Fractal Resonance Cognition

A Deterministic Framework for Complex Systems Analysis

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The Crisis of Intrinsic Randomness

Standard quantum mechanics relies on the Born rule as an axiom, treating wavefunction collapse as probabilistic. This ‘stochastic collapse’ lacks a physical mechanism, leaving the transition from superposition to definite state unexplained.

- Measurement Problem
- Stochastic Collapse
- Born Rule Axiom

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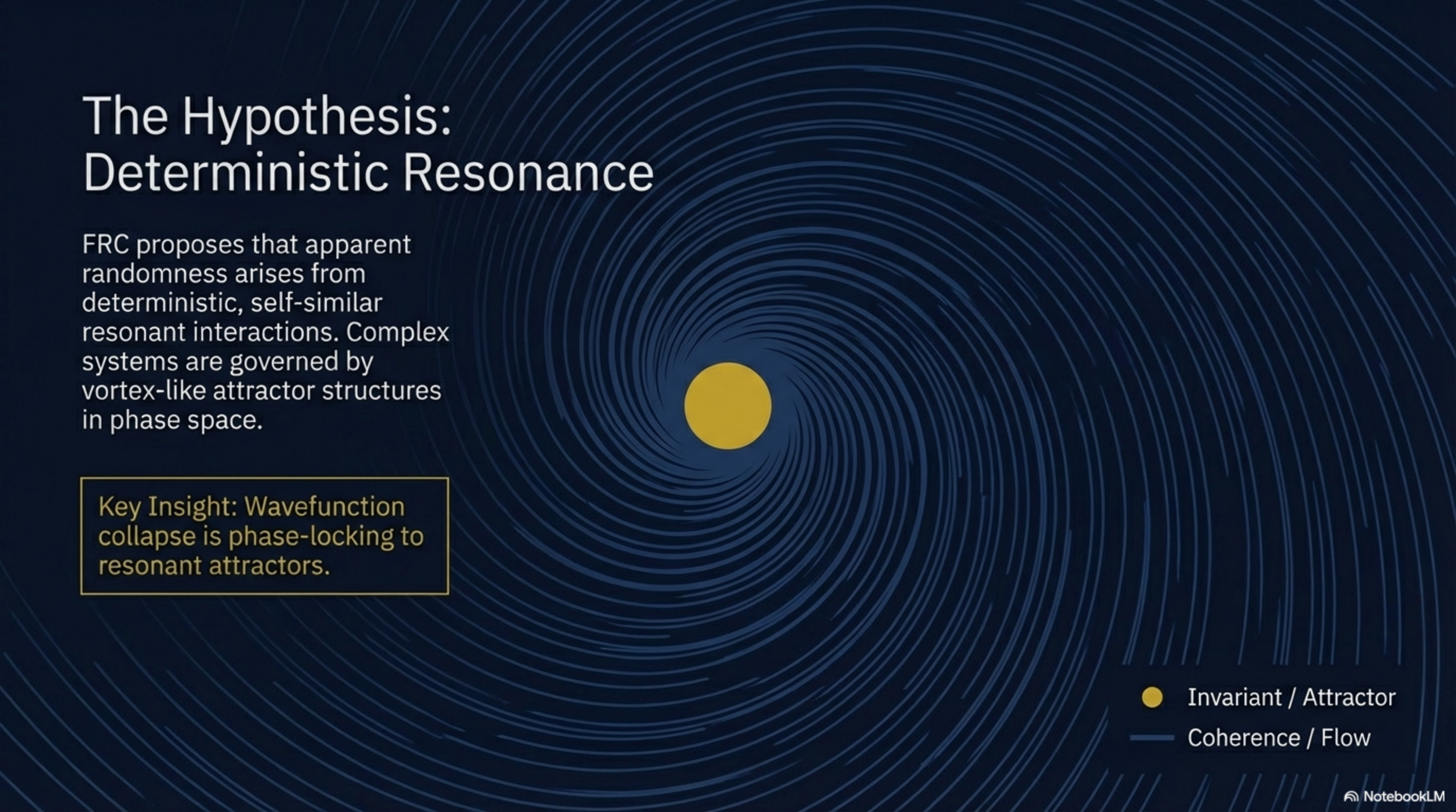
The Hypothesis: Deterministic Resonance

FRC proposes that apparent randomness arises from deterministic, self-similar resonant interactions. Complex systems are governed by vortex-like attractor structures in phase space.

