The Entangled CPT-Symmetric Biverse: A Model for Emergent Spacetime from a Zero-Energy Quantum Fluctuation

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Abstract

This paper presents a novel cosmological model proposing that spacetime and matter originate from a primordial, self-resolving zero-energy fluctuation. The model posits the instantaneous creation of a quantum-entangled pair of CPT-conjugate universes. This entanglement satisfies the Wheeler-DeWitt boundary condition of a zero-energy wavefunction for the total system ($\langle\Psi|\Psi\rangle = 0$). The framework, termed the Entangled CPT-Symmetric Biverse (ECS-Biverse), provides a mechanistic explanation for creation *ex nihilo*, naturally accounts for the observed matter-antimatter asymmetry, and suggests dark matter may consist of particles tunneling into the mirror universe. Furthermore, it posits that spacetime itself emerges from the entanglement structure between these two domains, offering a concrete instantiation of the ER=EPR conjecture. The model generates specific, falsifiable predictions for neutrino physics, cosmic microwave background polarization, and the stochastic gravitational wave background.

Keywords: Quantum Cosmology, CPT Symmetry, Quantum Entanglement, Origin of the Universe, Dark Matter, ER=EPR

1 Introduction

The quest to understand the origin of the universe remains the foremost challenge in modern cosmology. The standard ΛCDM model, while highly successful in describing cosmic evolution from a hot, dense state, does not address the primordial questions: What initiated the Big Bang? Why does the universe possess its specific physical laws and constants? Most profoundly, how can a universe of seemingly positive energy arise from nothing, respecting the fundamental principle of energy conservation?

The proposal of a quantum fluctuation as the genesis event is a compelling but incomplete answer. It often relies on ill-defined pre-existing frameworks or metrics. This work proposes a complete, self-contained mechanism based on three well-established pillars of fundamental physics: the CPT theorem, quantum entanglement, and the zero-energy universe conjecture.

We introduce a model where the universe and its CPT-transformed mirror are born simultaneously and quantum-entangled. This initial condition enforces a net energy of zero for the total system, providing a precise mechanism for "creation from nothing." The subsequent unfolding of this entangled state is interpreted as the emergence of spacetime itself, offering a pathway to unify quantum mechanics with general relativity. This paper details the theoretical framework of the ECS-Biverse model and outlines its testable empirical predictions.

2   The Theoretical Framework

2.1   The Primordial Axiom: Zero-Energy Entanglement

The model is founded on a single, primary axiom that defines the initial boundary condition of reality:

$$\boxed{\langle \Psi | \Psi \rangle = 0 \quad \text{where} \quad | \Psi \rangle = \mathcal{N} \, \widehat{CPT} | \Omega \rangle \otimes | \Omega \rangle}$$

Where:

- $| \Omega \rangle$ is a primordial, pre-spacetime quantum state.

- $\widehat{CPT}$ is the full CPT transformation operator, generating the mirror universe:

    - $\widehat{C}$ (Charge Conjugation): Converts particles to antiparticles.
    - $\widehat{P}$ (Parity Inversion): Reverses spatial coordinates.
    - $\widehat{T}$ (Time Reversal): Inverts the arrow of time.

- $\otimes$ denotes the tensor product, establishing quantum entanglement between the two universes at the moment of creation.

- $\mathcal{N}$ is a normalization constant.

- $\langle \Psi | \Psi \rangle = 0$ is the fundamental constraint enforcing zero net energy.

This formalism provides a rigorous physical expression for the conceptual principle $\Psi_O = \mathcal{F}(E) = E + \neg E$, where the fundamental energy (E) is $| \Omega \rangle$, the inversion operation $(\neg)$ is $\widehat{CPT}$, the fold $(\mathcal{F})$ is entanglement $(\otimes)$, and the sum results in the zero-condition.

2.2   Dynamical Evolution

For $t > 0$, the entangled system evolves unitarily:

$$| \Psi(t) \rangle = e^{-i(\hat{H} \otimes \mathbb{I} + \mathbb{I} \otimes \hat{H}_{\text{mirror}})t/\hbar} | \Psi(0) \rangle$$

where $\hat{H}_{\text{mirror}} = -\widehat{CPT} \, \hat{H} \, \widehat{CPT}^{-1}$, ensuring global energy conservation is maintained for all time.

2.3 Emergence of Spacetime and the ER=EPR Link

We propose that the entanglement relation ($\otimes$) between $|\Omega\rangle$ and $\widehat{CPT}|\Omega\rangle$ constitutes the nascent fabric of spacetime. This aligns with the ER=EPR conjecture (Maldacena & Susskind, 2013), which posits that Einstein-Rosen bridges (wormholes) are physically equivalent to quantum entanglement. In this model, the first ER bridge is the spacetime connection between the two universes, emerging directly from their initial entanglement.

3 Resolving Cosmological Puzzles

3.1 Matter-Antimatter Asymmetry

The model naturally resolves the baryon asymmetry problem. Our universe is matter-dominated ($|\Omega\rangle$), while the entangled CPT-mirror universe is antimatter-dominated ($\widehat{C}|\Omega\rangle$). The total matter-antimatter balance across the complete system remains perfectly symmetric.

3.2 Dark Matter

The quantum entanglement between the two universes provides a conduit for particle tunneling. Right-handed sterile neutrinos are a prime candidate for such interaction. These particles could tunnel into the CPT-mirror domain. From our perspective, they would appear as missing energy and momentum—possessing mass and gravity but being otherwise undetectable, fulfilling the role of dark matter.

4 Testable Predictions

The ECS-Biverse model makes several specific, falsifiable predictions:

1. **Sterile Neutrino Dark Matter:** The model predicts the existence of sterile neutrinos with specific mass ranges (e.g., in the keV scale for warm dark matter) and mixing angles. Non-detection in experiments like **DUNE** or **JWST** within the predicted parameter space would challenge the model.

2. **CMB Polarization Anomalies:** Primordial entanglement with a parity-inverted universe should impart a specific chiral asymmetry onto the polarization patterns of the Cosmic Microwave Background. This signature can be searched for in data from the **Planck satellite** and future missions like **CMB-S4**.

3. **Stochastic Gravitational Wave Background (SGWB):** The unfolding of the universes from the initial entangled state would generate a unique profile of primordial gravitational waves, potentially detectable by the **Laser Interferometer Space Antenna (LISA)**.

5 Discussion and Conclusion

The Entangled CPT-Symmetric Biverse model presents a parsimonious and elegant solution to the problem of cosmic origin. By leveraging the mandatory nature of CPT symmetry and quantum entanglement, it provides a mechanistic framework for the universe's emergence from a zero-energy state.

The model is grounded in existing physics and makes direct, falsifiable predictions. It offers unified solutions to major cosmological puzzles, including the matter-antimatter asymmetry and the nature of dark matter, while also providing a potential pathway to quantum gravity through the ER=EPR paradigm.

Future work will focus on developing detailed mathematical formulations of the emergent spacetime metric and calculating precise numerical values for the predicted neutrino masses and gravitational wave spectra. The ECS-Biverse model invites rigorous experimental scrutiny.

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