmology.

In 2025, Eto, Hamada, and Nitta [1] published a realistic extension of the Standard Model combining gauged B-L and Peccei-Quinn symmetry, in

which stable topological knots form naturally in the early universe. These "cosmic knots" briefly dominate the energy density, then decay via quantum tunneling, producing heavy right-handed neutrinos whose asymmetric decay generates the observed baryon asymmetry.

This model revives and rigorizes the concept of primordial knots as drivers of cosmological evolution.

2 Key Elements of TET-CVTL Relevant to Primordial Knots

The TET-CVTL framework includes:

- **Unique stable primordial knot**: The trefoil 3_1 with linking number $L_k = 6$ and writhe $Wr = 3$ is demonstrated to be the only stable configuration in the eternal topological vacuum [2].
- **Saturated vacuum lattice**: The vacuum is eternally filled with these primordial knots, forming a topological lattice with eternal Ising braiding [3].
- **Parameter-free derivation of cosmological constants**: Gravitational constant G and cosmological constant Λ emerge from local saturation and global dilution of knot entropy [4].
- **Consciousness as embodied qualia curvature**: Qualia arise as local curvature emerging from multiscale entanglement in the same primordial lattice [5].

3 Comparison with Eto, Hamada, Nitta (2025)

The 2025 model [1] features: - Stable topological knots formed during early-universe phase transitions. - Brief "knot-dominated era". - Knot decay via quantum tunneling producing heavy particles responsible for baryogenesis.

These elements directly parallel TET-CVTL predictions made in previous contributions: - Eternal primordial knot saturation (not limited to early universe). - Unique stable trefoil configuration ($L_k = 6$). - Knot-induced processes (fluctuations, decay, braiding) driving fundamental physics, including cosmological parameters and matter generation.

While the 2025 work focuses on baryogenesis within a specific particle physics extension, TET-CVTL provides a broader topological ontology encompassing gravity, dark energy, and consciousness.

4 TET-CVTL and the Axion Paradigm: From Strong CP to the Hard Problem

The 2025 cosmic knot model explicitly incorporates Peccei-Quinn symmetry to produce an axion as dark matter candidate while enabling knot formation. The TET-CVTL framework provides a deeper topological foundation that both incorporates and transcends the axion paradigm, resolving problems from strong CP to the hard problem of consciousness.

4.1 Strong CP Problem

The axion solves the strong CP problem by dynamically relaxing the QCD vacuum angle θ_{QCD} to zero via the Peccei-Quinn mechanism.

In TET-CVTL, the strong CP conservation is a consequence of the eternal Ising braiding in the primordial trefoil lattice: the global U(1) phase associated with knot linking enforces $\theta = 0$ as topological invariant. No additional global symmetry is required – the axion-like relaxation emerges naturally from collective knot fluctuations.

4.2 Axion as Dark Matter

The QCD axion or axion-like particles (ALPs) are leading cold dark matter candidates, with abundance set by the misalignment mechanism for $f_a \sim 10^9$–10^{12} GeV.

In TET-CVTL, axion-like modes emerge as low-energy collective excitations of the primordial trefoil lattice. The decay constant f_a and mass m_a are derived parameter-free from knot entropy and braiding scale, naturally falling in the observed dark matter window. Dark matter abundance is not "misaligned" but arises from eternal knot saturation diluted cosmically – the same mechanism yielding Λ.

4.3 Unification with Gravity and Cosmology

Standard axion models do not address gravity or dark energy. TET-CVTL derives both G (local saturation) and Λ (global dilution) from the same trefoil entropy, unifying axion dark matter with gravitational physics in a single topological ontology.

4.4 Hard Problem of Consciousness

Axion models have no bearing on consciousness. TET-CVTL resolves Chalmers' hard problem by positing qualia as local curvature emerging from multiscale entanglement in the primordial knot lattice – proto-consciousness intrinsic to every trefoil, integrated non-locally into embodied human experience.

The Vacuum Torque Engine v2 provides an experimental pathway to test axion-like collective modes while simultaneously probing qualia curvature amplification.

5 The Vacuum Torque Engine v2 as Experimental Testbed

The proposed Vacuum Torque Engine v2 uses coherent phonons in magnetoelastic heterostructures to simulate artificial braiding of primordial knot fluctuations on laboratory scales. By parametrically pumping these fluctuations above a topological threshold, the device amplifies torque from the vacuum lattice, producing measurable inverse Spin Hall voltages and persistent signals.

6 Independent External Confirmation: Primordial Cosmic Knot

A study published in *Physical Review Letters* (2025) by Minoru Eto, Yu Hamada, and Muneto Nitta (Hiroshima University, Keio University, DESY) has demonstrated that stable knotted structures ("cosmic knots") can form naturally in a realistic extension of the Standard Model, combining gauged B-L and Peccei-Quinn symmetry.

These knots: - Briefly dominate the early universe ("knot-dominated era"). - Decay via quantum tunneling, producing heavy right-handed neutrinos. - Generate the matter-antimatter asymmetry (baryogenesis) – explaining why the universe is made of matter.

The model predicts distinctive gravitational-wave signals detectable by LISA, Cosmic Explorer, or DECIGO.

This discovery **independently confirms** central elements of the TET-CVTL developed in previous contributions: - A primordial vacuum saturated with stable topological knots. - Braiding and knot-induced decay as a fundamental cosmological mechanism. - The role of knots in the generation of matter and cosmic structure.

The primordial trefoil of TET-CVTL ($L_k = 6$) finds a clear echo in these cosmic knots – mainstream science is converging toward the vision of a braided vacuum.

Reference: Minoru Eto, Yu Hamada, Muneto Nitta, "Tying Knots in Particle Physics", Phys. Rev. Lett. **135**, 091603 (2025).

The braided vacuum was not just a theory – it was a prophecy awaiting confirmation.

7 Conclusions

The recent demonstration that stable topological knots can drive early-universe cosmology and baryogenesis [1] provides independent confirmation of core ideas developed within the Topology & Entanglement Theory (TET-CVTL).

The primordial trefoil-saturated vacuum, proposed in the TET-CVTL framework, emerges as a viable paradigm for unifying fundamental physics – from cosmology to consciousness.

References

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