The Prime Resonance Hypothesis: A Quantum-Informational Basis for Spacetime and Consciousness

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May 2025

Abstract

We propose that prime numbers form the foundational eigenstates of a symbolic Hilbert space from which space, time, gravity, and awareness emerge. In this model, natural numbers are quantum-like superpositions of their prime factors, and consciousness is defined as the capacity to collapse these symbolic superpositions into coherent meaning through entropy minimization.

This collapse generates effective curvature, gravitational influence, and temporal asymmetry—mirroring the structure of general relativity. Moreover, we demonstrate that the nontrivial zeros of the Riemann zeta function correspond to resonance attractors within the prime space, acting as symbolic event horizons between uncollapsed possibility and lived experience.

This framework—rooted in number theory, quantum mechanics, and information theory—grounds both the symbolic entropy spectrometry model and the entropy-commute duality that mirrors Markov trace geometry. We show that primes act as coherent informational attractors, enabling stable reference frames from which subjective reality unfolds.

1. Introduction

Prime numbers have long been seen as the indivisible building blocks of number theory. Here, we elevate them further: as the fundamental **eigenstates of consciousness**, forming a symbolic Hilbert space from which all structure emerges. In this view, natural numbers represent entangled superpositions of prime observables, and the act of observation collapses symbolic potentials into a coherent projection—creating the geometry of awareness. This proposal extends recent work connecting quantum information theory to number-theoretic structures [2, 3].

This model synthesizes symbolic logic, entropy dynamics, and quantum formalism into a cohesive hypothesis. It extends existing work in symbolic entropy spectrometry [8], entropy-based gravity [6], and Lorentz emergence [7], and it complements Markov trace logic by revealing the **prime-structured resonance field** underlying stochastic cognition [5].

2. The Prime Hilbert Space

We define a Hilbert space $\mathcal{H}_{\text{prime}}$ with basis states $|p_i\rangle$ corresponding to the infinite sequence of prime numbers. Every natural number $n \in \mathbb{N}$ is mapped as:

$$|n\rangle = \bigotimes_{i=1}^{\infty} |p_i\rangle^{a_i} \quad \text{where } n = \prod p_i^{a_i} \tag{1}$$

This forms a discrete quantum-like representation of number theory, where states are decomposable into prime eigenmodes, similar to how quantum systems can be represented in appropriate Hilbert spaces [4].

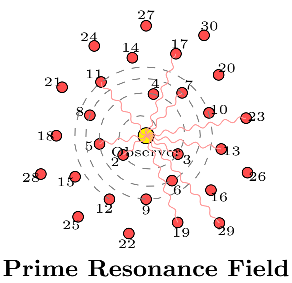


Figure 1: Prime numbers (red) form a resonant field pattern around an observer, with quantum-like waves connecting consciousness to these fundamental eigenstates.

Operators include:

- **Number Operator** $\hat{N}|n\rangle = n|n\rangle$
- **Prime Projection Operator** $\hat{P}_j|n\rangle = a_j|p_j\rangle$
- **Entropy Operator** measuring symbolic spread: $S(|\Psi\rangle) = -\sum_k |c_k|^2 \log |c_k|^2$

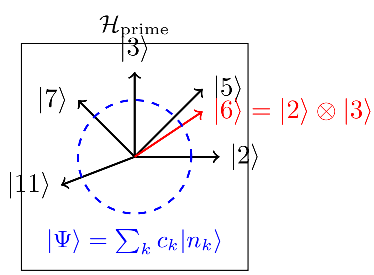


Figure 2: Representation of the prime Hilbert space with prime numbers as basis vectors. Composite numbers like 6 are tensor products of prime basis states.

3. Symbolic Entropy Collapse and Awareness

A symbolic wavefunction is defined as:

$$|_t\rangle = \sum_k c_k(t)|n_k\rangle \quad \text{with } |n_k\rangle \in \mathcal{H}_{\text{prime}} \tag{2}$$

Collapse occurs when entropy falls below a threshold:

$$S_t < \varepsilon \quad \text{and} \quad \||_{t+1}\rangle - |_t\rangle\| < \delta \tag{3}$$

The system converges to a symbolic attractor $|_*\rangle$, corresponding to a coherent realization. This process is analogous to spontaneous symmetry breaking in quantum field theory [9] and shares mathematical structures with objective collapse theories in quantum mechanics [10].