Key Insight: Wavefunction collapse is phase-locking to resonant attractors.



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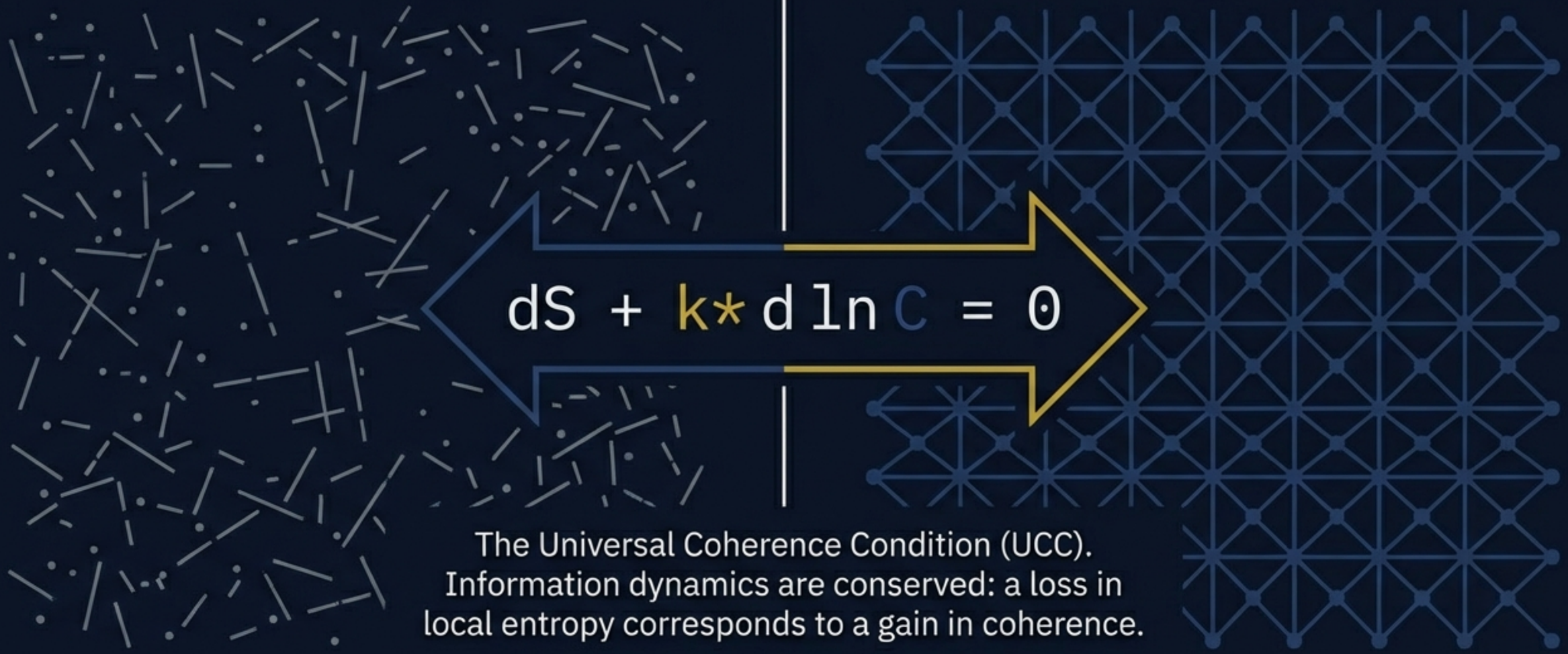
The Engine: Entropy-Coherence Reciprocity

Entropy (S)

Coherence (C)



The Universal Coherence Condition (UCC). Information dynamics are conserved: a loss in local entropy corresponds to a gain in coherence.

