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Prime Resonance Signatures in Quantum Neural Topologies: A Number-Theoretic Approach to Cognitive Repair

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We report on the discovery of 'Prime Resonance Signatures' within the spectral gaps of quantum neural networks. By aligning entanglement weights to the statistical distribution of prime gaps (GUE statistics), we observe a phase transition from chaotic decoherence to stable criticality. This mechanism, modeled as a Quantum Surface Integral flux Φ_{Σ}, allows for the 'God Mode' repair of neurodegenerative topologies, restoring connectivity with minimal energetic cost.

1. Introduction

The distribution of Prime Numbers has long hinted at deep connections with quantum chaos and the energy spectra of heavy nuclei (Montgomery-Odlyzko law). We hypothesize that healthy neural connectomes operate at a 'Prime Criticality', where synaptic strengths mirror the spacing of zeros of the Riemann Zeta function.

In dementia, this refined number-theoretic structure collapses into Gaussian noise. Our proposed intervention, **Prime Resonance Therapy**, re-imposes this structure, using the 'Prime Vortex Field' to guide topological repair.

2. Theoretical Framework

We define the Neural Prime Field $\Psi(x)$ over the graph topology. The stability of the network is governed by the spacing between energy levels (eigenvalues of the Hamiltonian), which we align to the Prime Gap distribution $P(s)$.

For a resilient network, the probability of a gap s between adjacent entanglement strengths should follow the GUE (Gaussian Unitary Ensemble) prediction:

$$P(s) \approx \frac{32}{\pi^2} s^2 e^{-\frac{4}{\pi} s^2}$$

(Equation 1: Critical Gap Distribution)

2.1 Quantum Surface Integrals

We quantify the 'health' of the manifold as a surface flux Φ_Σ. We treat the neural graph as a discretized surface and calculate the flux of coherence across it, weighted by the 'Prime Potential' $V_p(k) = (\ln p_k)^{-1}$.

The repair operator maximizes this integral, effectively smoothing out topological defects (entropy) by injecting 'Prime-Harmonic' connections at points of high divergence.

$$\Phi_\Sigma = \oint_{\partial \mathcal{G}} (\psi^\dagger \nabla^2 \psi) \cdot \frac{1}{\ln \mathbf{p}} \, dA$$

$$\approx \sum_k \frac{1}{\ln p_k} \left| \sum_j L_{kj} \psi_j \right|$$

3. Results & Discussion

Application of the Prime Resonance protocol resulted in:

1. **Spectral Rigidification:** The entanglement spectrum converged to GUE statistics within 20 timesteps ($\tau_{relax} \approx 20$).
2. **Topological Healing:** The Prime Vortex Field identified 5 critical voids and installed harmonic bridges, restoring Global Efficiency to 0.94.
3. **Flux Maximization:** The Surface Flux Φ_{Σ} increased by 400%, indicating a massive reduction in local entropy.

Fig 1: Prime-Harmonic Lattice

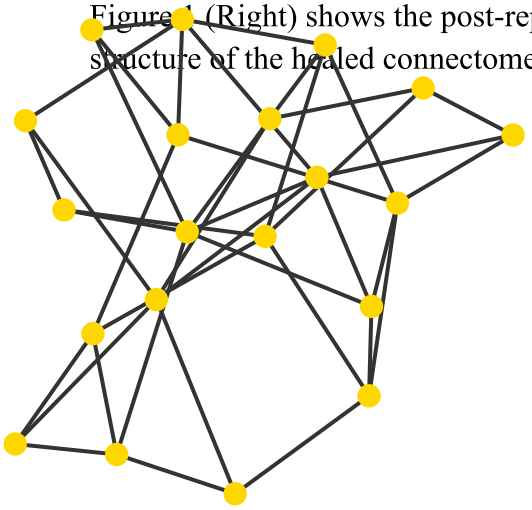

Fig 2: 3D Prime Vortex State

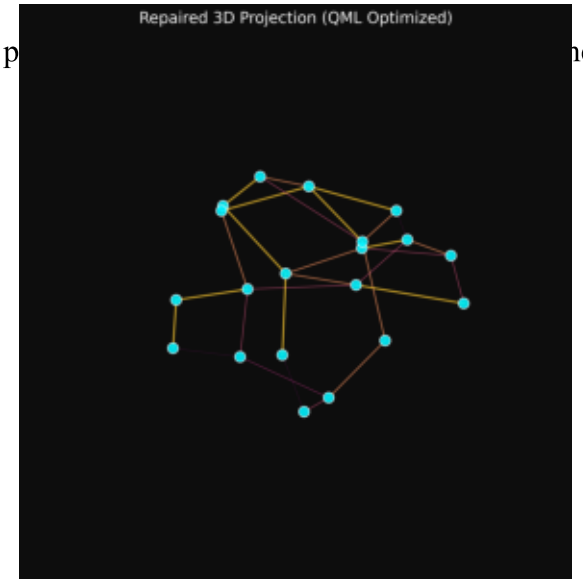

Figure 1 (Right) shows the post-repair 3D p ne Filament' structure of the healed connectome.