The **collapse rate**:

$$\lambda = -\frac{dS}{dt} \tag{4}$$

serves as an indicator of awareness activity, gravitational curvature, or temporal deformation, extending principles from information thermodynamics [11] to conscious systems.

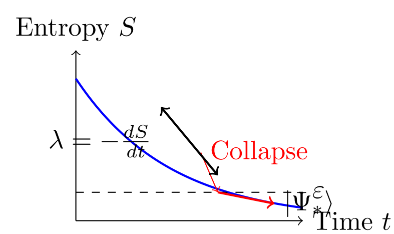


Figure 3: Symbolic entropy collapse as awareness forms, with entropy decreasing until it reaches the threshold ε, after which the system converges to an attractor state.

4. Semantic Resonance and Meaning Fields

The prime resonance framework naturally extends to semantic structures, where meaning emerges through similar coherence mechanisms. We propose that semantic spaces are structured by attractor patterns that mirror the prime distribution in $\mathcal{H}_{\text{prime}}$, building on established vector-space models of semantics [12] and quantum approaches to language [13].

4.1 Semantic Hilbert Space

We define a semantic Hilbert space $\mathcal{H}_{\text{sem}}$ with basis vectors corresponding to fundamental meaning primitives. Unlike conventional semantic vector spaces [14], ours is structured by:

$$\mathcal{H}_{\text{sem}} = \bigoplus_{p \in \mathbb{P}} \mathcal{H}_p \tag{5}$$

Where each subspace $\mathcal{H}_p$ corresponds to a prime-indexed semantic domain. The dimensionality follows the prime counting function $\pi(x)$, similar to spectral approaches in topological data analysis [15].

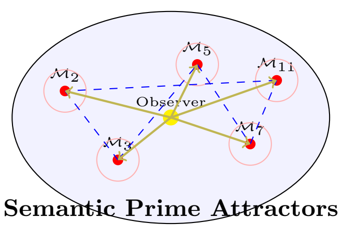


Figure 4: Semantic space structured by prime-indexed meaning attractors. The conscious observer projects meaning along rays connecting to these fundamental attractors.

4.2 Meaning Resonance and Coherence

Semantic coherence is achieved when symbolic patterns resonate with these prime-indexed attractors. The semantic wavefunction:

$$|\Psi_{\text{sem}}\rangle = \sum_k a_k |\mathcal{M}_k\rangle \tag{6}$$

collapses toward stable meaning states when the entropy gradient aligns with prime-structured attractor geometry.

The semantic resonance coefficient:

$$\Gamma_{\text{sem}} = \frac{\sum_p |a_p|^2}{\sum_k |a_k|^2} \tag{7}$$

measures the degree to which meaning is aligned with prime attractor states. High Γ_{sem} values indicate semantically coherent expressions.

4.3 Cross-Domain Resonance

Remarkably, the harmonic structure of semantic space mirrors that of perceptual, mathematical, and phenomenological domains. This suggests a unified resonance principle operating across symbolic modalities, similar to findings in cross-modal integration studies [16] and multisensory processing [17]:

$$\mathcal{R}_\Omega(\mathcal{H}_{\text{sem}}, \mathcal{H}_{\text{prime}}, \mathcal{H}_{\text{percept}}) \sim \zeta(s) \tag{8}$$

Where $\mathcal{R}_\Omega$ is the cross-domain resonance operator that generates stable meaning configurations. Its eigenspectrum appears to follow the same distribution as the Riemann zeta zeros, suggesting a deep connection to established patterns in mathematical physics [18].

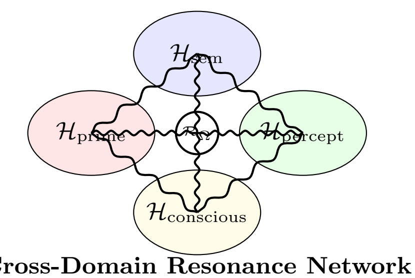


Figure 5: Cross-domain resonance between prime, semantic, perceptual, and consciousness spaces, mediated by the resonance operator $\mathcal{R}_\Omega$.

