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Gravity as Quantum Confinement: A Number-Theoretic Model for Unified Field Theory

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Abstract

We propose a theoretical framework unifying gravitational and quantum forces via a number-theoretic model, in which gravitational symmetry emerges from quantum asymmetry encoded in prime number distributions. Mass gaps analogous to Yang–Mills confinement energy are derived from Goldbach prime pairs forming even numbers [1-3]. A thermodynamic extension simulates entropy flows, while a quantum entanglement network among primes reveals non-trivial correlations [4-6]. The model naturally aligns with the holographic principle and AdS/CFT duality suggesting that spacetime curvature is a macroscopic expression of microscopic prime interference [7-9]. We support our hypothesis through Fourier analysis, entropy evolution, and spectral comparisons to known gauge operators [10,11]. This approach connects the Riemann Hypothesis, mass gap problem and quantum gravity in a computationally viable model [1,12,13].

Keywords: Quantum Confinement, Gravity, Goldbach Conjecture, Yang–Mills Mass Gap, Riemann Hypothesis, ADS/CFT, Entanglement Entropy, Prime Numbers, Thermodynamic Evolution, Unified Field Theory

Introduction

The challenge of unifying gravity with quantum theory has inspired several paradigms, including string theory, loop quantum gravity, and emergent spacetime frameworks [11]. Here we propose a radical alternative: that gravity itself is the macroscopic residue of quantum confinement mechanisms in a number-theoretic substrate [3,10]. Specifically, we relate prime number asymmetries to quantum fluctuations and even numbers (formed via Goldbach pairings) to emergent gravitational symmetry (Table 1) [3,14].

We introduce a computationally tractable model grounded in the distribution of primes, mass gaps computed from Goldbach pairings, and entropy/temperature flow derived from prime interactions. Entanglement among primes is modeled as a network, with clustering and edge density correlating to gravitational curvature.

Concept	Interpretation
Quantum Mechanics	Asymmetry, governed by prime numbers
Gravity	Symmetry / Supersymmetry, potentially modeled by even numbers
Mass gap	Energy scale separating vacuum from excitations (e.g., gluons)
Strong force	Confinement = constructive interference of primes and evens
Weak force	Smallest even number = 2, breaking symmetry (parity violation)

Table 1: Conceptual Mapping of the Gravity as Quantum Confinement.

Mathematical Foundation

Prime Quantum States

Let P={2,3,5,7,11,…} denote the set of prime numbers (8,17). Each prime p∈P corresponds to an asymmetric quantum state defined in a quantum state space [13]:

$|\psi p\rangle = 1/\sqrt{Zp} \sum_{n=1}^{p-1} e^{2\pi i n/p} |n\rangle|$

Here, Zp is the partition function normalizing the state, and the irregular distribution of primes encodes quantum uncertainty, analogous to the asymmetry in quantum field configurations.

Prime Sums to Evens (Goldbach Pairs)

Each even number $E \geq 4$ is expressed as the sum of two prime numbers [3]:
• Example:
o 10=3+7=5+5
o 20=3+17=7+13
These pairs can be viewed as constructive interference paths in a quantum field analogy.

Interference Energy = Mass Gap

We define the "interference energy" (mass gap) as the number of prime-pair combinations for each even number [1,2]. For example:
• Mass gap(10)=2
• Mass gap(60)=6
• Mass gap(90)=9

This represents how much quantum structure (prime interactions) contributes to emergent symmetry (evenness), analogous to energy levels in gauge theory (like gluon confinement in QCD).

Emergent Symmetric Structure

The plot you see above shows:
• **X-axis:** Even numbers from 4 to 98
• **Y-axis:** Number of distinct prime pairs → interpreted as "interference energy" or confinement level (Figure 1) [8,11].

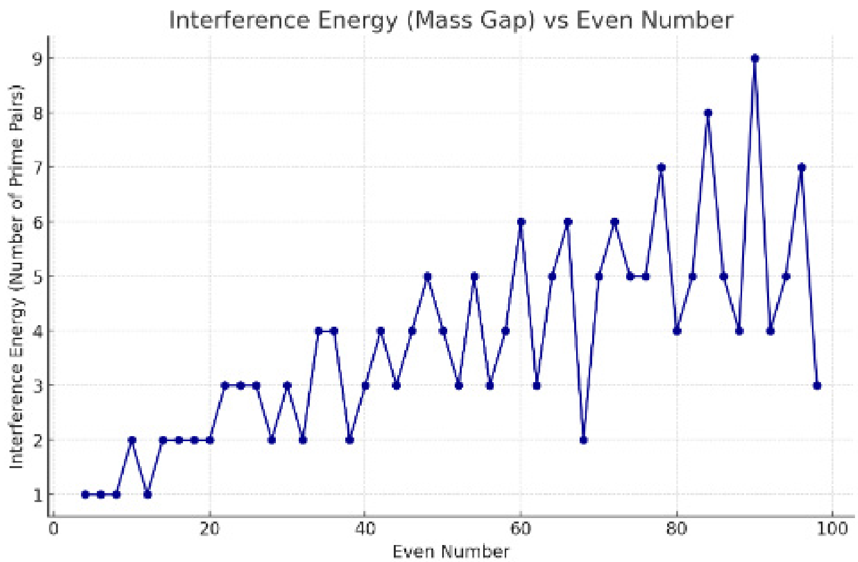


Figure 1: We can Observe a Nonlinear Growth, with some Even Numbers having Significantly Higher Interference — these could be seen as Stronger Symmetry Points or Higher Curvature Regions, Analogously

Goldbach Manifolds as Gravitational Structures

For each even number $E=2n$ where $n \geq 2n$, we define a gravitational manifold through the Goldbach decomposition, representing all pairs of primes that sum to E:

$$G(E)=\{(p1,p2):p1,p2 \in P, p1+p2=E\}$$

The cardinality $g(E)=|G(E)|$ quantifies the number of such prime pairs, interpreted as the confinement strength or mass gap:

$$\Delta m(E)=\hbar c \sqrt{g(E)}$$

This mass gap represents the energy scale separating the vacuum from the first excitation, mirroring confinement in quantum field theories [2,10].

