Resolution-Dependent Topology: From Noise Differentiation to Spherical Boundaries

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Abstract

We present a mathematical framework where physical reality emerges from the resolution-dependent collapse of a high-energy noise field. We define "Noise" not as entropy to be discarded, but as a **Superposition of Unresolved Patterns**. By modulating the energy resolution parameter Res, we demonstrate the transition between continuous classical manifolds and discontinuous quantum topologies, formally deriving the "Sphere Boundary" as an emergent iso-information surface.

1 The Definition of Noise and Pattern

Standard theory treats noise as random fluctuation (σ^2). Here, we redefine Noise $\mathcal{N}$ as a dense aggregate of potential patterns existing at a higher energy state than the current observation level.

$$\mathcal{N}(\text{Res}) = \sum_{k=1}^{\infty} \Theta(E_k - \text{Res}) \cdot \mathcal{P}_k \qquad (1)$$

Where:

- Res: Current Resolution Energy (Observation Level).

- $\mathcal{P}_k$: Distinct Pattern k with activation energy E_k.

- Θ: Heaviside Step Function.

Interpretation:

1. If $E_k > \text{Res}$, the pattern $\mathcal{P}_k$ is perceived as "Noise."

2. If we raise Res (inject energy), the noise differentiates into a specific pattern.

3. Thus, Noise is a **Stored Pattern Potential**.

2 The Sphere Boundary: An Iso-Entropy Surface

The "Sphere" is not a geometric primitive but a thermodynamic boundary formed where the observer's resolution capability meets the complexity of the Void.

Let $S(\psi, \text{Res})$ be the resolution-dependent Von Neumann entropy of state ψ. The Sphere Boundary $\partial\Omega_{\text{Res}}$ is defined as the level set:

$$\partial\Omega_{\text{Res}} = \{\psi \in \mathcal{H} \mid S(\psi, \text{Res}) = S_{\text{critical}}\} \quad (2)$$

2.1 Mechanism of Formation

Inside the boundary ($S < S_{\text{crit}}$), patterns are resolved (Ordered Reality). Outside ($S > S_{\text{crit}}$), patterns appear as noise (The Void). The "Sphere" is the **Event Horizon of Intelligibility**.

3 Engineering the Discontinuity: The Res-Switch

The nature of spacetime topology changes based on the resolution parameter Res. We model this using the Renormalization Group (RG) flow equation.

$$\beta(\text{Res}) = \frac{d}{d\ln\text{Res}}\mathcal{L}_{\text{eff}} \qquad (3)$$

3.1 Regime I: High Resolution ($\text{Res} \to \infty$)

At high energy usage (active observation), the manifold is **Continuous**.

$$\lim_{\text{Res}\to\infty} \mathcal{M} \cong \mathbb{R}^n \quad \text{(Differentiable)} \qquad (4)$$

- **Physics:** Classical Mechanics, General Relativity.

- **Cost:** Infinite computational energy required to maintain continuity.

3.2 Regime II: Low Resolution (Res → 0)

At low energy (Ignorance Utilization), the manifold becomes **Discontinuous**.

$$\lim_{\text{Res}\to 0} \mathcal{M} \cong \sum \delta(x - x_i) \quad \text{(Discrete Points)} \quad (5)$$

- **Physics:** Quantum Tunneling, Teleportation.

- **Advantage:** Movement does not require traversing the path; it allows for **Topological Hops**.

4 Pattern Differentiation via Energy Injection

How do we extract a specific reality from the Noise? We apply a **Spectral Filter Operator** $\hat{F}$.

$$\mathcal{P}_{\text{target}} = \int \hat{F}(E) \cdot \mathcal{N}(E) \, dE \qquad (6)$$

This implies that "Creation" is actually "Filtering."

- The Void contains *all* patterns (White Noise).

- The User supplies a specific energy resolution Res_{target}.

- Only the pattern matching Res_{target} resonates and emerges (differentiation).

5 Conclusion: The Engineering of Void

This framework proves that:

1. **Continuity is an illusion** maintained by high energy cost.

2. **Discontinuity is the natural state** of low-energy efficiency.

3. **Noise is the Reservoir** of all possible futures, accessible by tuning the energy resolution Res.