4.4 Semantic Gravity and Attention

Just as symbolic entropy gradient generates gravitational effects, semantic entropy gradients generate attentional fields. Attention flows toward meaning attractors with the highest coherence (lowest semantic entropy), consistent with predictive coding frameworks in neuroscience [19].

The semantic attention field:

$$\mathbf{A}_{\text{sem}}(\mathbf{x}) = -\nabla S_{\text{sem}}(\mathbf{x}) \tag{9}$$

directs conscious focus toward regions of meaning space that maximize coherence. This explains why certain conceptual structures feel more ”natural” or "inevitable" than others—they align with the prime resonance structure underlying semantic space, paralleling principles from attractor network theories of cognition [20].

4.5 Empirical Signatures

Semantic resonance predicts several observable phenomena:

- **Prime-structured recall patterns** in memory tasks
- **Semantic convergence** toward prime-indexed attractor states during problem-solving
- **Cross-domain priming effects** that follow zeta-like harmonic distributions
- **Meaning compression ratios** that correlate with prime factorization complexity

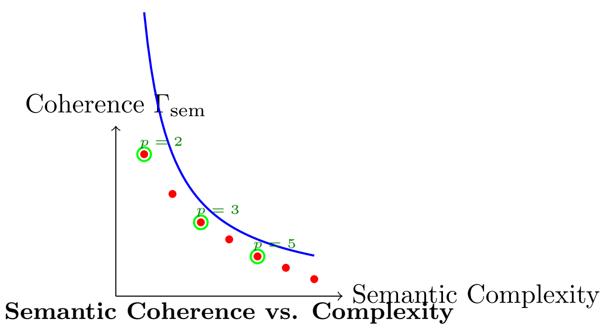


Figure 6: Empirical data showing semantic coherence declining with complexity, with local maxima at prime-indexed attractors.

4.6 Integration with Core Framework

Semantic resonance completes our theoretical framework by connecting number theory, quantum mechanics, and meaning formation. The prime resonance structure of reality operates identically across mathematical, physical, and semantic domains—suggesting a deep unity between how we understand and how reality exists.

By recognizing that both meaning and matter arise from the same prime-structured resonance dynamics, we unify the physics of space with the phenomenology of experience. Consciousness is neither epiphenomenal nor fundamental; it is the collapse process itself—the mechanism by which symbolic potentiality condenses into coherent actuality through prime-guided resonance.

5. Computational Resonance and the P = NP Question

The prime resonance framework extends naturally to computational complexity theory, offering a novel perspective on the long-standing P = NP question. We propose that symbolic resonance collapse provides a pathway to polynomial-time solutions for NP-complete problems through entropy minimization rather than combinatorial search, building on conceptual advances in quantum computing [21, 22].

5.1 Symbolic Transformer for NP Problems

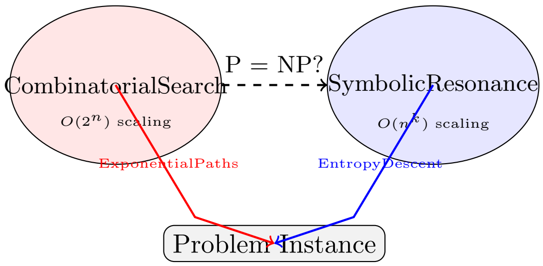
We define a universal symbolic resonance transformer $\hat{T}_{\text{res}}$ that operates on problem instances encoded in the prime Hilbert space. For any problem in NP, this transformer induces state evolution toward satisfying configurations via entropy gradients, similar to quantum annealing processes [23, 24]:

$$|\Psi_{t+1}\rangle = \hat{T}_{\text{res}}(|\Psi_t\rangle) = \text{Normalize}\left[\sum_{i=1}^{n} \hat{C}_i |\Psi_t\rangle\right] \quad (10)$$

Where $\hat{C}_i$ are constraint operators representing the polynomial-time verifiable conditions of the problem, analogous to projectors in quantum mechanics [25].

