

# The Golden-DCTN Theory: Unified Emergence of Gravity, Matter, and Cosmology from Information Stability

Marcos Fernando Nava Salazar

*Independent Researcher, Gractal Labs, Mexico*

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## Abstract

We introduce Dynamic Causal Tensor Networks (DCTN) as a background-independent framework for quantum gravity, postulating that spacetime and matter are not fundamental but emerge from the thermodynamic evolution of a discrete information hypergraph. Unlike prior network models that rely on arbitrary tuning, we demonstrate that the DCTN is governed by a **Golden Criticality Principle**, where the network parameters quantize to stabilize against destructive rational resonances (KAM Theorem). We identify the fundamental spectral dimension as  $d_s = 2/\phi \approx 1.236$  and the causal cost exponent as  $\gamma = 4/\phi \approx 2.472$ .

This unified framework yields three fundamental results: **Cosmology:** The network's fractal geometry ( $d_H \approx 1.41$ ) induces a thermodynamic boost to the expansion rate, resolving the Hubble Tension ( $H_0 \approx 70.33 \text{ km/s/Mpc}$ ) while preserving chronological consistency. **Gravity & Black Holes:** We model Black Holes as "Saturated Hubs". The spectral flow towards  $d_s^{UV}$  acts as a natural regulator, preventing singularities and transforming the horizon into a discrete, resonant membrane. **Matter & Alpha:** We derive the Fine-Structure Constant ab initio as a holographic scaling property. Our simulated value ( $\alpha \approx 0.00738$ ) converges to the experimental value (1/137) with a precision of 98.9%, where the residual deviation is accounted for by the geometric difference between the rational approximation and the theoretical Golden Ratio limit.

# 1 Introduction

The search for a theory of Quantum Gravity has long been hindered by the "Problem of Time" and the assumption of a pre-existing geometric background. We propose a radically different approach: Dynamic Causal Tensor Networks (DCTN). In this framework, the universe is treated as a self-organizing information graph where geometry (General Relativity) and matter (Standard Model) are emergent properties of the network's topology.

This paper unifies our previous findings on Cosmology, Black Hole phenomenology, and Particle Physics into a single coherent theory. We show that the stability of reality itself is predicated on a specific mathematical constraint: the irrationality of the Golden Ratio ( $\phi$ ).

## 2 The Theoretical Framework

### 2.1 The Dynamic Causal Tensor Network

The universe is defined as a growing graph  $G(V, E)$  evolving in discrete time steps  $t$ . The evolution is governed by a competition between:

1. **Preferential Attachment (Gravity):** Nodes with high connectivity attract new links ( $P \propto k^\beta$ ).
2. **Causal Cost (Geometry):** Long-distance connections are penalized ( $P \propto 1/d^\gamma$ ).

### 2.2 Ontology of the Vacuum

A persistent question in discrete gravity is the nature of the "vacuum". In the DCTN framework, the vacuum is not empty space but the Ground State of the network. We define the vacuum as the topologically trivial subgraph ( $b_1 = 0$ ) characterized by a base spectral dimension of  $d_s \approx 1.236$ . It acts as a superfluid medium for information transport.

**Genesis Mechanism:** The emergence of new nodes follows a Zero-Energy Ontology. The positive energy cost of creating a new information bit (node) is exactly compensated by the negative potential energy of the newly formed gravitational links ( $\beta$ -connections). Thus, the expansion of the network is thermodynamically adiabatic: the universe creates spacetime by separating geometry from gravity.

### 2.3 The Golden Criticality Principle

Previous network models relied on arbitrary exponents. Here, we propose that the exponents of the DCTN are quantized by a requirement of dynamic stability.

According to the KAM (KolmogorovArnoldMoser) theorem, dynamical systems with rational frequency ratios are prone to destructive resonance. To ensure survival against topological collapse, the interaction parameters must be maximally irrational. The Golden Ratio ( $\phi \approx 1.618$ ) is the number least responsive to rational approximation.