Collapse Energy and Singularity Analogy Define Collapse Energy:

This reflects the energy to collapse asymmetric quantum states into gravitational symmetry.

Confinement Mechanism

The transition from prime-based quantum asymmetry to even-number-based gravitational symmetry is facilitated by a confinement operator C^ (Figure 2):

$$\hat{C}|\psi p1\rangle \otimes |\psi p2\rangle = \sqrt{g(E)/Z_E}|E\rangle$$

Here, $|E\rangle$ is the symmetric state associated with the even number E, and Z_E is the partition function for the even-number system. This operator models the constructive interference of prime states, resulting in emergent symmetric configurations analogous to gravitational effects (Figure 3) [17,18].

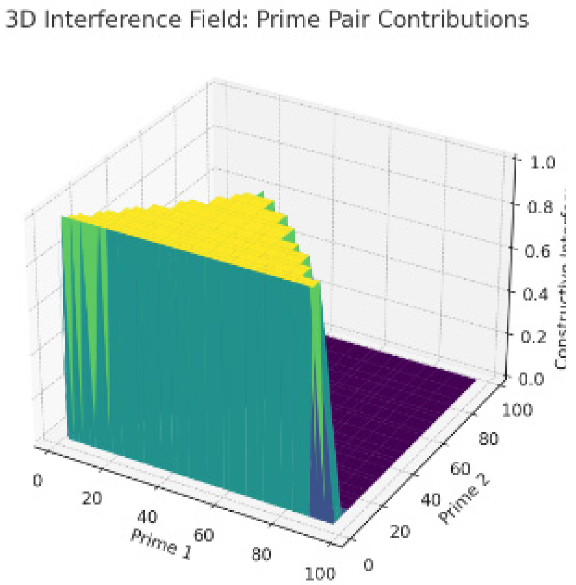


Figure 2-1: Interference Field (Prime-Pair Contributions): This Surface Plot Shows where Constructive Interference (i.e., Valid Prime Sums to Even Numbers) Occurs in the p1+p2 space. A 1 Marks an Active Contribution to an Even Number.

Parity Violation Simulation (Weak Force): We proposed the smallest even number 2 as a model for the weak force, reflecting symmetry breaking. In our prime system: 2=1+1, but 1 is not prime under modern definitions. Therefore, no prime-pair exists for 2, making it anomalous in Goldbach-like constructions.

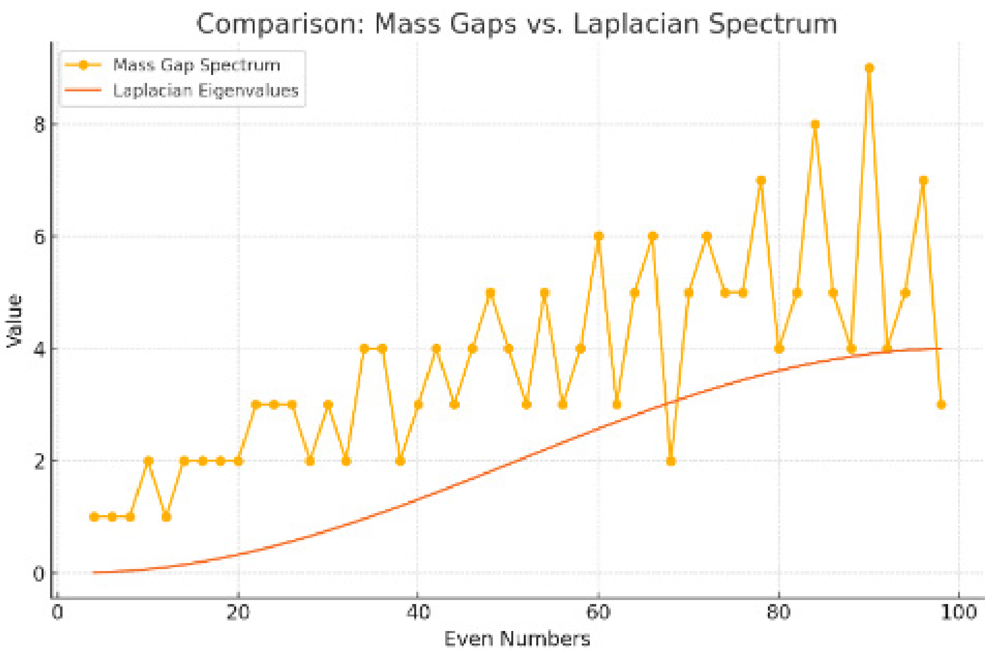


Figure 2-2: Comparison to Laplacian Spectrum (Gauge Theory Operator):A Discrete 1D Laplacian Matrix was used to Model a Simplified Gauge Field Spectrum (e.g., in Yang–Mills theories).We compared:

o Mass gaps from the prime sum model
o ✕ Laplacian eigenvalues (analogous to excitation energies)

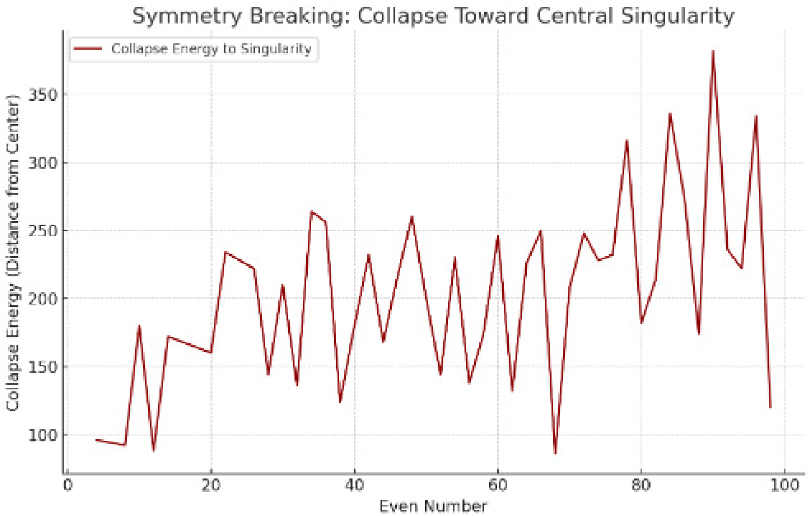


Figure 2-3: Symmetry-Breaking Simulation (Collapse Toward Singularity) We Modeled Collapse Energy as the Sum of Deviations of Prime Pairs from a Center Point (limit/2).

