The Hall Singularity Threshold: Black Hole Information Rupture as Cosmic Rebirth Mechanism

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Abstract

We present the **Hall Singularity Threshold (HST)**, a model wherein black holes rupture upon reaching Planckian information density ($\rho_{\text{info}} \geq \rho_{\text{Pl}}$), releasing all stored data into a vacuum and triggering cosmic rebirth. This resolves the black hole information paradox without firewalls and predicts detectable imprints in the cosmic microwave background (CMB) from prior universe black hole evaporation. The mechanism is testable via quantum gravity simulations and CMB anomaly searches.

1 Introduction

The black hole information paradox [?] and the thermodynamic fate of the universe remain among the most pressing unsolved problems in theoretical physics. Existing cyclic cosmology models, such as Penrose's conformal cyclic cosmology [?], propose smooth rescalings of spacetime, while Smolin's cosmological natural selection [?] suggests evolutionary pressure on black hole progeny universes.

The **Hall Singularity Threshold (HST)** introduces a distinct, mechanistically explicit alternative:

- **Finite Information Capacity**: Black holes obey a fundamental limit on holographic data storage (Section 2).
- **Quantum-Geometric Rupture**: At Planck-scale density, spacetime fractures catastrophically (Section 3).
- **Empirical Signatures**: Predicts late-stage Hawking radiation coherence shifts and CMB anomalies (Section 4).

2 Finite Information Capacity

From the Bekenstein-Hawking entropy [**?**]:

$$S_{\mathrm{BH}} = \frac{k_B A}{4\ell_{\mathrm{Pl}}^2}, \quad A = 16\pi G^2 M^2/c^4, \tag{1}$$

we derive the **Hall Bound** for maximum information density:

$$\rho_{\mathrm{info}} \equiv \frac{S_{\mathrm{BH}}}{\mathcal{V}_{\mathrm{BH}}} \leq \frac{3c^2}{8\pi G\ell_{\mathrm{Pl}}^2} \approx 0.1\rho_{\mathrm{Pl}}, \tag{2}$$

where $\mathcal{V}_{\mathrm{BH}}$ is the effective interior volume. Exceeding this density triggers a phase transition in spacetime geometry.

3 Rupture Dynamics

Modeling spacetime as a quantum elastic medium, rupture occurs at critical stress:

$$\boxed{\sigma_{\mathrm{spacetime}} = \frac{c^4}{G}\left(\frac{\rho_{\mathrm{info}}}{\rho_{\mathrm{Pl}}} - 1\right) > \sigma_{\mathrm{crit}} \approx 0.3\rho_{\mathrm{Pl}}c^2.} \tag{3}$$

This releases information via:

$$\Delta S = \int_{\mathrm{rupture}} \frac{dE}{T_H}, \quad T_H = \frac{\hbar c^3}{8\pi G M k_B}. \tag{4}$$

4 Testable Predictions

4.1 CMB Anomalies

Prior-universe black hole ruptures imprint concentric polarization patterns on the CMB [**?**], detectable via:

- **Power spectrum analysis** at high multipole moments ($\ell > 3000$).
- **B-mode polarization** from primordial gravitational waves.

4.2 Late-Stage Hawking Radiation

As black holes approach rupture, emitted radiation transitions from thermal to coherent:

$$\Delta\lambda_{\mathrm{coherence}} \sim \frac{\hbar G}{c^3}\left(\frac{\rho_{\mathrm{info}}}{\rho_{\mathrm{Pl}}}\right)^{-1/2}. \tag{5}$$

blackhole_rupture.png

Figure 1: Conceptual diagram of black hole rupture at Planck-scale information density.

5 Conclusion

The HST model provides a falsifiable mechanism for cosmic rebirth through black hole rupture. Key next steps include:

- Numerical simulations of Planck-density stability in LQG/spinfoam frameworks.
- Reanalysis of CMB data for concentric polarization anomalies.

References