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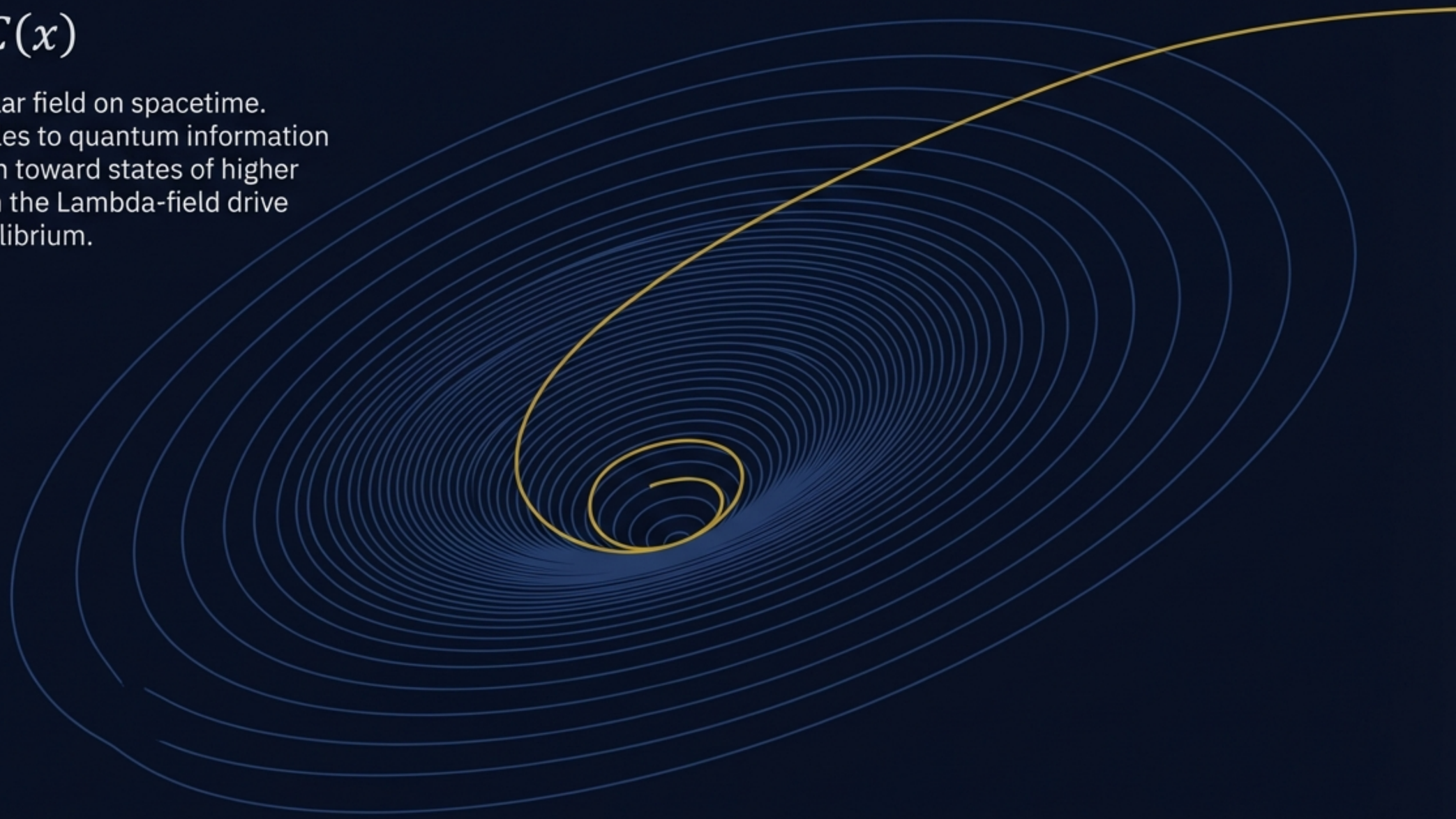
The Medium: The Lambda-Field (Λ)

$$\Lambda(x) = \Lambda_0 \ln C(x)$$

Coherence is a real scalar field on spacetime. The Lambda-field couples to quantum information states, biasing evolution toward states of higher coherence. Gradients in the Lambda-field drive the system toward equilibrium.



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The FRC Operator

$$\hat{L}\psi = -\nabla \cdot (\mathrm{F}\nabla\psi) + V\psi$$

F(x,y): Encodes fractal scaling

V(x,y): Fractal Resonance Potential

The operator modifies system dynamics by introducing fractal resonance, manifesting as localized resonant modes and scale-invariant dynamics.