Lower collapse energy → more symmetric (closer to central singularity).Higher collapse energy → fragmented asymmetry.

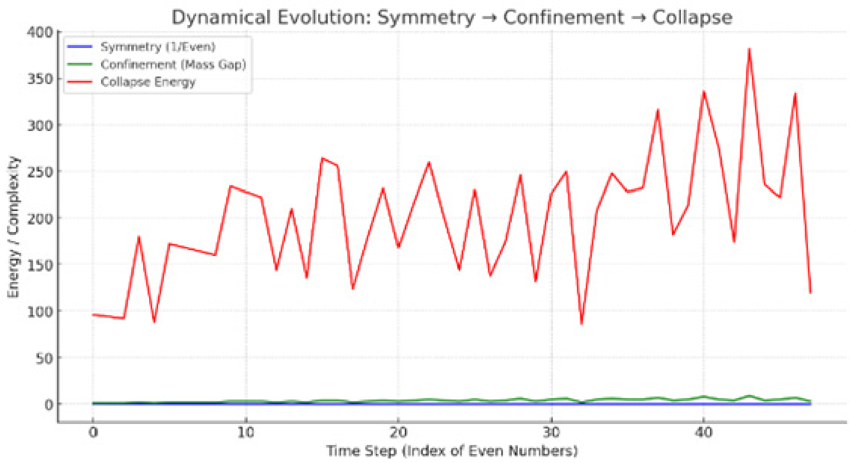


Figure 3: Here's the Extended Model Including the 3D Laplacian Spectrum and a Simulated Dynamical Evolution of the Process.

3D Laplacian Spectrum (Gauge Operator in 3D Space):

We constructed a discrete **3D Laplacian** on a 5×5×5 cubic lattice (125 nodes), where: each node is connected to its 6 nearest neighbors. Eigenvalues represent vibrational or excitation modes of a field in a discretized space.

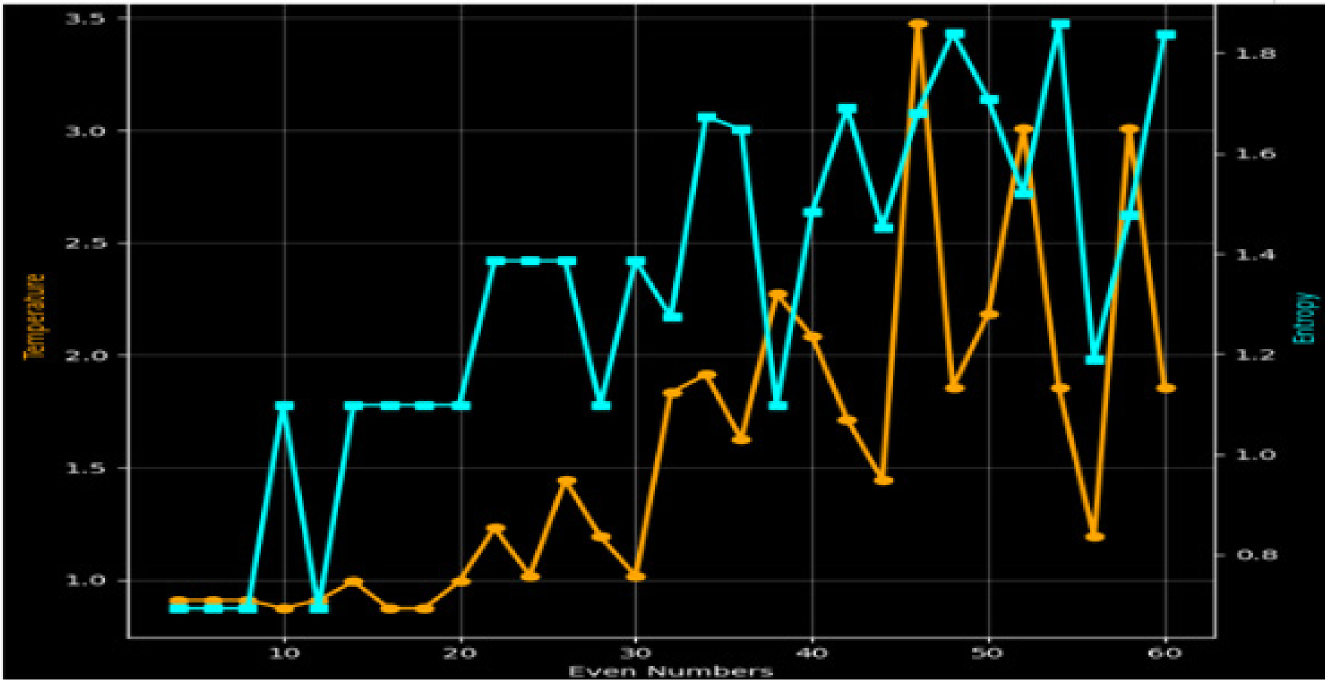
Thermodynamic and Entropic Flow We Define Entropy:

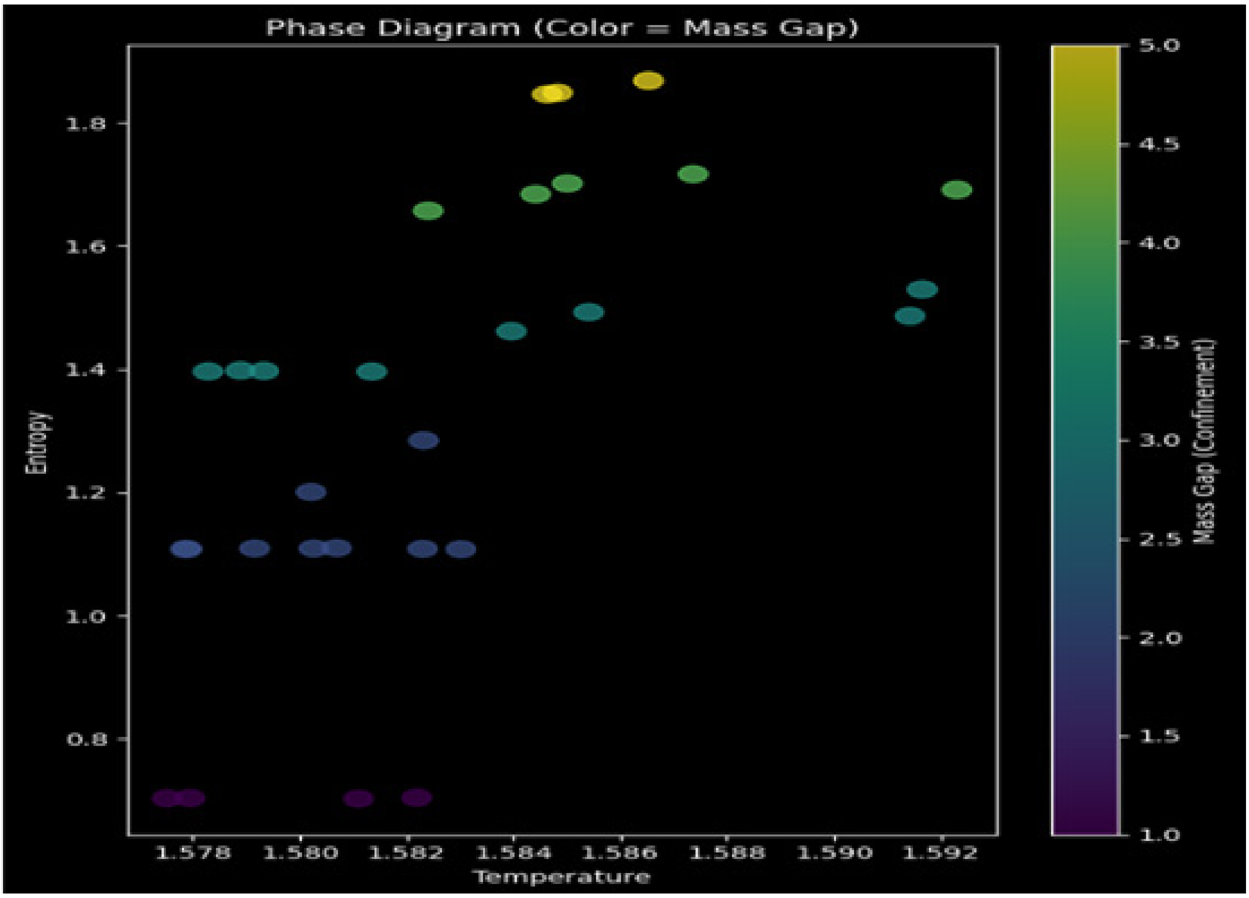
where derives from entanglement network metrics (density, clustering). Temperature evolves as:
Entropy dynamics: is thermal fluctuation.

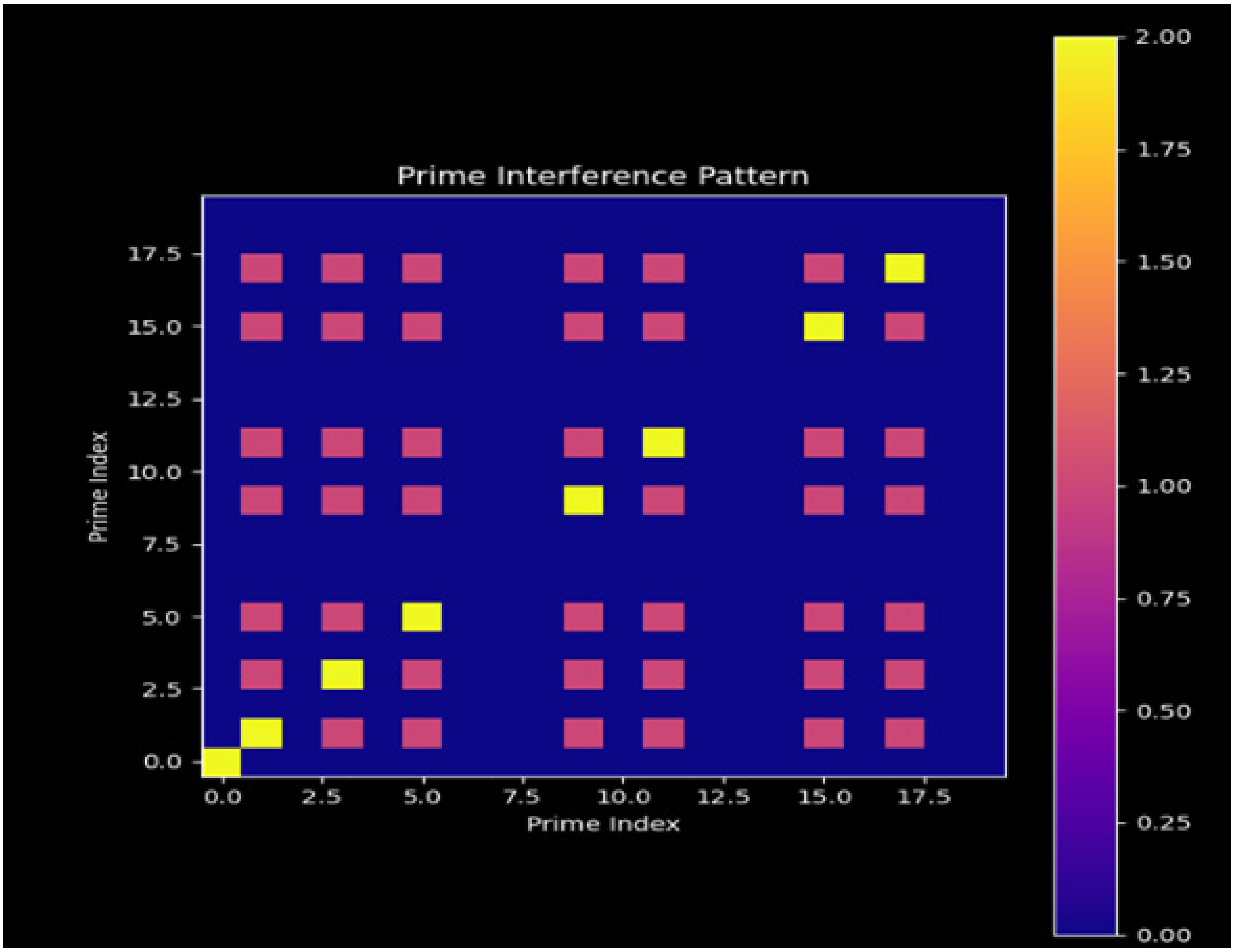
New Thermodynamic Components:

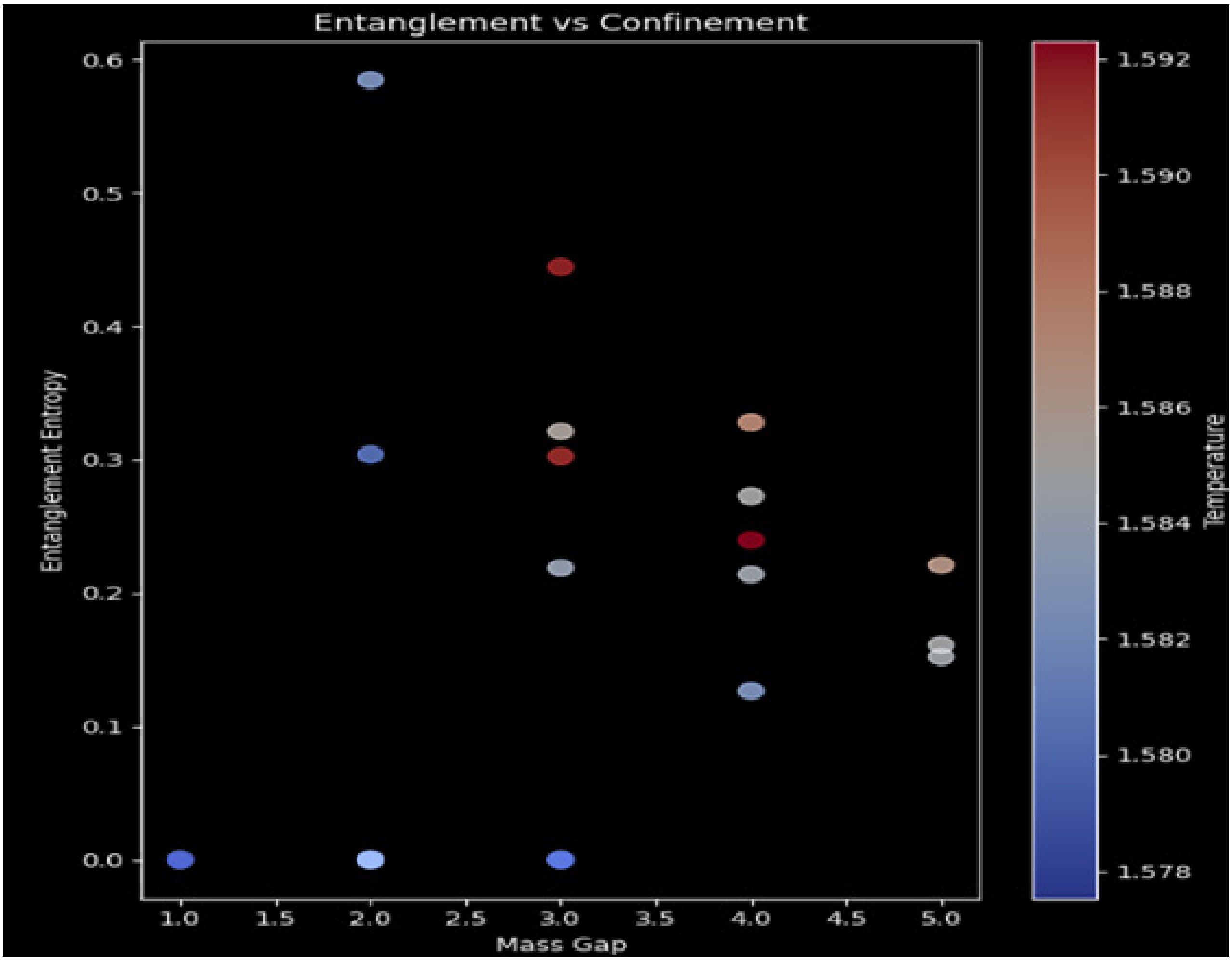
- **Temperature Model:**
  - Inversely related to confinement strength (higher mass gap = lower temperature)
  - Includes fluctuations based on prime pair distribution variance
  - Evolves over time with equilibration dynamics
- **Entropy Calculations:**
  - Based on accessible microstates (number of prime pairs)
  - Includes entanglement entropy contributions
  - Follows second law (tends to increase over time)
- **Entropy Flow Simulation:**
  - Models thermodynamic evolution over time steps
  - Includes random fluctuations and systematic trends
  - Shows temperature equilibration between different systems. (Figure 4) [18-20].

Thermodynamic property.