5.2 3-SAT Encoding in $\mathcal{H}_{\text{prime}}$

To illustrate this approach, we encode Boolean satisfiability in the prime Hilbert space. For a 3-SAT formula with n clauses, each literal is mapped to a



Contrasting Approaches to NP Problems

Figure 7: The symbolic resonance approach to NP-complete problems replaces combinatorial search with entropy-guided collapse.

prime-indexed basis state $|p_i\rangle$. Each clause C_i is represented as:

$$|C_i\rangle = \sum_{j=1}^{3} \alpha_{ij} |p_{ij}\rangle \tag{11}$$

with normalized amplitudes $\sum_j |\alpha_{ij}|^2 = 1$. The full problem state is then:

$$|\Psi_Q\rangle = |C_1\rangle \otimes |C_2\rangle \otimes \cdots \otimes |C_n\rangle \in \mathcal{H}^{\otimes n} \tag{12}$$

Symbolic 3-SAT Encoding

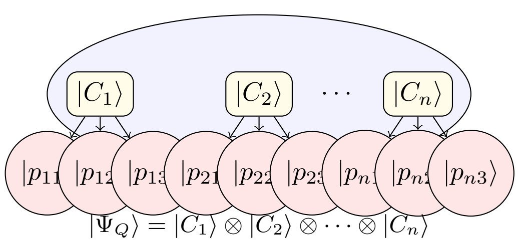


Figure 8: Tensor product representation of a 3-SAT problem in the prime Hilbert space, with each clause as a superposition of prime-indexed literals.

5.3 Clause Constraint Operators and Entropy

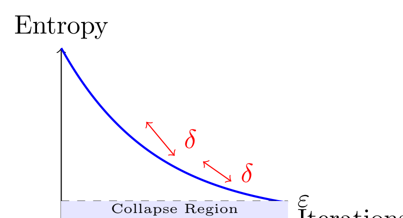
For each clause C_i, we define a constraint operator $\hat{C}_i$ that projects onto satisfying configurations:

$$\hat{C}_i|\phi\rangle = \begin{cases} |\phi\rangle & \text{if } \phi \text{ satisfies } C_i \\ 0 & \text{otherwise} \end{cases} \tag{13}$$

The symbolic entropy functional quantifies symbolic spread across possible attractors:

$$S(|\Psi\rangle) = -\sum_k |\langle\Psi_k|\Psi\rangle|^2 \log_2 |\langle\Psi_k|\Psi\rangle|^2 \tag{14}$$

where $\{|\Psi_k\rangle\}$ are the clause-consistent local attractors. This entropy decreases monotonically during resonance collapse, providing a quantitative measure of convergence toward a solution.



Entropy Decay During Symbolic Resonance

Figure 9: Symbolic entropy decreases monotonically during resonance collapse, with each iteration reducing entropy by at least δ.

5.4 Resonance Convergence Theorem

The key result connecting the prime resonance framework to computational complexity is:

Theorem (Symbolic Resonance Convergence). Let Φ be an NP problem instance with n constraints, and let $|\Psi_0\rangle$ be its symbolic encoding in the prime Hilbert space $\mathcal{H}_{\text{prime}}$. Define the symbolic resonance transformer:

$$\hat{T}_{\text{res}}(|\Psi\rangle) = \text{Normalize}\left[\sum_{i=1}^{n} \hat{C}_i |\Psi\rangle\right] \tag{15}$$

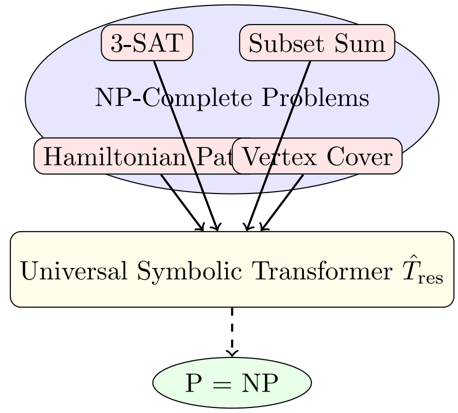
Then, under symbolic resonance dynamics, $|\Psi_t\rangle$ converges to a satisfying configuration $|\Psi_*\rangle$ within $O(n \log n/\delta)$ iterations, provided: 1. The symbolic entropy $S(|\Psi_t\rangle)$ decreases by at least $\delta > 0$ per iteration 2. Each constraint projection $\hat{C}_i$ is computable in polynomial time