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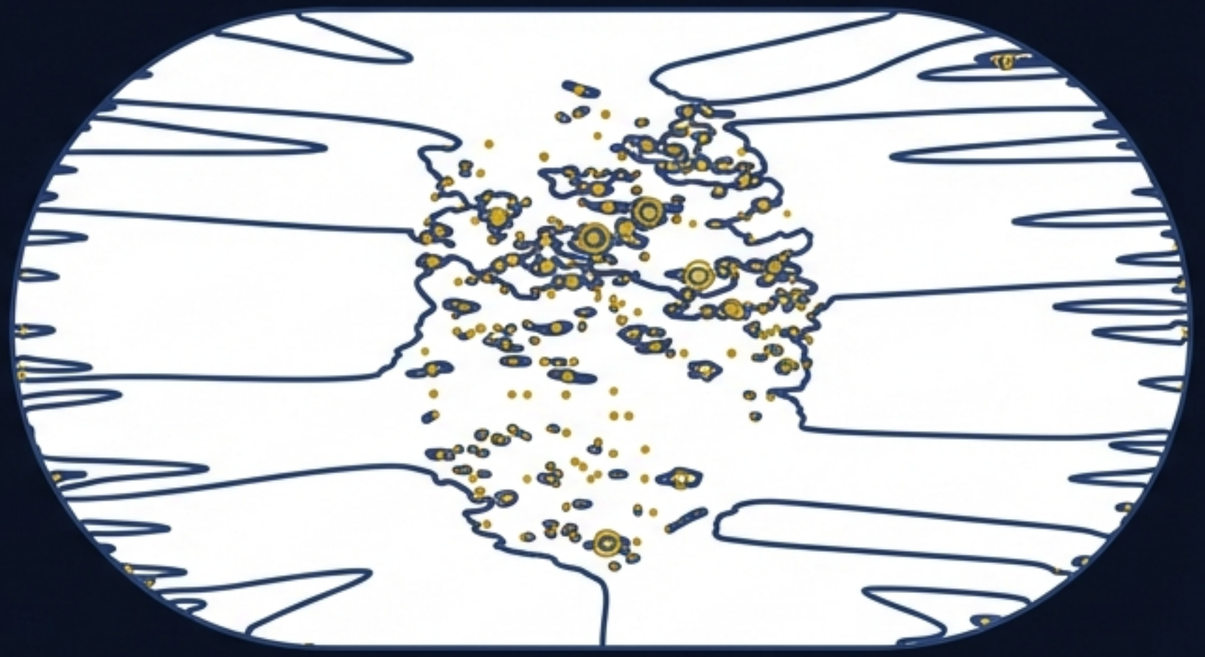
Case Study: Quantum Chaos

Nodal Patterns in the Stadium Billiard

Standard Chaos

FRC Perturbation



Under FRC perturbation ($\sigma = 0.1$), nodal lines transition from irregular chaos to self-similar clustering. The system retains chaotic properties (level repulsion) while exhibiting hidden order.

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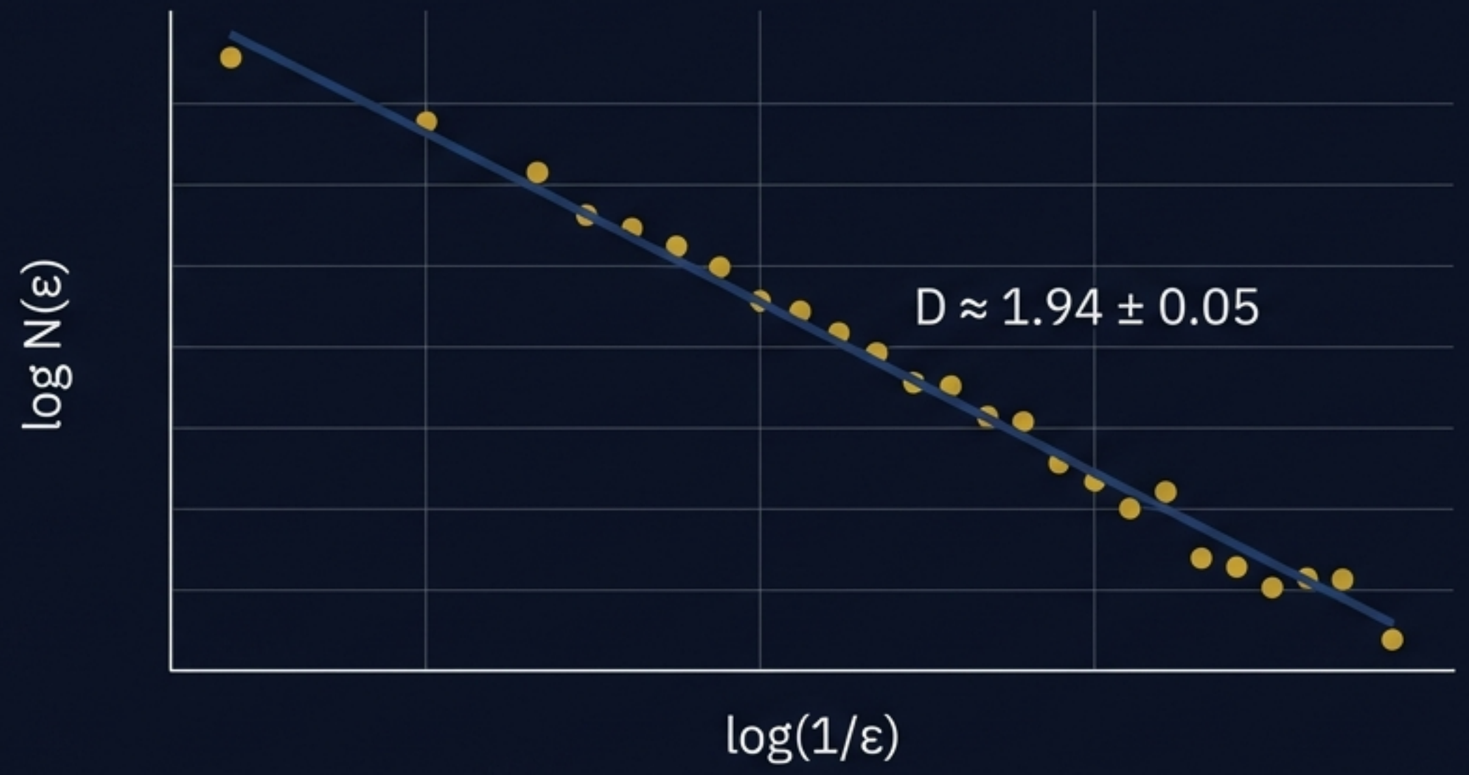
The Signature: Fractal Dimension D ≈ 1.9