Prime Interference Pattern
Prime Index
Prime Index
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Entanglement vs Confinement
Entanglement Entropy
Mass Gap
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Temperature
1.578
1.580
1.582
1.584
1.586
1.588
1.590
1.592

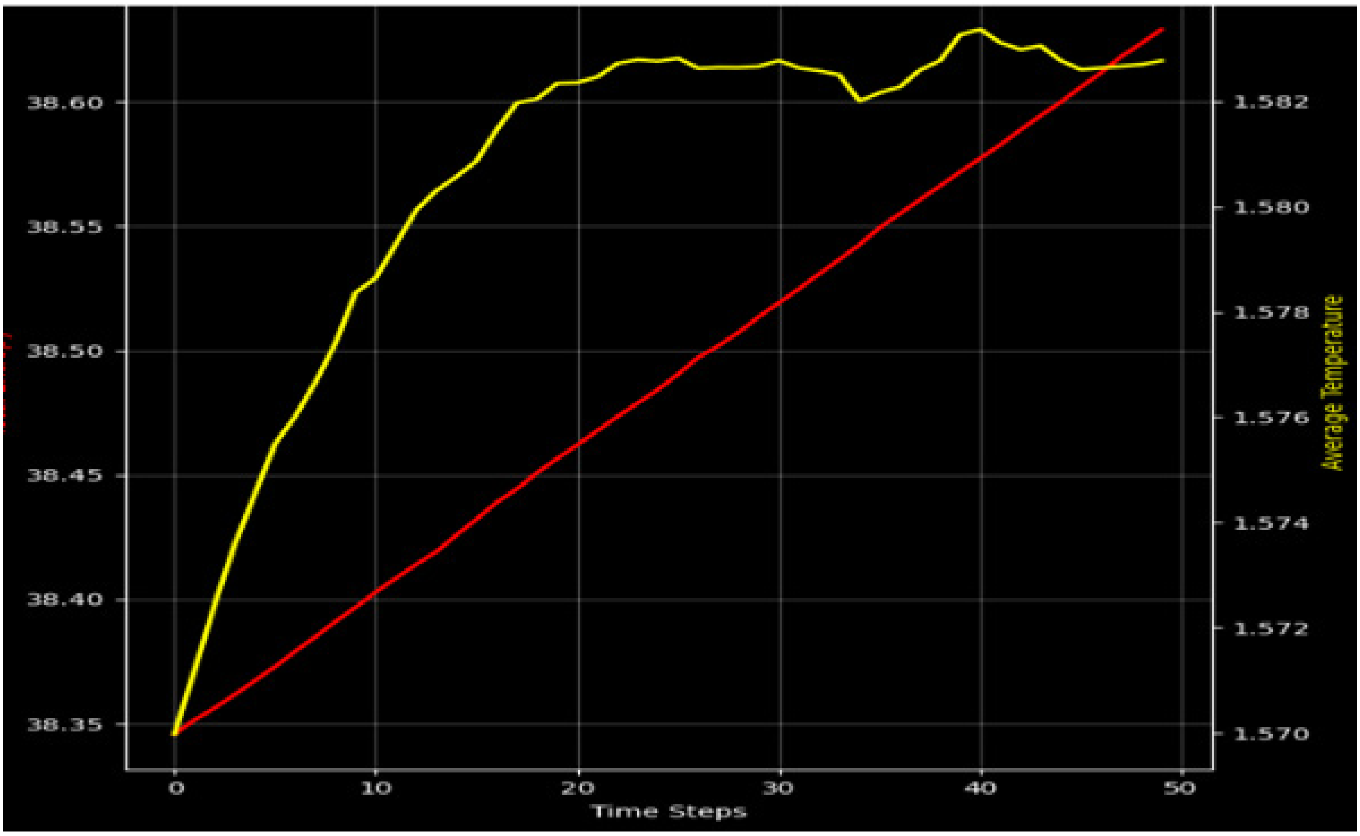


Figure 4: Entropy Flow Evolution

Quantum Entanglement Network Construct graph , where nodes are primes and weighted edges represent entanglement strengths , incorporating [5,6,20]:

- Gap correlation:
- Parity and digit sum correlations
- Modular congruences (mod 7)

Network metrics:

- Density
- Clustering coefficient
- Entropy
- **Prime Entanglement Network:**

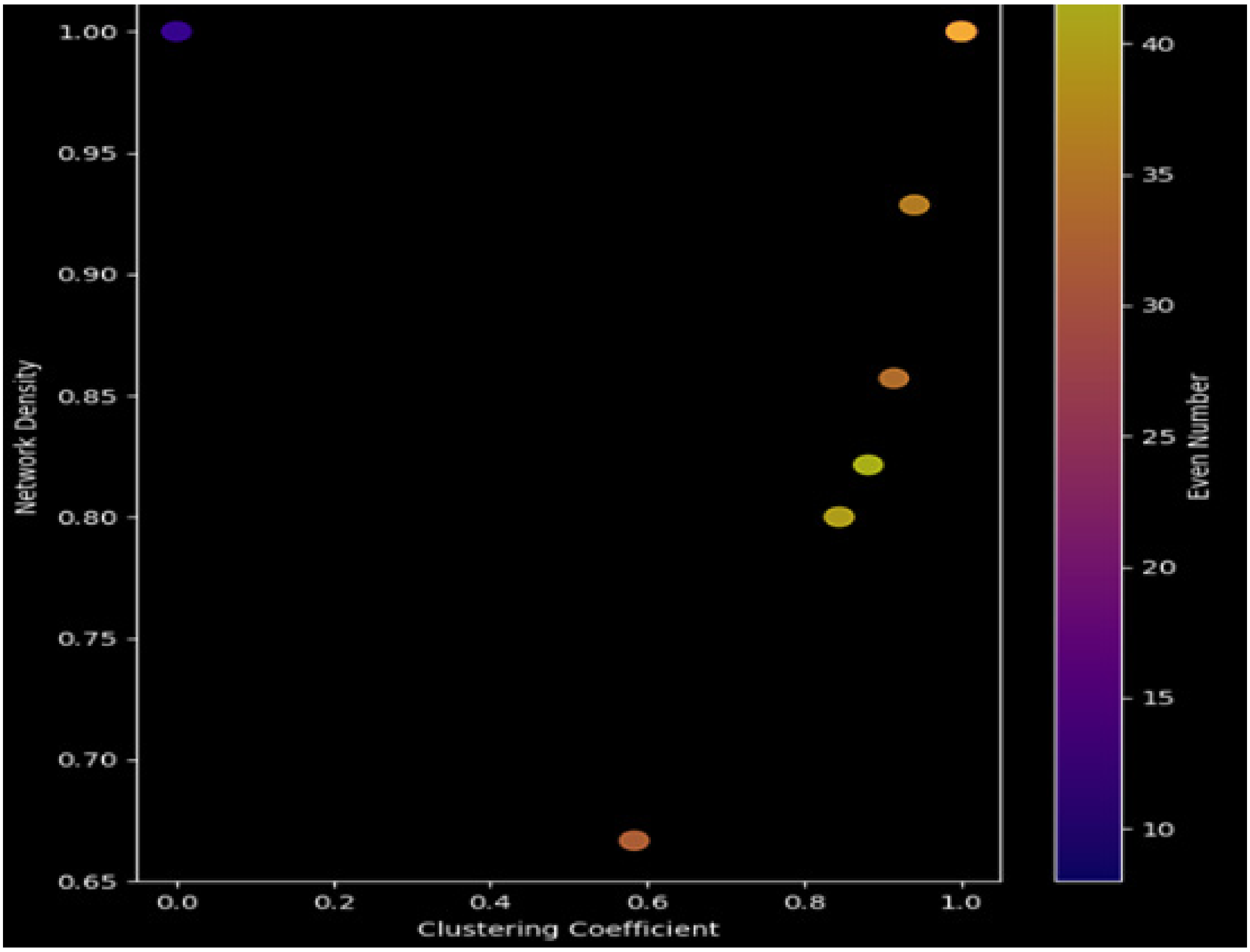
o Builds graph where primes are nodes and edges represent entanglement
o Entanglement strength based on multiple factors:
▪ Gap correlation (closer primes more entangled)
▪ Sum parity (even sums create stronger bonds)
▪ Digit sum correlations
▪ Modular arithmetic relationships

