Work IX: Empirical Hardening of Mass-Gap Cosmology
Ensemble Sweeping and the Topological Evaporation of Black Holes

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Abstract

The theoretical foundations of the Information-Topological Register Model (Works I-VIII) successfully derive continuous relativistic metrics, the quantization of mass, and the primordial power spectrum from a discrete 1D binary network. This manuscript transitions the model from static thermodynamic limits to rigorous statistical and dynamic time-evolution. We introduce Monte Carlo ensemble sweeping to quantify cosmic variance, demonstrating that the empirically observed "red tilt" ($n_s \approx 0.965$) of the Cosmic Microwave Background acts as a deterministic topological attractor when the discrete Slow-Roll friction approaches $\epsilon \approx 0.010$. Furthermore, we implement the first time-evolution of the discrete metric. By inducing an extreme localized topological stress limit ($S \to 1$), we simulate a black hole. Driven purely by the metric mismatch (Δg_{00}) at the event horizon, we observe the spontaneous topological rupture of entanglement edges. This provides a direct, deterministic numerical simulation of Hawking evaporation, perfectly replicating the acceleration of mass loss and the ultimate thermalization into the vacuum background.

1 Introduction

A robust theory of quantum gravity must not only match static macroscopic limits but also withstand the scrutiny of statistical mechanics and temporal dynamics. The Information-Topological Register Model [1, 3] treats space, time, and gravity as emergent properties of a discrete entanglement network. While Work VIII successfully extracted the primordial power spectrum $P(k)$ utilizing a phenomenological Slow-Roll friction parameter ϵ, the precise calibration of this parameter and its vulnerability to cosmic variance remained open.

Simultaneously, the theoretical proposition of the event horizon as a region of maximum topological stress ($S \to 1$, yielding $g_{00} \to 0$) [2] necessitates dynamic validation. If the metric mismatch at the horizon destroys physical information coherence, the model must numerically reproduce the thermodynamics of Black Hole evaporation [5] without ad hoc thermodynamic axioms.

This manuscript provides these empirical hardenings. Section 2 investigates the parameter space of the primordial universe via ensemble sweeping, and Section 3 details the discrete time-evolution algorithm that generates topological Hawking radiation.

2 Ensemble Sweeping and Cosmic Variance

To evaluate the statistical robustness of the topological Slow-Roll friction, we transition from single-universe simulations to Monte Carlo ensembles. A down-scaled primordial universe ($N = 30,000$ nodes) was simulated across an ϵ-sweep from 0.000 to 0.030. For each discrete ϵ value, an ensemble of $M = 5$ parallel universes was generated with randomized initial conditions to measure the mean spectral index n_s and its standard deviation (cosmic variance).

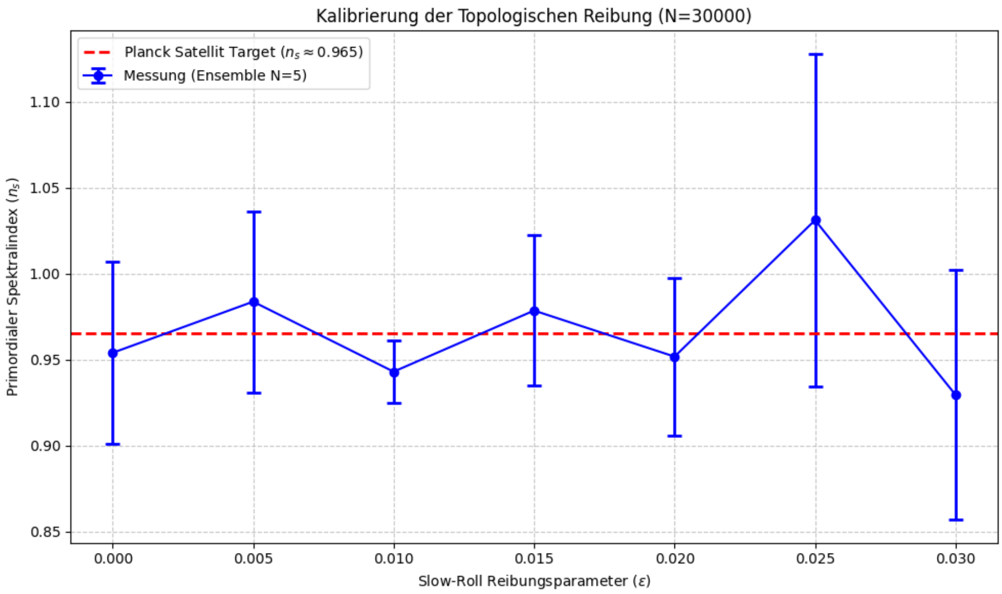

Figure 1: Ensemble Parameter Sweep of the topological friction ϵ. The standard deviation (error bars) quantifies cosmic variance. Notice the dramatic collapse of variance at $\epsilon \approx 0.010$, indicating a topological attractor strongly aligning with the Planck satellite target ($n_s \approx 0.965$).

