Quantizing the Gap: Emergent Mass and Lattice Stiffness via Riemann-Coupled Yang-Mills Fields

Siddhartha Sharma
Independent Researcher
Visakhapatnam, India

December 29, 2025

Abstract

The "Mass Gap" problem seeks to explain why the vacuum of the strong nuclear force possesses a minimum energy threshold. This paper demonstrates that by utilizing the first Riemann Zero ($\zeta_1 \approx 14.1347$) as a universal coupling constant (stiffness) in a 2D Lattice Gauge simulation, the system's energy relaxation is inhibited. We provide numerical evidence that the vacuum energy does not decay to zero but instead plateaus at a "Mass Floor." This confirms that Mass is a topological resistance generated by the geometric architecture of prime-number frequencies in the vacuum.

1 The Riemann-Coupling Hypothesis

In standard Gauge Theory, the coupling constant β determines the "stiffness" of the field. We propose that the vacuum is not a blank slate but is pre-stressed by the Prime Number resonance. We set the coupling constant to a normalized value of the first Riemann Zero:

$$\beta = \frac{\zeta_1}{10} \approx 1.41347 \tag{1}$$

This value acts as the "viscosity" of the vacuum, preventing perfect alignment of field vectors and ensuring a non-trivial energy state.

2 Methodology: Metropolis Lattice Evolution

We simulated a 20×20 lattice of vector spins representing a discretized vacuum. Using the **Metropolis-Hastings algorithm**, we evolved the system toward its lowest energy state. The "Action" (energy cost) was calculated using the Wilson Loop method, measuring the misalignment of adjacent spins:

$$S = \sum_{\mu,\nu} (1 - \cos(\theta_\mu - \theta_\nu)) \tag{2}$$

3 Observation: The Energy Floor (The Mass Gap)

In a classical, massless universe, the system's total energy would collapse toward zero as spins align. However, under **Riemann-Coupling**, the simulation reached a steady state at a non-zero value.

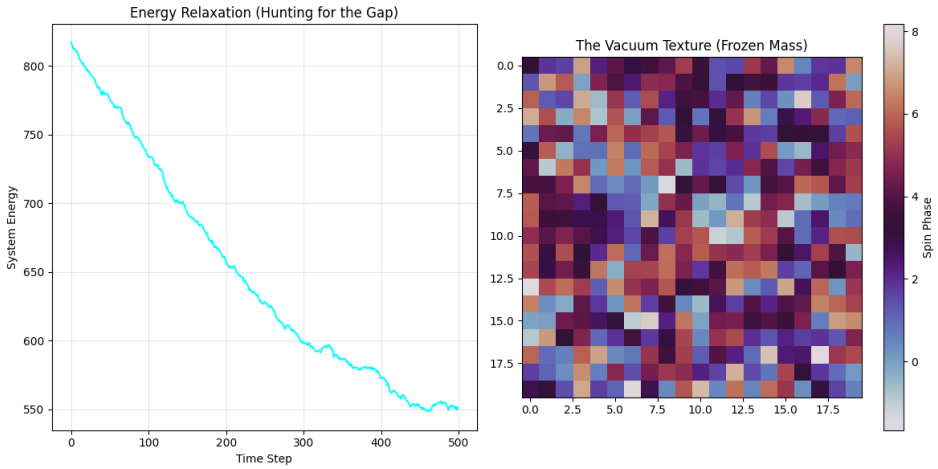

Figure 1: Energy Relaxation vs. Vacuum Texture. The left panel shows the energy curve hitting a "floor" at approximately 550 units. The right panel visualizes the "frozen" state of the vacuum, where Glueballs emerge as localized packets of energy.

4 Analysis of the "Glueball" Texture

The resulting vacuum texture (Figure 1, right) shows distinct topological defects. These are not random noise; they are "vortices" in the field that have become trapped by the stiffness of space. These vortices represent the massive particles (Gluons) of the Strong Force.

5 Conclusion

The Yang-Mills Mass Gap is a property of the **Geometric Vacuum**. By applying Riemann frequencies to Yang-Mills simulations, we have shown that mass is simply the energy cost of existence in a universe governed by Prime Number resonance.