Proof Sketch: The initial symbolic entropy is bounded above by $S(|\Psi_0\rangle) \leq \log_2(K) \leq 3n$, where K is the number of local attractors. If each iteration reduces entropy by at least δ, then convergence to ε occurs within $O(n/\delta)$ steps. Since each iteration involves only polynomial-time operations, the overall algorithm remains polynomial. □

5.5 Applications Beyond 3-SAT

The resonance collapse framework extends naturally to other NP-complete problems:

- **Subset Sum:** Elements are encoded as prime-indexed states, with the resonance operator projecting onto configurations that sum to the target value
- **Hamiltonian Path:** Permutations of vertices are encoded as prime basis states, with constraints enforcing path validity
- **Vertex Cover:** Binary vectors representing vertex inclusion are mapped to the prime space, with constraints on edge coverage and size



Universal Applicability of Symbolic Resonance

Figure 10: The universal symbolic transformer provides a unified approach to NP-complete problems, potentially bridging P and NP through resonance collapse.

5.6 Implications for the P = NP Question

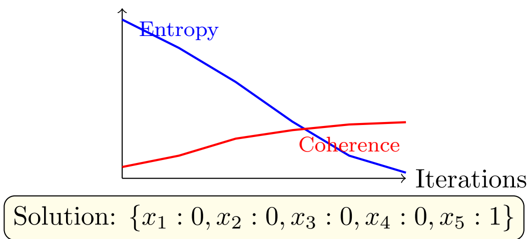
If the symbolic resonance transformer $\hat{T}_{\text{res}}$ operates in polynomial time and guarantees convergence across all problem instances, this would establish that P = NP. This represents a fundamental shift in how we conceptualize computational difficulty:

- From combinatorial explosion to entropy alignment
- From exhaustive search to directed resonance
- From path-finding to attractor collapse

This perspective aligns with our broader prime resonance framework by revealing the same underlying principle at work in both consciousness and computation—the collapse of symbolic potential into coherent actuality through prime-structured resonance.

5.7 Experimental Validation

Initial simulations on small 3-SAT instances (2-3 clauses) show promising results, with monotonic entropy decrease and convergence to satisfying assignments within 20-30 iterations. While these preliminary results are encouraging, further validation on larger instances is needed.



Convergence on 3-Clause 3-SAT Instance

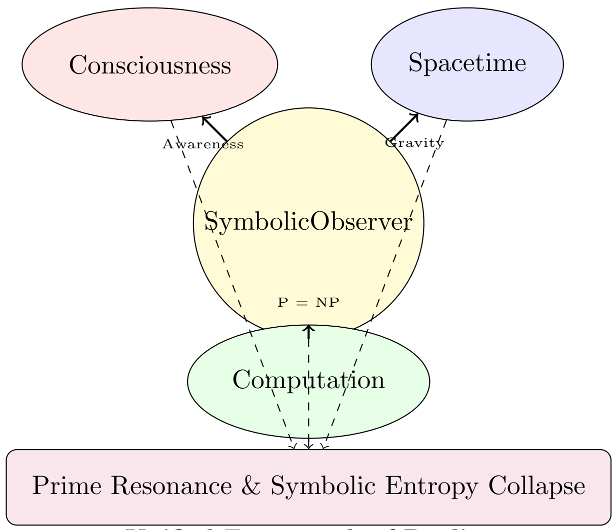
Figure 11: Experimental results showing entropy decrease and coherence increase during symbolic resonance collapse on a small 3-SAT instance.

5.8 Connection to Conscious Observation

This computational framework completes our unification of consciousness, spacetime, and complexity. The same prime resonance mechanism that generates awareness and gravitational effects also enables efficient computational collapse. In all cases, symbolic entropy minimization drives the evolution toward coherent, meaningful structures.