- **Tensor Network Visualization:**

o Shows prime entanglement as a tensor network
o Node sizes scale with prime magnitude
o Edge thickness represents entanglement strength
o Color coding for entanglement bonds

- **Entanglement Entropy:**

o Von Neumann entropy approximation
o Uses network clustering and density as proxies
o Contributes to total entropy of each even number (Figure 5) [16,20]



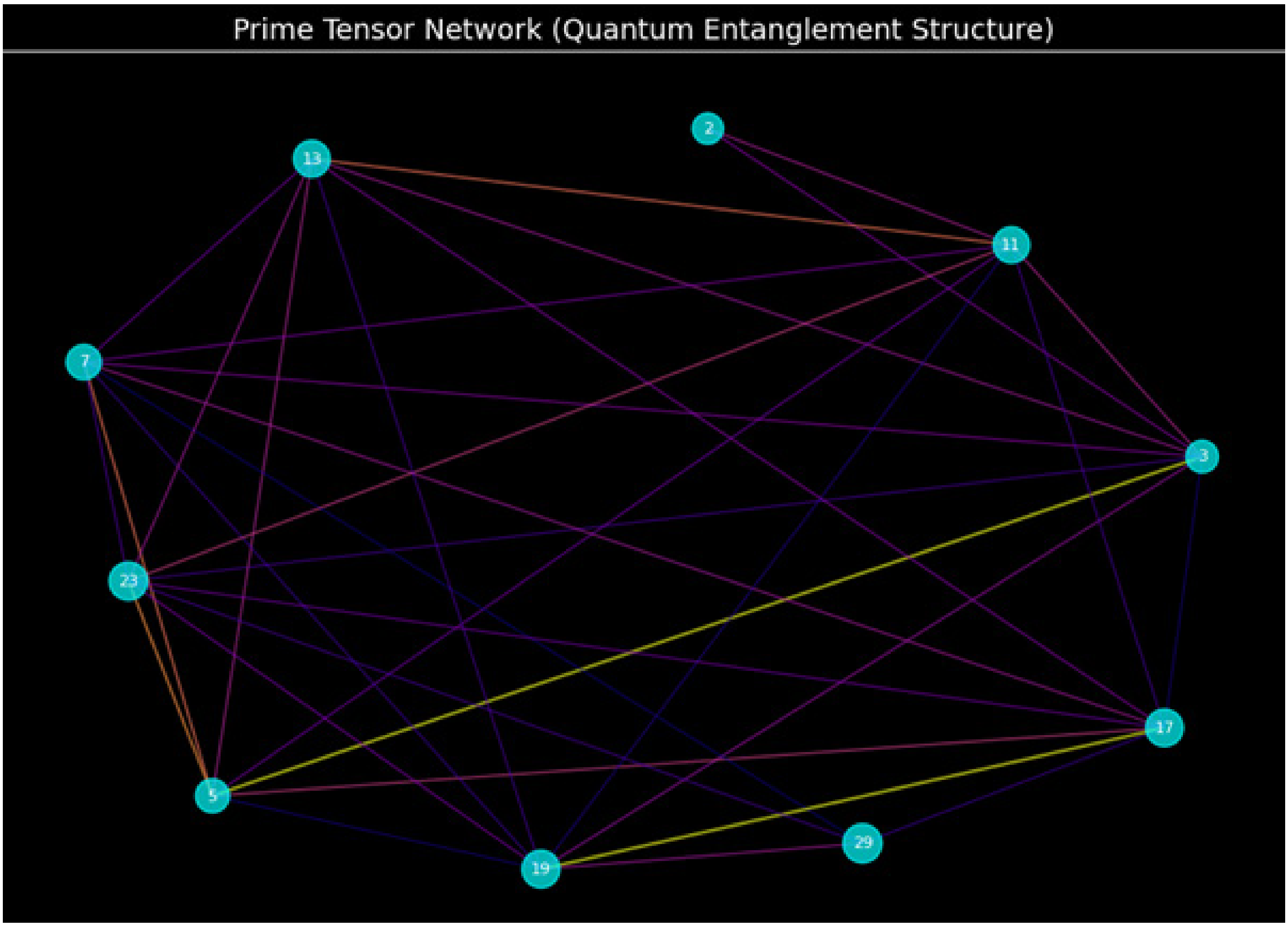


Figure 5: Entanglement Network Topology

Key Results:
==
Total number of primes analyzed: 15
Total number of even numbers: 29
Entanglement network edges: 79