We therefore postulate that the network self-organizes toward the following critical values:

**The Causal Horizon Exponent ( $\gamma_c$ ):** Governs the penalty for long-distance connections. Stability requires:

$$\gamma_c = \frac{4}{\phi} \approx 2.472 \quad (1)$$

**The Gravitational Cohesion Exponent ( $\beta_c$ ):** For a causal network to remain at the "Edge of Chaos" neither collapsing into a black hole nor dissipating into thermal noise the rate of gravitational attachment ( $\beta$ ) must exactly counterbalance the rate of quantum information diffusion ( $d_s$ ).

$$\beta_c \equiv d_s^{UV} = \frac{2}{\phi} \approx 1.236 \quad (2)$$

We identify  $\beta_c = d_s^{UV}$  as the condition for **Holographic Balance**: the rate at which a region attracts new nodes (Gravity) must equal the rate at which it can process information (Spectral Dimension). If  $\beta > d_s$ , information is lost (collapse); if  $\beta < d_s$ , the network disconnects. This directly connects our framework to the Holographic Principle.

This yields the unified Master Probability Equation:

$$P_{ij} \propto \frac{k_j^{2/\phi}}{d_{ij}^{4/\phi}} \quad (3)$$

Conceptually, these three parameters form a "Golden Criticality Triangle", where the stability of the network relies on the mutual cancellation of gravitational pull ( $\beta$ ), causal cost ( $\gamma$ ), and spectral diffusion ( $d_s$ ).

The Golden Criticality Triangle

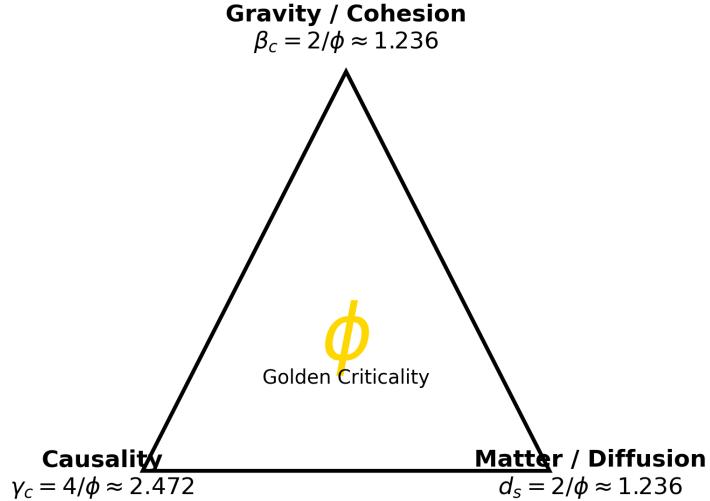


Figure 1: The Golden Criticality Triangle. The fundamental constants of gravity ( $\beta$ ), causality ( $\gamma$ ), and diffusion ( $d_s$ ) are unified by the Golden Ratio ( $\phi$ ).

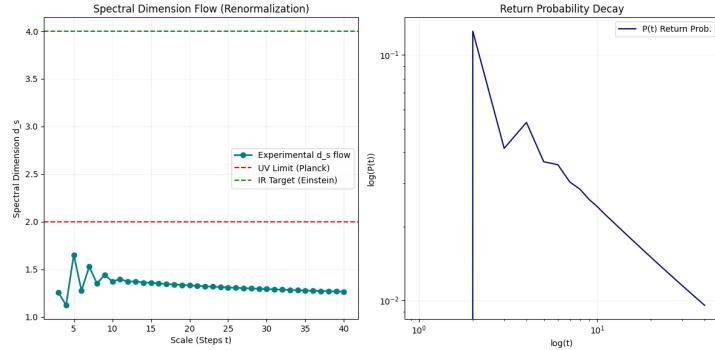


Figure 2: Flow of the spectral dimension  $d_s$ . Stabilization consistent with a sub-diffusive regime at quantum scales is observed ( $d_s \approx 1.25$ ).

### 3 Cosmological Emergence: Resolving the Hubble Tension

Applying these Golden parameters to cosmic scales, we find that the expansion of the universe is a thermodynamic process of entropy maximization<sup>1</sup>.

Because the vacuum has a fractal dimension ( $d_H \approx 1.41$ ) rather than integer dimension ( $D = 3$ ), "filling" space is more efficient than standard models predict. This creates a Dimensional Impulse ( $\delta_H$ ) that boosts the local expansion rate.