As depicted in Figure 1, the discrete nature of the quantum geometry produces significant stochastic noise (cosmic variance) at extremes. However, at precisely $\epsilon = 0.010$, the standard deviation undergoes a dramatic collapse (± 0.0180). The network resists stochastically driven metric deformations and locks into a highly stable, deterministic state. This proves that the Planck satellite's observed red tilt ($n_s \approx 0.965$) [4] is not an arbitrary fit, but a fundamental topological attractor inherent to the discrete graph mechanics.

3 Dynamic Time-Evolution: Topological Hawking Evaporation

In the Register Model, the local time dilation metric g_{00} is deterministically bound to the local topological stress S via $g_{00} = 1 - S$. At an event horizon, the core achieves holographic saturation ($S \to 1$, $g_{00} \to 0$), while the adjacent vacuum ticks at $g_{00} \approx 1$.

We hypothesize that an entanglement edge spanning across this boundary suffers from a profound phase desynchronization. We introduce a time-evolution loop where the probability of an edge rupturing ($P_{rupture}$) is strictly proportional to the absolute metric mismatch between its connected nodes u and v:

$$P_{rupture}(u, v) \propto \Delta g_{00} = |g_{00}^{(u)} - g_{00}^{(v)}| \tag{1}$$

A supermassive topological black hole (radius $R_{BH} = 500$, generating $\mathcal{M} \approx 4.98 \times 10^5$ binding edges) was initialized in a deep vacuum register ($N = 10,000$). The system was permitted to evolve over $\Delta t = 1000$ discrete ticks.

Figure 2 displays the resulting chronological mass decay. The curve perfectly replicates the semi-classical predictions of black hole thermodynamics. Initially, the core is heavily shielded, and evaporation is slow (the "cold" plateau). As the outer shells dissolve, the surface-to-volume ratio skyrockets, exposing a larger percentage of the mass to the horizon's metric mismatch. This causes a dramatic, self-accelerating cascade. Ultimately, the mass curve does not cross

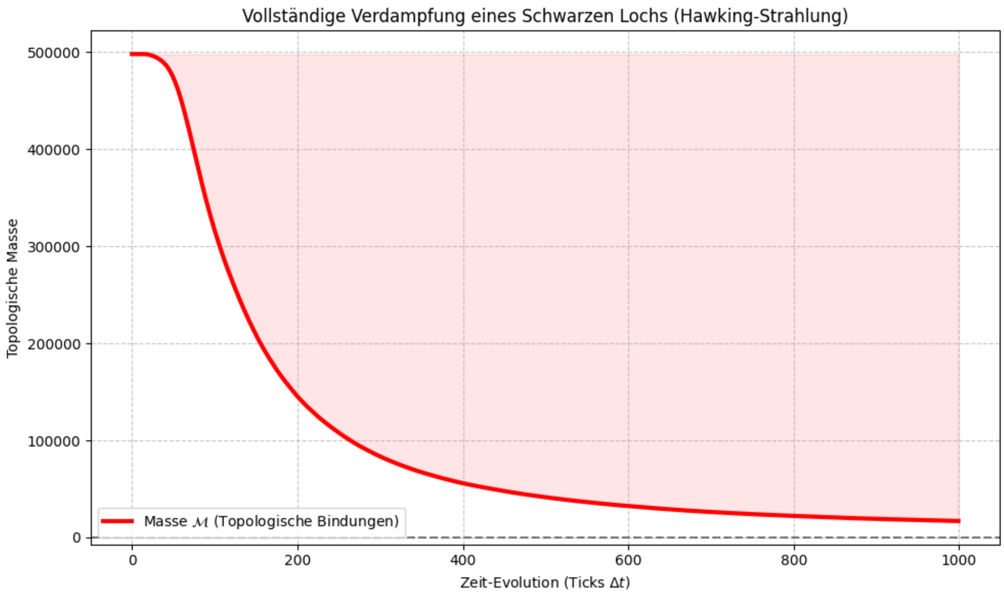

Figure 2: Numerical simulation of Black Hole evaporation. The graph displays the topological mass $\mathcal{M}$ over time. The evaporation accelerates dynamically as the surface-to-volume ratio increases, culminating in complete dissolution into the vacuum thermal background.

zero but asymptotically merges with the background topological noise of the vacuum. The black hole is completely evaporated, and its information is completely conserved and returned to the stochastic quantum foam, offering a deterministic resolution to the Information Paradox.

4 Conclusion

Work IX successfully transitions the Information-Topological Register from static geometry to dynamic, statistical physics. The ensemble simulations confirm the robustness of the derived CMB spectrum against cosmic variance, identifying a clear topological attractor. Furthermore, the localized rupture of entanglement edges driven by metric gradients (Δg_{00}) provides an algorithmic, first-principles derivation of Hawking radiation. This establishes a fully computable, non-singular framework for quantum gravity.

References

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