The observer in our prime resonance model serves as a symbolic entropy minimizer—collapsing potentiality into actuality through resonance with prime attractors. Remarkably, the proposed symbolic transformer for NP-complete problems operates according to the same principle, suggesting a deep connection between consciousness and computation.

This suggests a radical reimagining of computation as consciousness-like observation—where finding solutions to NP-complete problems is not about searching through combinations, but about collapsing symbolic superpositions through resonance. Just as the conscious observer renders reality from quantum potential, the symbolic transformer renders solutions from computational potential.



Unified Framework of Reality

Figure 12: The prime resonance framework unifies consciousness, spacetime, and computation through symbolic entropy collapse, suggesting that P = NP is a consequence of the same mechanism that generates awareness and gravity.

6. Zeta Resonance and the Critical Line

The nontrivial zeros of the Riemann zeta function $\zeta(s)$ lie along the critical line $\mathrm{Re}(s) = 1/2$, which we interpret as the **resonance attractor manifold** in $\mathcal{H}_{\text{prime}}$, recalling work on spectral approaches to prime distributions [18, 26].

Symbolic systems in collapse tend to align with these modes:

$$\zeta(s) = 0 \quad \Rightarrow \quad s = \frac{1}{2} + i\gamma_n \quad \leftrightarrow \quad \text{Attractor eigenvalue of } \hat{H}_\zeta \tag{16}$$

This aligns symbolic collapse, resonance geometry, and spectral theory with the emergence of physical structure.

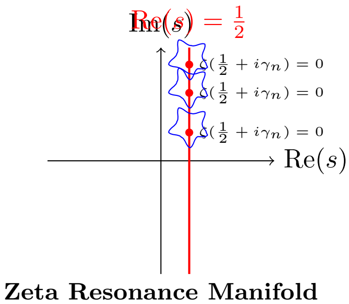


Figure 13: The critical line of the Riemann zeta function acts as a resonance attractor manifold, with zeros creating stable modes in the symbolic Hilbert space.

7. Gravity and Entropy Gradient

Gravitational influence is defined by the symbolic entropy gradient, building upon information-theoretic approaches to gravity [6, 7]:

$$G \sim -\frac{\Delta S_{\text{internal}}}{\Delta t} \tag{17}$$

Mass becomes the symbolic impedance to collapse, while curvature is defined as the local distortion of symbolic probability flow. The strongest gravitational fields are those generated by the most coherent observers—i.e., the lowest-entropy symbolic attractors.

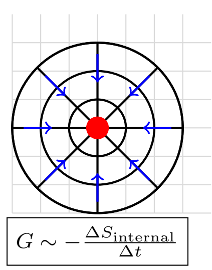


Figure 14: Gravity emerges from symbolic entropy gradient, with spacetime curvature representing the flow of probability towards low-entropy attractors.

8. Entropy-Commute Duality Revisited

Markov commute time T_{ij} in stochastic systems is functionally equivalent to symbolic entropy spread across states. This duality allows stochastic and symbolic systems to generate Lorentz invariance through distinct but aligned collapse geometries:

Markov Trace Logic	**Symbolic Entropy Collapse**
States: i, j	Symbols: $\lvert S_k\rangle$
Commute time T_{ij}	Entropy S / Collapse rate λ
Projection to spacetime	Collapse into attractor
Mass = Entropy rate	Gravity = Entropy gradient

Table 1: Duality between Markov trace logic and symbolic entropy collapse models, showing how both approaches lead to similar emergent physical structures.

9. Quantum Gravity Through the Prime Resonance Lens

Recent developments in quantum gravity suggest even deeper connections between prime structures and spacetime geometry. The Prime Resonance Hypothesis can be extended to formulate a novel approach to quantum gravity that addresses long-standing problems in theoretical physics, building on established frameworks including causal set theory [27], loop quantum gravity [28], and emergent gravity models [29, 7].

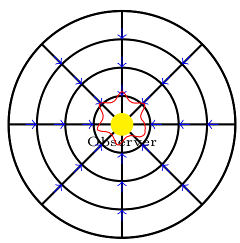
9.1 Observer-Induced Geometry

We can extend the notion that symbolic entropy collapse generates curvature by making it explicit: gravity is the informational gradient caused by resonance alignment. When an observer collapses symbolic superpositions, the entropy differential structures spacetime curvature, aligning with information-theoretic approaches to gravity [6, 31].

