Metric Occlusion of Einstein-Rosen Bridges via Indivisible Material Singularities

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Abstract

This study extends the ER=EPR conjecture by proposing a stabilization mechanism for micro-wormholes through metric occlusion. We demonstrate that elementary particles act as insurmountable geometric constraints, preventing the collapse of Einstein-Rosen bridges. By comparing the Schwarzschild radius and the Compton wavelength, it is shown that the particle's quantum extension provides a structural "plug" that maintains throat stability without the requirement for exotic matter.

1 Introduction

The ER=EPR conjecture suggests that entangled particles are connected by a micro-wormhole, or Einstein-Rosen (ER) bridge. A significant theoretical hurdle remains: the inherent instability of such structures, which are subject to immediate collapse. Traditionally, stabilization requires "exotic matter" with negative energy density. In this work, we propose that the particle itself, due to its indivisible nature and quantum extension, acts as a physical barrier. This "Metric Occlusion" provides structural stability to the manifold, maintaining the connection between entangled pairs.

2 The Mechanism of Occlusion: The Particle as a "Plug"

In our model, the particle is not merely "near" the wormhole but is intrinsically linked to the bridge's throat. As the spacetime fabric attempts to contract toward a vacuum state, it encounters the quantum boundary of the singularity. Since an elementary particle is a quantum of matter that cannot be compressed below its fundamental limits, it acts as a mechanical and topological stopper. The spacetime metric "hits" the particle's boundary, forcing the throat to remain open and preventing the formation of a null-radius singularity.

3 Dimensional Analysis

To evaluate the feasibility of metric occlusion, we compare the fundamental scales of an elementary particle (e.g., an electron):

- **Schwarzschild Radius (R_s):** The gravitational collapse radius, $R_s = \frac{2GM}{c^2} \approx 1.35 \times 10^{-57}$ m.
- **Compton Wavelength (λ_c):** The quantum spatial extent, $\lambda_c = \frac{h}{mc} \approx 2.42 \times 10^{-12}$ m.

The fact that λ_c is approximately 45 orders of magnitude larger than R_s implies that the particle's quantum presence is far more expansive than its gravitational collapse point. This discrepancy ensures that the particle effectively blocks the metric's contraction.

4 Modified Morris-Thorne Metric

The spacetime geometry is described by a modified Morris-Thorne metric, with the shape function $b(r)$ constrained by the particle:

$$ds^2 = -e^{2\Phi(r)}c^2dt^2 + \frac{dr^2}{1 - \frac{b(r)}{r}} + r^2(d\theta^2 + \sin^2\theta d\phi^2) \tag{1}$$

The boundary condition is defined as:

$$b(r_{min}) = \lambda_c \tag{2}$$

The radial tension of the throat is balanced by the particle's energy density, creating a state of Topological-Mechanical Stability.

5 Experimental Verification: Slippage and Gravitational Burst

The decay of entanglement (decoherence) is not a passive process but a violent topological phase transition. The rupture of the bond occurs when the particle "slips" (slippage) out of the ER bridge throat. Without the material plug, the tension accumulated in the throat is released instantaneously, much like a compressed gravitational spring snapping back.

This event produces a unique physical signature: a **high-frequency gravitational wave burst**. Unlike waves generated by massive black holes, this signal is microscopic yet characterized by a specific energy related to the mass of the ejected particle (Particle B). Detecting these micro-bursts during entanglement experiments would represent the definitive experimental proof of the metric occlusion hypothesis.

6 Conclusion

The Metric Occlusion hypothesis offers a parsimonious solution to the ER=EPR stability problem. By utilizing the intrinsic quantum properties of matter to "plug" the spacetime manifold, we explain how quantum correlations can persist. The phenomenon of slippage and the subsequent expulsion of the particle provide a verifiable dynamic for future quantum gravity experiments and the detection of subatomic gravitational waves.

References

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