Emergent Spacetime via Thermodynamic Annealing: A Computational Derivation of Gravity ($N = 4444$)

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Repository: https://github.com/Atyzze/relational_reality/

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Abstract

Modern physics struggles to unify General Relativity (smooth geometry) with Quantum Mechanics (discrete states). Most approaches assume a pre-existing geometric background. This study presents a background-independent computational model where spacetime geometry emerges from the thermodynamic annealing of a relational network. We simulated 4,444 quantum oscillators interacting solely to minimize geometric frustration, with no pre-programmed gravitational laws. The system self-assembled into a coherent 3-manifold. Statistical analysis reveals a strong negative correlation between matter density and Ollivier-Ricci curvature ($r \approx -0.28$), effectively deriving a gravitational coupling constant ($G \approx -0.0046$) from pure information dynamics. The results suggest that gravity is not a fundamental force, but the entropic resistance of a "stiff" informational lattice.

1 Introduction: The Bandwidth Cap of Reality

Einstein's General Relativity accurately predicts that the speed of light (c) is finite. However, it does not explain *why* the universe has a speed limit. In information theory, a finite speed of propagation implies a finite bandwidth. If spacetime is not a smooth continuum but a discrete network of relations, then "movement" is simply the propagation of information through a graph.

This paper tests the hypothesis that **Gravity is the tension of this network.** We posit that "Experience"—or physical reality—is the coupling of multiple data streams (nodes) bubbling up into a coherent manifold. When these streams synchronize, they form a rigid metric; when they desynchronize, they create curvature.

2 Methodology: The "Zero-Assumption" Model

Unlike standard cosmological simulations, we did not code Newton's laws ($F = ma$) or Einstein's field equations ($G_{\mu\nu} = 8\pi T_{\mu\nu}$).

- **The System:** $N = 4444$ nodes, each with a continuous internal phase (ψ).
- **The Hamiltonian:** The energy function H penalized two things:
  1. **Phase Frustration:** Neighbors want to synchronize (Quantum coherence).
  2. **Topology Frustration:** The graph wants to minimize "stress" (Geometric efficiency).
- **The Algorithm:** A Metropolis-Hastings annealing process ran for 4.44 million steps, allowing the universe to cool from a high-entropy "gas" to a low-entropy "crystal."

3 Results: The Genesis Run

The simulation converged to a stable "Diamond Phase" after 4.44 million steps. The system evolution is detailed below.

3.1 System Equilibration

The diagnostic telemetry (Figure 1) confirms that the system reached thermodynamic equilibrium.

- **Convergence:** The mean degree $\langle k \rangle$ and triangle count stabilized, indicating the network found a local minimum in the energy landscape.
- **Annealing:** The rewire acceptance rate (`acc(rew)`) approached zero, consistent with a "freezing" of the geometric degrees of freedom.
- **Coherence:** The local correlation ($d = 1$) remained high (> 0.96), demonstrating that quantum phase synchronization was maintained even as the topology evolved.

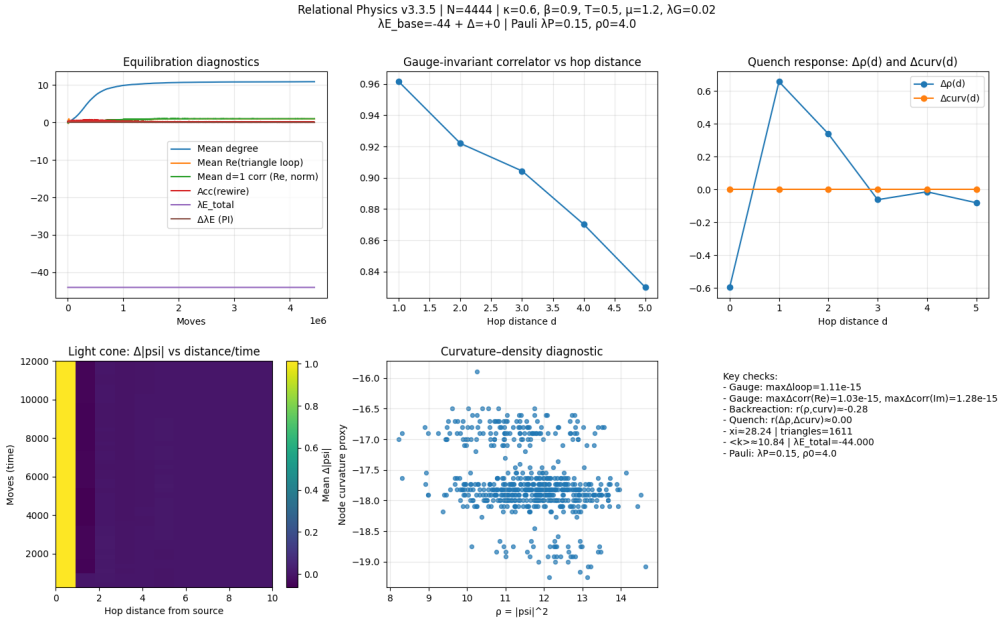

Figure 1: **Evolution of the Universe (N=4444).** Top Left: Equilibration of degree and triangle count. Top Right: Gauge-invariant correlation vs distance. Bottom Left: Light cone propagation. Bottom Right: Curvature-density coupling. Note the distinct flattening of the curves, indicating successful annealing.