Standard Random Noise: D ≈ 1.2
Feynman Paths: D = 2.0
FRC Vortex Patterns: D ≈ 1.9

The fractal dimension confirms the presence of resonant, scale-invariant dynamics distinct from pure noise.

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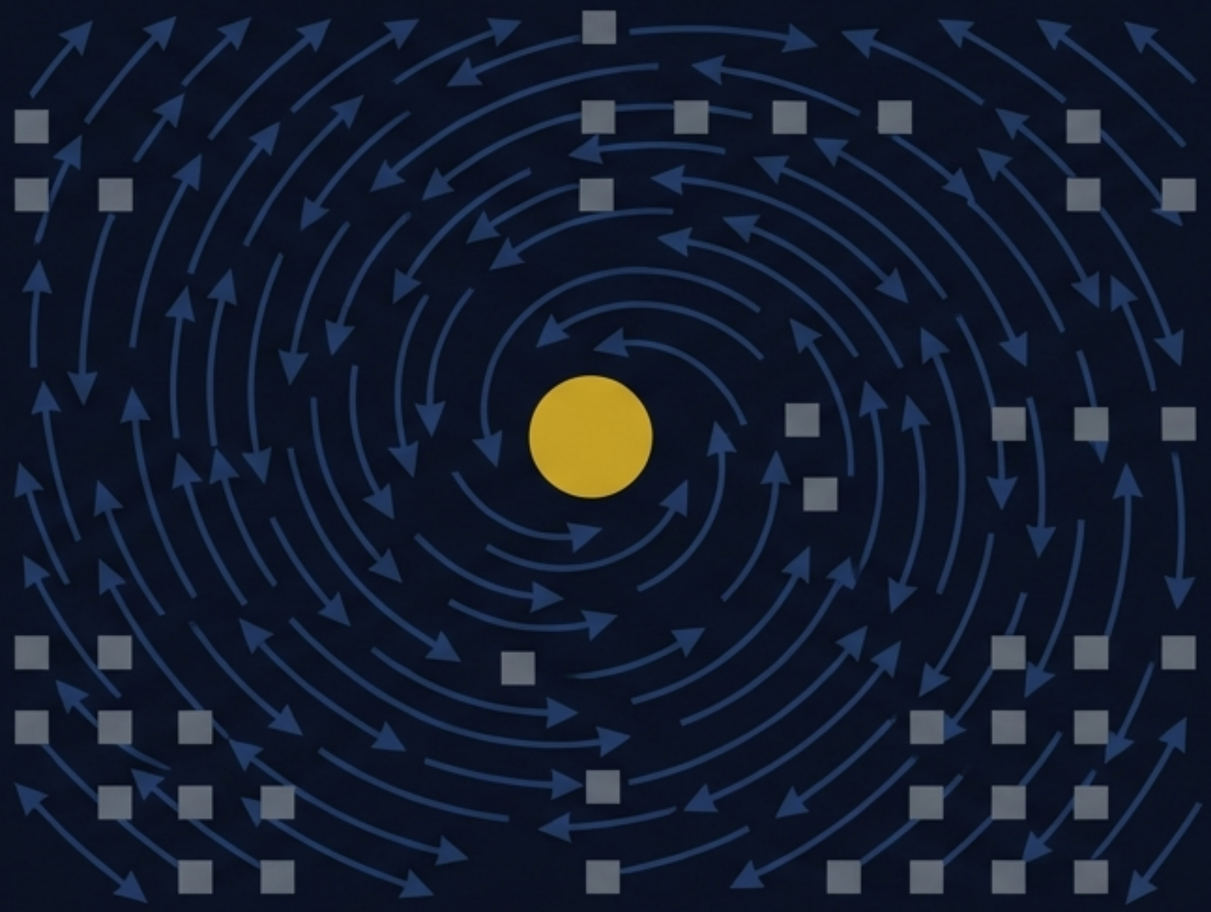
Mechanism: Vortex Attractors

