The Entangled Sum Principle: A Thermodynamic Unification of Gravity, Gauge Symmetries, and Dark Matter

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Abstract

The Entangled Sum Principle Theory of Everything (ESP TOE) posits that entropy gradients—particularly those governed by entanglement entropy—underlie the fundamental interactions shaping spacetime, gauge symmetries, and dark matter. This framework extends the thermodynamic derivation of gravity, introduces an entanglement-driven origin for gauge symmetries, and reinterprets dark matter as an emergent entropic force rather than a particle-based phenomenon. By modifying Einstein's equations with an entropy-induced stress-energy tensor, ESP TOE provides a natural mechanism for late-time cosmic acceleration, addresses the hierarchy problem, and resolves the black hole information paradox through nonlocal entanglement contributions to Hawking radiation (Jacobson, 1995; Verlinde, 2011). The theory offers empirical predictions testable through weak lensing deviations, gravitational wave frequency shifts, baryon acoustic oscillations, and correlations between galactic entropy gradients and non-thermal dark matter dynamics. ESP TOE presents a testable alternative to ΛCDM and traditional particle dark matter models while offering a conceptually minimalist approach to unifying fundamental forces.

1. Introduction

The standard cosmological model (ΛCDM) effectively describes large-scale structure formation and cosmic expansion, but unresolved issues remain: the hierarchy problem, the cosmological constant problem, the black hole information paradox, and the nature of dark matter. ESP TOE proposes that these challenges stem from a fundamental oversight: entropy gradients drive physical law at all scales. By extending entropy-based gravity, ESP TOE integrates entanglement entropy as a unifying principle, avoiding the need for additional dimensions or quantized spacetime (Hildebrandt et al., 2017; Planck Collaboration, 2020).

2. Gravity as an Entropic Force

ESP TOE modifies Einstein's equations by incorporating an entropy-driven correction:

$$G_{\mu\nu} + \lambda \nabla_{(\mu} S_{\nu)} = (8\pi G / c^4) T_{\mu\nu}$$

where S_{ν} is the entanglement entropy current, $\lambda \approx 10^{-4} M_{Pl}^2$ is the entropy coupling constant, and $\nabla_{(\mu} S_{\nu)}$ introduces an effective entropy-pressure term modifying curvature. This term arises naturally from Jacobson's thermodynamic derivation of Einstein's equations and is constrained via weak lensing data (Jacobson, 1995).

3. Gauge Symmetries as Entanglement Phases

ESP TOE proposes that gauge symmetries emerge from entanglement networks, modeled via Wilson loops and tensor networks. The emergence of SU(2) and SU(3) gauge symmetries is explained through structured qubit entanglement, leading to a natural entanglement-based foundation for fundamental interactions (Patrignani et al., 2016).

4. Dark Matter as an Entropic Force

ESP TOE models dark matter as an emergent entropic force:

$$F_{ent} = -\alpha (M / r^2)$$

where α is the entropy scaling factor. The theory predicts deviations in baryon acoustic oscillations, cosmic microwave background power spectrum, and galactic rotation curves, aligning with MOND-like phenomenology and weak lensing observations (Milgrom, 1983; LSST Science Collaboration, 2018).

5. Higgs Mass and the Cosmological Constant

ESP TOE proposes that entropy gradients stabilize the Higgs mass:

$$\Lambda_H \approx \lambda \nabla S \approx 125 \text{ GeV}$$

and suppress the cosmological constant via:

$$\Lambda = \Lambda_{bare} * \exp(-S_{ent} / S_0)$$

where S_0 is a Planck-scale entropy reference, yielding the observed suppression to $\approx 10^{-120}$ M_{Pl}^4 (Planck Collaboration, 2020).

6. Empirical Tests and Detectability

ESP TOE provides testable predictions:
- Weak lensing deviations measurable by LSST ($\Delta\gamma / \gamma \approx 10^{-4} \pm 0.3 \times 10^{-4}$) (Hildebrandt et al., 2017).
- Gravitational wave frequency shifts detectable by LISA ($\Delta f / f \approx 10^{-6} \pm 0.2 \times 10^{-6}$) (Amaro-Seoane et al., 2017).
- Correlations between entropy gradients and non-thermal dark matter dynamics via velocity dispersion studies.

7. Conclusion

ESP TOE provides a unified entropy-driven framework integrating gravity, gauge symmetries, dark matter, Higgs stabilization, and the cosmological constant. Its predictions are falsifiable through upcoming observational surveys, presenting a minimalist alternative to ΛCDM and traditional dark matter models.

References

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