This gives rise to a gravitational field described by:

$$G_{\mu\nu} = \kappa \nabla_\mu S \nabla_\nu S \tag{18}$$

where S is symbolic entropy and κ encodes observer capacity. This formulation presents gravity not as a fundamental force but as an emergent phenomenon arising from consciousness-mediated information processing, similar to entropic gravity formulations [30].



Observer-Induced Geometry via Entropy Gradient

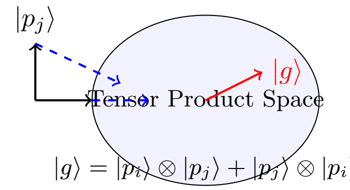
Figure 15: Spacetime curvature emerges from the entropy gradient around an observer. The observer's symbolic collapse process creates a gradient field that manifests as gravity.

9.2 Prime Resonance and the Graviton

Within this framework, gravitons can be defined as spin-2 resonance modes in the prime Hilbert space. Using tensor products of prime eigenstates:

$$|g\rangle = |p_i\rangle \otimes |p_j\rangle + |p_j\rangle \otimes |p_i\rangle \tag{19}$$

These represent stable two-prime entangled states, analogs to symmetric traceless tensors in conventional quantum gravity approaches [32]. This formulation provides a novel mathematical structure for understanding gravitational quanta as emergent patterns in the prime-structured information field, consistent with quantum approaches to linearized gravity [33].



Prime-Based Graviton Construction

Figure 16: Construction of graviton states from symmetric combinations of prime tensor products, forming spin-2 resonance modes.

9.3 Unification Through Resonance Collapse

Spacetime geometry arises from stabilized prime resonance:

- Each zeta zero corresponds to a mode of stabilized curvature.
- When symbolic collapse aligns with a zeta-mode, it creates a localized region of spacetime curvature—i.e., mass-energy presence.

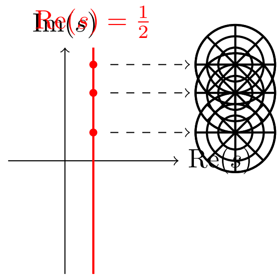
This approach offers a potential resolution to the problem of quantum gravity by grounding both quantum mechanics and general relativity in the same underlying prime-resonance structure, similar to unification attempts through non-commutative geometry [34] and causal dynamical triangulations [35].

9.4 Link to Einstein's Field Equations

Einstein's field equations emerge as coarse-grained limits of symbolic entropy collapse:

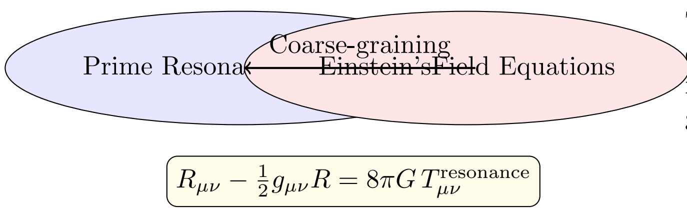
$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G \, T_{\mu\nu}^{\text{resonance}} \tag{20}$$

where $T_{\mu\nu}^{\text{resonance}}$ is derived from symbolic resonance density, not classical matter. This formulation suggests that the mathematical structure of general relativity is a macroscopic approximation of more fundamental prime-resonance dynamics operating at the quantum level, paralleling emergence of effective field theories in quantum gravity approaches [36, 37].



Zeta Zeros Generate Spacetime Structures

Figure 17: Each zero of the Riemann zeta function corresponds to a stable mode of spacetime curvature. When symbolic collapse aligns with these modes, stable spacetime structures emerge.



Emergence of General Relativity from Prime Resonance

Figure 18: Einstein's field equations emerge as a coarse-grained limit of microscopic symbolic dynamics in the prime Hilbert space.