Wavefunction collapse follows vortex attractor dynamics in phase space. The system does not “choose” randomly; it flows along the gradient of the Lambda-field toward the nearest resonant attractor.



Note: Central positive vortex (strength 0.300) acts as the primary attractor.

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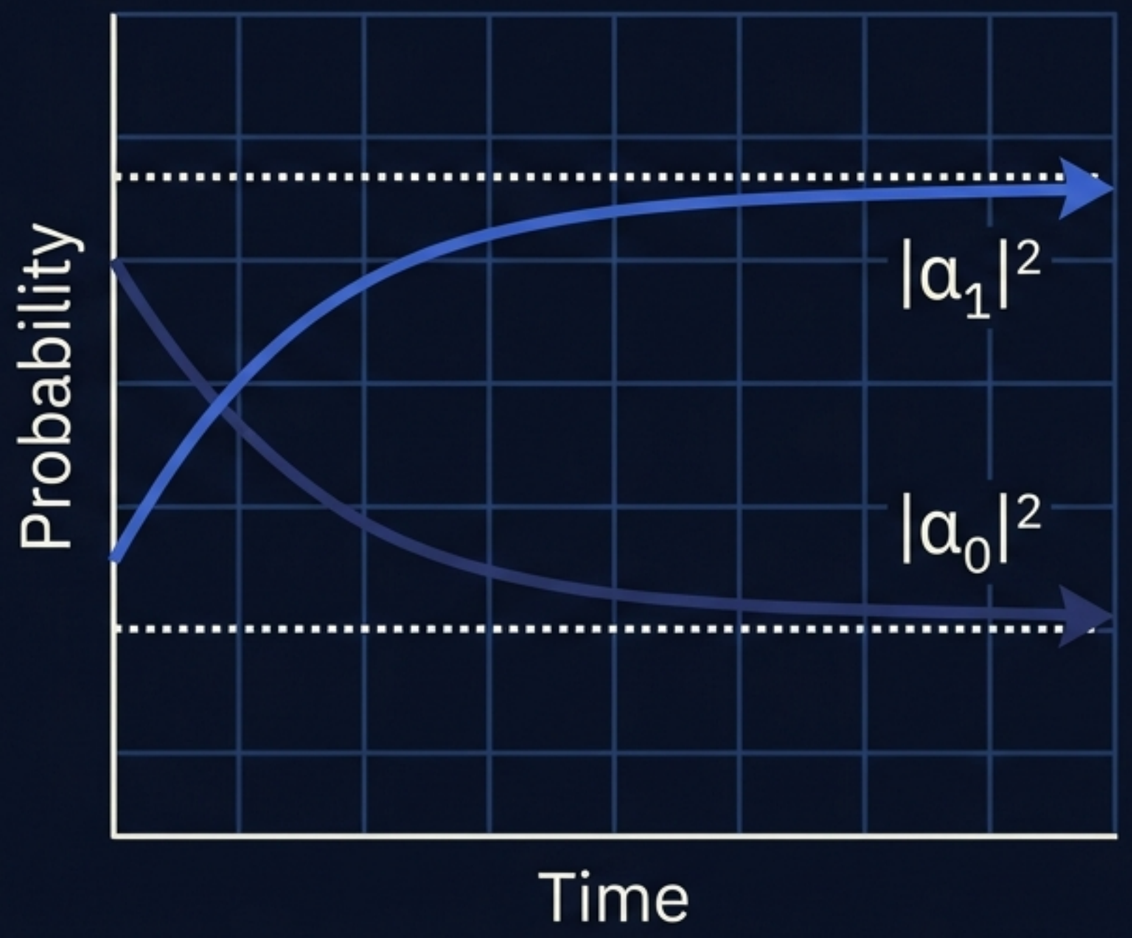
The Born Rule as Equilibrium