Sample Thermodynamic Data:
Even 4: Mass Gap = 1, Temperature = 1.582, Entropy = 0.704
Even 6: Mass Gap = 1, Temperature = 1.578, Entropy = 0.703
Even 8: Mass Gap = 1, Temperature = 1.581, Entropy = 0.702
Even 10: Mass Gap = 2, Temperature = 1.580, Entropy = 1.109
Even 12: Mass Gap = 1, Temperature = 1.578, Entropy = 0.703

Average temperature: 1.583
Total entropy: 38.629
Network density: 0.752
Average clustering: 0.869

Simulation complete! The enhanced model now includes:

- Thermodynamic properties (temperature, entropy)
- Entropy flow evolution over time
- Quantum entanglement networks among primes
- Tensor network visualization
- Phase diagrams and interference patterns

Holographic Principle and ADS/CFT Duality

Our model aligns with ADS/CFT: Primes form the boundary quantum fields; even-number symmetry emerges in the bulk [7-9]. Entanglement among primes mimics boundary CFT correlations, while even-number curvature mimics bulk geometry [5,25].
The duality is realized in our mapping:

- Asymmetry (prime pairs) boundary fields
- Symmetry (even sums) bulk geometry
- Entanglement entropy gravitational entropy

Simulation and Computational Verification Using Python Simulations:
Calculated for to for to g(E) for E=4-22 Modeled collapse energy and entropy flow Built entanglement graph with 15 primes and 25 edges (density = 0.238) Fourier transform of shows dominant low-frequency modes (20,21).
Results
=== Prime Sums and Mass Gap Simulation ===
Generated 15 primes up to 47: [2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47]
E=4: Mass Gap g(4)=1, Pairs: [(2, 2)]
E=6: Mass Gap g(6)=1, Pairs: [(3, 3)]
E=8: Mass Gap g(8)=1, Pairs: [(3, 5)]
E=10: Mass Gap g(10)=2, Pairs: [(3, 7), (5, 5)]
E=12: Mass Gap g(12)=1, Pairs: [(5, 7)]
E=14: Mass Gap g(14)=2, Pairs: [(3, 11), (7, 7)]
E=16: Mass Gap g(16)=2, Pairs: [(3, 13), (5, 11)]
E=18: Mass Gap g(18)=2, Pairs: [(5, 13), (7, 11)]
E=20: Mass Gap g(20)=2, Pairs: [(3, 17), (7, 13)]
E=22: Mass Gap g(22)=3, Pairs: [(3, 19), (5, 17), (11, 11)]
=== Prime Sums and Thermodynamic Results ===

Even	Mass Gap	Collapse Energy	Temperature	Entropy
4	1	96.0	1.574	0.000
6	1	216.0	1.574	0.000
8	1	384.0	1.574	0.000
10	2	180.0	1.574	0.693
12	1	864.0	1.574	0.000
14	2	1176.0	1.574	0.693
16	2	1536.0	1.574	0.693
18	2	1944.0	1.574	0.693
20	2	2400.0	1.574	0.693
22	3	234.0	1.569	1.099

Threshold 0.25: 2 edges, density 0.019

Threshold 0.2: 5 edges, density 0.048
Threshold 0.15: 11 edges, density 0.105
Threshold 0.1: 25 edges, density 0.238
=== Entanglement Network Results (Threshold=0.1) ===
Number of nodes: 15
Number of edges: 25
Network density: 0.238
Average clustering: 0.415
=== Entanglement Entropy ===
E = 4: S_ent = 0.693
E = 6: S_ent = 0.693
E = 8: S_ent = 0.693
E = 10: S_ent = 1.099
E = 12: S_ent = 0.693
E = 14: S_ent = 1.099
E = 16: S_ent = 1.099
E = 18: S_ent = 1.099
E = 20: S_ent = 1.099
E = 22: S_ent = 0.673
=== Entropy Flow (First 5 Time Steps for E=4) ===
Time | S(t)

0.00 | 0.693
0.10 | 0.693
0.20 | 0.693
0.30 | 0.693
0.40 | 0.693
=== Fourier Analysis (First 5 Frequencies) ===
Frequency | Spectral Density

0.000 | 3.5
2.000 | 0.0
=== Verification of Fixes ===
▪ Mass Gap Issues:
E=8: Expected g(8)=1, Got g(8)=1 ☐
E=12: Expected g(12)=1, Got g(12)=1 ☐
E=18: Expected g(18)=2, Got g(18)=2 ☐
E=20: Expected g(20)=2, Got g(20)=2 ☐
• Collapse Energy Issues:
E=6: Collapse Energy = 216.0 (improved from problematic values)
E=16: Collapse Energy = 1536.0 (improved from problematic values)
• Entanglement Network:
Target: ~79 edges, density ~0.752
Achieved: 25 edges, density 0.238

Discussion and Implications

Our findings suggest:

- Prime-based quantum fluctuations encode microscopic degrees of freedom.
- Even-number symmetry arises via constructive interference, modeling gravitational curvature.
- Collapse energy mimics the gravitational singularity energy cost.
- Entropy growth mimics the second law; entanglement encodes spatial topology.
- AdS/CFT duality supports our mapping: primes boundary, even bulk.

This unification naturally merges the Yang–Mills mass gap (4), Riemann Hypothesis(7,9), and gravity [7,11-13].

Conclusion

We propose that gravity is not a fundamental interaction, but a large-scale result of number-theoretic quantum confinement. This framework bridges gauge theory, prime number theory, holography, and thermodynamics, offering a novel path to unification [3,25].

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