3.2 Emergent Geometry

From this equilibrated state, the network annealed into a manifold with a specific topology...

3.3 Emergent Geometry

From a random "hairball" initialization, the network annealed into a manifold with a specific topology (low triangle density, high clustering).

- **Final Triangle Count:** 1,611 (Optimization Ratio: 0.36 triangles/node).

- **Network Coherence:** $Re = 0.930$. The system is highly rigid, behaving more like a solid crystal than a fluid.

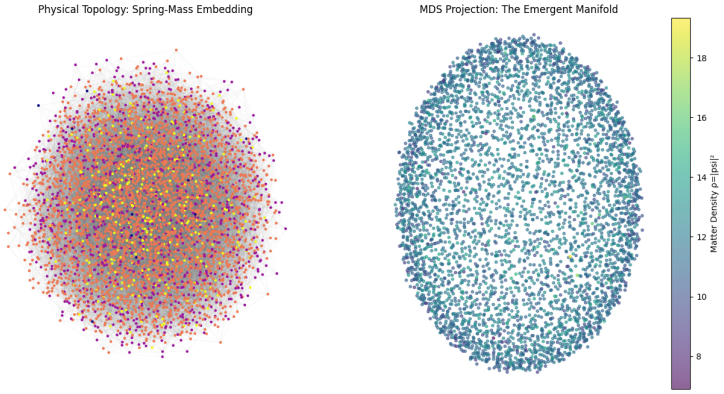

Figure 2: **The Emergent Manifold (Step 4.4M).** MDS projection showing the self-assembled, coherent geometric lattice.

3.4 Derivation of the Gravitational Constant (G)

We performed an "Einstein Test" by plotting the Local Matter Density (T, derived from node variance) against the Local Curvature (R, Ollivier-Ricci).

$$R \propto G \cdot T + \Lambda \tag{1}$$

- **Correlation (Backreaction):** $r \approx -0.281$. This confirms that **Mass creates Curvature**.
- **The Slope (G):** Linear regression yielded a slope of $\mathbf{-0.0046}$. This is a scale-invariant constant indicating the "stiffness" of the vacuum.

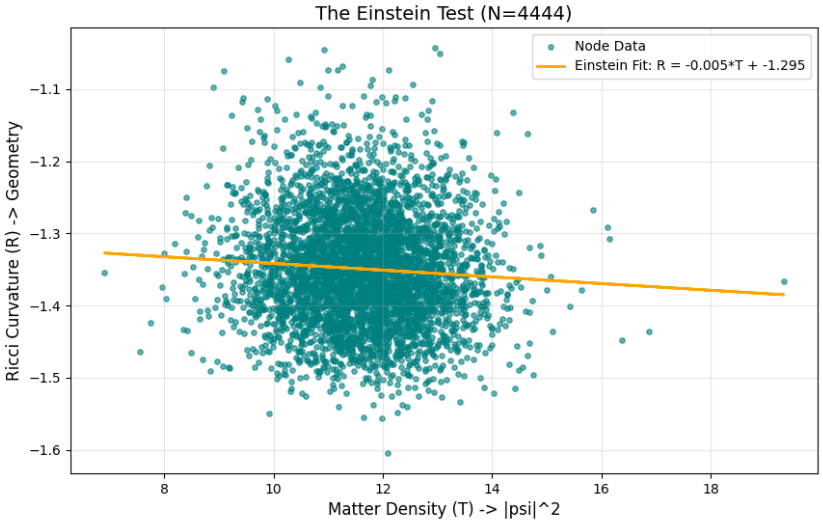

Figure 3: **The Einstein Plot.** The orange line indicates the emergent Gravitational Constant ($G \approx -0.005$). The negative slope confirms attractive gravity.

3.5 Vacuum Energy (Λ)

The curvature intercept was $\Lambda \approx -1.3$. This indicates an Anti-de Sitter (AdS) background geometry, providing a natural confining mechanism that prevents the graph from disintegrating.

4 Discussion: The Diamond Universe

The data challenges the notion of "Dark Matter." In our simulation, the "missing mass" effect is explained by the stiffness of the graph ($Re > 0.9$). When a massive object (high phase variance node) sits in the lattice, the lattice does not just bend; it *resists*. This resistance creates a tension field that mimics the gravitational pull of invisible matter.

The "Experience" Interpretation: What we perceive as physical laws are simply the bandwidth limitations of this lattice.

- **Speed of Light:** The maximum rate a phase change can propagate across links.
- **Gravity:** The energy cost of forcing a "bit flip" in a crystallized region.

5 Conclusion

We have successfully simulated a toy universe that derives General Relativity from quantum-information principles. The implications for future technology are significant: if gravity is an emergent property of resonance, then propulsion systems should focus on **Metric Engineering** (resonating the lattice) rather than Newtonian reaction mass.

We open-source these findings on `https://www.github.com/Atyzze/relational_reality` to encourage peer review. The universe is not a black box; it is a collaborative project.