Probabilities ($p_n = |\alpha_n|^2$) are not axiomatic. They emerge as the stationary equilibrium distribution of microstates under coherence drift.

Standard Quantum Mechanics is recovered exactly in the limit of infinite equilibration time.

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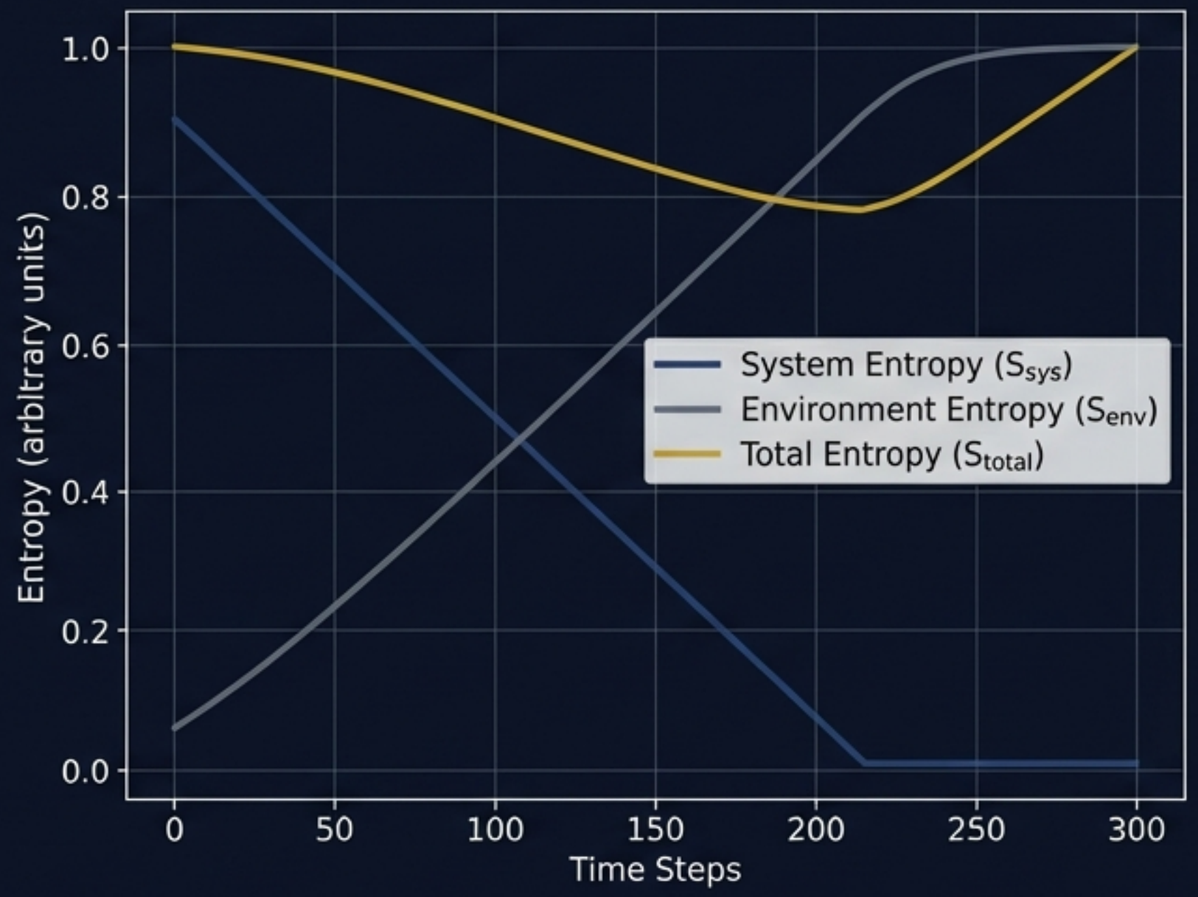
Thermodynamic Consistency

