The Entropic Force-Field Hypothesis: A Unified Framework for Quantum Gravity

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18th February 2025

Abstract

This paper presents a comprehensive theory of quantum gravity based on the **Entropic Force-Field Hypothesis (EFFH)**, wherein entropy is proposed as the **fundamental force-field** governing all interactions in nature. By introducing an **Entropic Action**, we derive field equations that are positioned towards unifying general relativity and quantum mechanics as emergent consequences of entropy-driven dynamics. This theory extends the thermodynamic interpretation of gravity, reinterprets black hole physics, and provides a novel resolution to the black hole information paradox. Furthermore, the entropic time limit (ETL) is introduced as a fundamental constraint on quantum interactions, distinct from the Planck time. The framework suggests testable predictions and empirical validations that can distinguish EFFH from existing theories such as string theory and loop quantum gravity.

1 Introduction

1.1 The Problem of Quantum Gravity

Quantum mechanics and general relativity have long remained incompatible, with no clear unifying theory. Traditional approaches, such as string theory and loop quantum gravity, treat spacetime as an entity governed by separate dynamical laws. The **Entropic Force-Field Hypothesis (EFFH)** proposes that entropy is the fundamental field underlying all forces, including gravitation.

1.2 The Entropic Paradigm

Entropy has traditionally been viewed as a **statistical descriptor of disorder**. In this theory, we elevate entropy to a **real, physical field** that actively governs the structure and evolution of the universe. The implications extend

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[‡]This is a work in progress, which principally is the author's independent investigations into entropy as an active field rather than a mere [quantum statistical] descriptor of disorder.

beyond gravity, unifying electromagnetism, the weak force, and the strong force as emergent entropic effects.

2 Mathematical Framework of the Entropic Force-Field

2.1 The Entropic Action

We define the **Entropic Action** S_{EFF} as:

$$S_{EFF} = \int d^4x\sqrt{-g}\left(\frac{1}{16\pi G}R + \mathcal{L}_{EFF}\right), \tag{1}$$

where $\mathcal{L}_{EFF}$ is the Lagrangian density governing the entropic force-field.

2.2 Field Equations

Varying the action with respect to the metric tensor $g_{\mu\nu}$ leads to modified Einstein field equations:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G\left(T_{\mu\nu}^{(matter)} + T_{\mu\nu}^{(EFF)}\right), \tag{2}$$

where $T_{\mu\nu}^{(EFF)}$ is the stress-energy tensor for the entropic field.

2.3 The Entropic Field Tensor

We introduce the entropic field tensor $S^{\mu\nu}$, analogous to the energy-momentum tensor, but derived from entropy gradients:

$$S^{\mu\nu} = \frac{1}{4\pi G}\left(\nabla^\mu S\nabla^\nu S - \frac{1}{2}g^{\mu\nu}\nabla_\alpha S\nabla^\alpha S\right). \tag{3}$$

3 Implications for General Relativity and Quantum Mechanics

3.1 Gravity as an Entropic Emergent Force

Verlinde's entropic gravity suggests that gravity arises from the information structure of spacetime. EFFH refines this by proposing that entropy actively shapes spacetime curvature, with information constraints generating force-like effects.

3.2 Entropic Time Limit (ETL) and Quantum Mechanics

We introduce the **Entropic Time Limit (ETL)** τ_E, which sets a minimum time interval for physical interactions:

$$\tau_E = \frac{h}{E_{EFF}} \tag{4}$$

This differs from Planck time by incorporating entropy gradients as a fundamental constraint.

4 Black Hole Physics and the Entropic Force-Field

4.1 Revisiting Hawking Radiation

Hawking Radiation is reinterpreted as the result of **gravitational energy conversion into radiative energy** mediated by the entropic field. Instead of relying on quantum particle pairs, EFFH suggests that entropy gradients near the horizon facilitate energy redistribution, leading to emission.

4.2 The Black Hole Information Paradox

EFFH proposes that the black hole entropy stabilizes in the remnant states, preventing complete information loss. This aligns with **holographic principles**, suggesting that entropy governs the transfer of quantum information at event horizons.

4.3 The Entropic Gap and Energy Redistribution

EFFH introduces the concept of an **Entropic Gap (OG)**, a finite region at the event horizon where entropy-driven energy redistribution occurs, influencing the decay of black holes:

$$P_{radiation} = -\nabla^{\mu} S \nabla_{\mu} S + \frac{\alpha}{M^{\kappa}}. \tag{5}$$

5 Cosmological Consequences

5.1 Entropy as the Driver of Cosmic Evolution

EFFH suggests that cosmic expansion is governed by entropy-driven interactions rather than an external dark energy field. The acceleration of the universe is a natural consequence of increasing entropy, with the cosmological constant Λ emerging as an entropic parameter.

5.2 Predictions for Cosmic Microwave Background (CMB) Fluctuations

EFFH predicts entropy-induced fluctuations in the CMB that differ from those expected in inflationary models. Detecting deviations in temperature anisotropies could provide empirical support.

6 Experimental and Theoretical Tests

6.1 Quantum Entanglement and Nonlocality

EFFH suggests that quantum entanglement is an entropy-driven correlation, which imposes a limit on nonlocal interactions. Precision tests of Bell inequalities may reveal deviations predicted by this model.

6.2 Gravitational Lensing Anomalies

Modifications to gravitational lensing effects in regions of high entropy gradients could serve as another testable signature of EFFH.

7 Conclusion and Future Directions

The **Entropic Force-Field Hypothesis** represents a paradigm shift in our understanding of gravity, quantum mechanics, and cosmic evolution. By establishing entropy as the fundamental field, this theory unifies general relativity and quantum mechanics under a single framework. Future research should focus on refining the entropic field equations, exploring connections to string theory and loop quantum gravity, and identifying novel experimental tests.

8 Acknowledgments

The author wishes to thank **Dr.'Lekan T. Owolawi** and **Daniel Alemoh** for their help while thinking through this new way of understanding our Cosmos and the World we live in; the former for his constant prodding, challenge, and inspiration; and the latter for his relentless, investigative queries and "inquisitions".

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