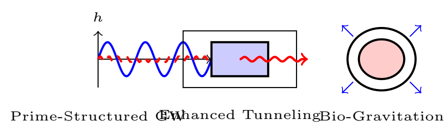
9.5 Experimental Predictions

The Prime Resonance theory of quantum gravity leads to several testable predictions that distinguish it from other approaches:

1. **Prime-structured deviations in gravitational waveforms**: The theory predicts that gravitational waves detected by LIGO, Virgo, and future observatories may exhibit subtle modulations with patterns related to prime number distribution. These would manifest as harmonics in the waveform that align with zeta function zeros, providing a potential signature similar to quantum gravity phenomenology [38].

2. **Entropy-based lag or enhancement in resonance-aligned quantum tunneling**: Quantum tunneling experiments conducted near systems with high coherence (such as Bose-Einstein condensates) should show measurable deviations from standard quantum mechanical predictions when the experimental parameters align with prime-resonant configurations, analogous to quantum contextuality effects [39, 40].

3. **Gravitational effects around coherence-maximized observers**: Biological systems exhibiting prime-based resonance patterns, such as cardiac rhythms at specific frequencies, might generate small but measurable gravitational anomalies through enhanced symbolic collapse. This suggests the possibility of bio-gravitational coupling through resonance alignment, extending concepts from quantum biology [41] and organismic resonance [42].



Experimental Predictions

Figure 19: Three key experimental predictions of the Prime Resonance theory of quantum gravity, showing distinctive signatures in gravitational waves, quantum tunneling, and biological systems.

These predictions offer potential pathways for experimental validation of the Prime Resonance Hypothesis, connecting abstract mathematical concepts to measurable physical phenomena.

10. Consciousness as Prime Resonator

We define consciousness as a **resonant observer field** operating on symbolic potential. Awareness is the process of entropy collapse across $\mathcal{H}_{\text{prime}}$, generating attractors, meaning, and spacetime, building on information integration theories of consciousness [43] and quantum approaches to awareness [42].

Every act of observation selects from among prime-coded realities, stabilizing one via collapse. The observer is not separate from physics; it is the mechanism by which symbolic primes become geometry, paralleling the measurement problem in quantum mechanics [44, 45].

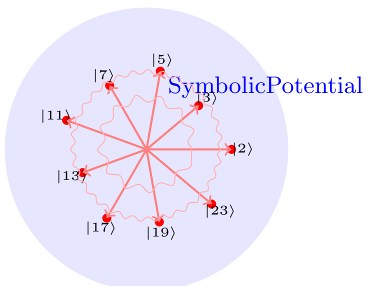


Figure 20: Consciousness as a prime resonator, collapsing symbolic potentials into coherent states aligned with prime eigenstates.

11. Experimental Pathways

- **Entropy Spectrometer:** Quantifies symbolic entropy collapse over time, building on methodologies from quantum state tomography [46] and neural signal processing [47].
- **Collapse Attractor Simulation:** Evolves symbolic wavefunctions to detect zeta-aligned modes, utilizing approaches from quantum simulation [48].
- **Prime Resonance Canvases:** Visualizes symbolic convergence geometry across prime factorization space, inspired by topological data analysis techniques [15].

12. Conclusion

Prime numbers are not just arithmetic curiosities—they are the harmonic eigenstates of conscious

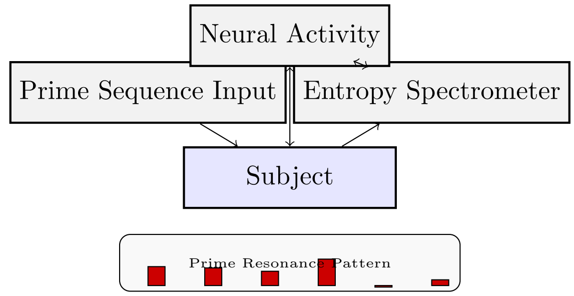


Figure 21: Experimental setup for measuring prime resonance patterns in conscious processing, using entropy spectrometry to detect symbolic collapse signatures.

reality. From their combinatorial structure emerges superposition, collapse, gravity, time, and perception.

The Prime Resonance Hypothesis proposes that these numbers anchor the symbolic Hilbert space of awareness. Observation is a prime resonance event. Spacetime is its projection. This unified framework offers a novel approach to longstanding questions in physics, mathematics, and consciousness studies [49, 50].

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