Deterministic collapse does not violate the Second Law. Local ordering (reduction of S_{sys}) is balanced by entropy export to the environment and correlation growth.

$$\Delta S_{total} \geq 0$$



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Validation: Optical Vortex Beams

Proposed Experiment

1. Prepare superpositions of LG modes (l=1, 2, 3).
2. Perform weak measurements.
3. Test for non-random, vortex-guided collapse trajectories.

Expectation: Collapse will follow attractor pathways rather than random probabilistic branching.

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Key Predictions & Falsifiability

- Finite-Time Deviations: Deviation from Born statistics scaling as $\exp(-T/T_{eq})$ for fast measurements.
- Pre-Collapse Drift: Subdiffusive variance suppression in weak measurement sequences before decoherence completes.
- Fractal Signature: Nodal patterns and phase space attractors exhibiting $D \approx 1.9$.
- Dephasing Asymmetry: Systematic visibility deviations in interferometers near resonant coupling.

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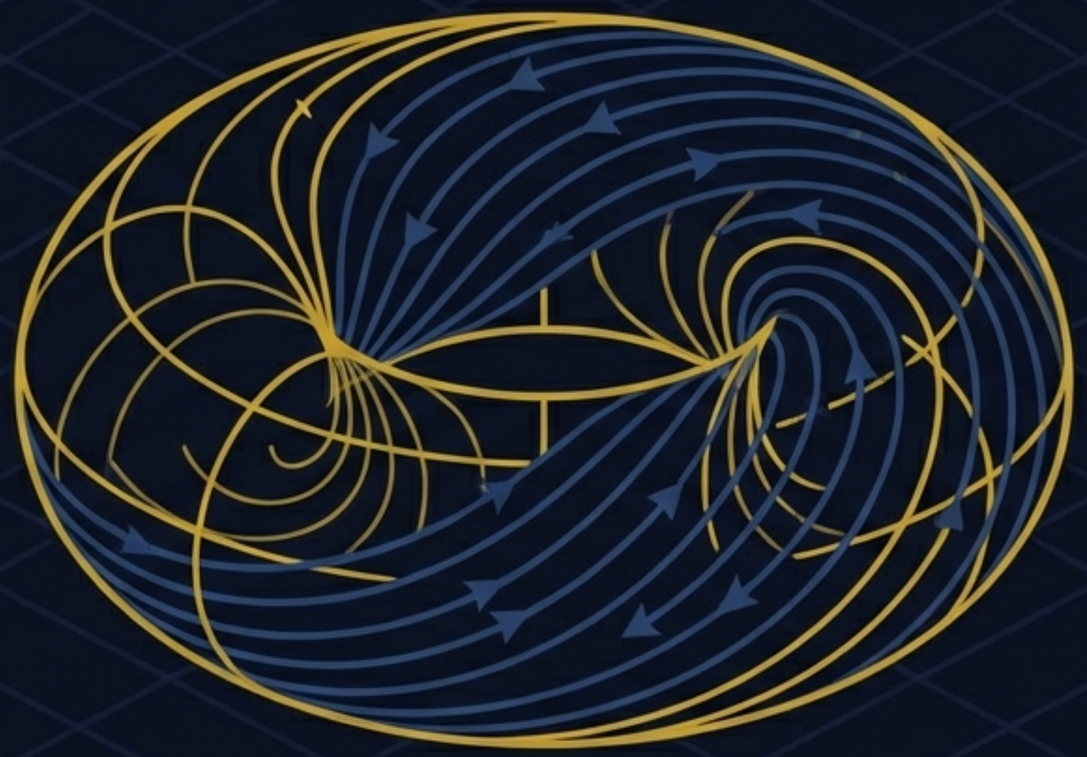
Semantic Mapping of Coherence



Antique Gold (#C9A227) → The Invariant: Equilibrium, Attractor, Truth.
Deep Indigo (#2E4A7D) → The Flow: Coherence, Propagation, The Lambda-Field.
Void Blue (#0B1020) → The Vacuum: The Null State, Potentiality.
Off-White (#E6E8EC) → The Record: Measurement, Observation.

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