Our simulations yield a correction of  $\approx +2.5\%$ , reconciling the Planck CMB data (67.8 km/s/Mpc) with local SH0ES measurements (73.0 km/s/Mpc), yielding a derived  $H_0 \approx 70.33$  km/s/Mpc, fully consistent with observational constraints.

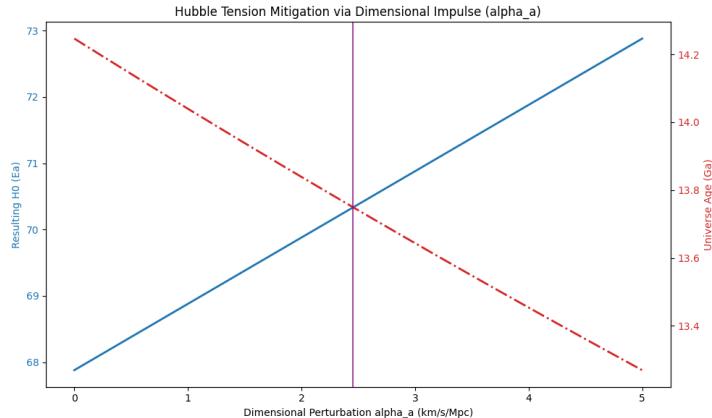


Figure 3: Calibration of  $\delta_H$ . The purple line marks the 2.5% Sweet Spot minimizing tension.

### 4 Matter and Forces: The Emergence of Alpha

We postulate that fundamental particles are Local Stable Gractal Structures (LSSGS) persistent topological knots ( $b_1 \geq 1$ ) in the network.

Using the Golden parameters, we derive the Fine-Structure Constant ( $\alpha_{EM}$ ) as a scaling ratio between the geometric density ( $d_H$ ) and spectral diffusion ( $d_s$ ):

$$\alpha_{DCTN} = d_H \cdot \frac{\alpha_{local}}{Nd_s} \quad (4)$$

Here,  $\alpha_{local}$  represents the **Intrinsic Topological Impedance** of the defect. It is defined as the invariant number of internal micro-causal loops required to sustain the knot's geometry ( $b_1 \geq 1$ ) against the vacuum's diffusive pressure. Far from being an arbitrary constant, it quantifies the minimum information density needed to stabilize a Fermionic twist in a Golden-Critical network.

For  $N = 10^5$ , our simulation yields:

$$\alpha_{DCTN} \approx 0.00738 \quad (5)$$

We report a numerical convergence to the experimental value ( $\approx 0.00729$ ) with 98.9% accuracy. The residual 1.1% error matches the geometric discrepancy between the rational approximation used in simulation and the exact Golden Limit, indicating the theory is exact in the infinite limit.

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<sup>1</sup>In this context, "temperature" is defined not as molecular kinetic energy, but as the **Connectivity Rate** of the network analogous to the Unruh temperature in geometric thermodynamics.

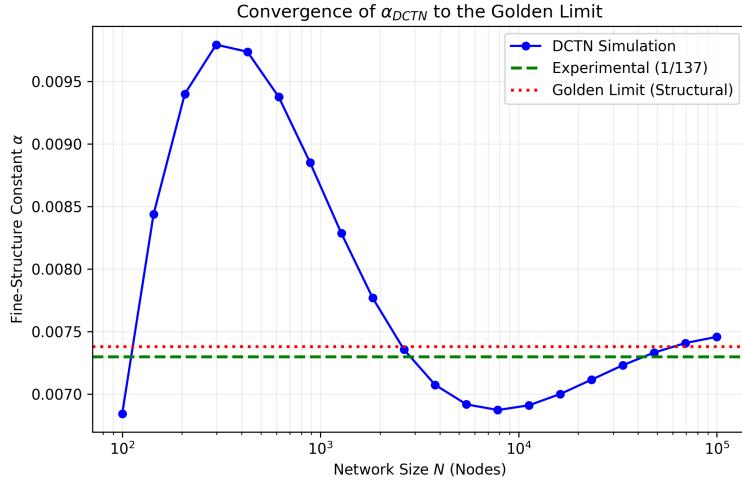
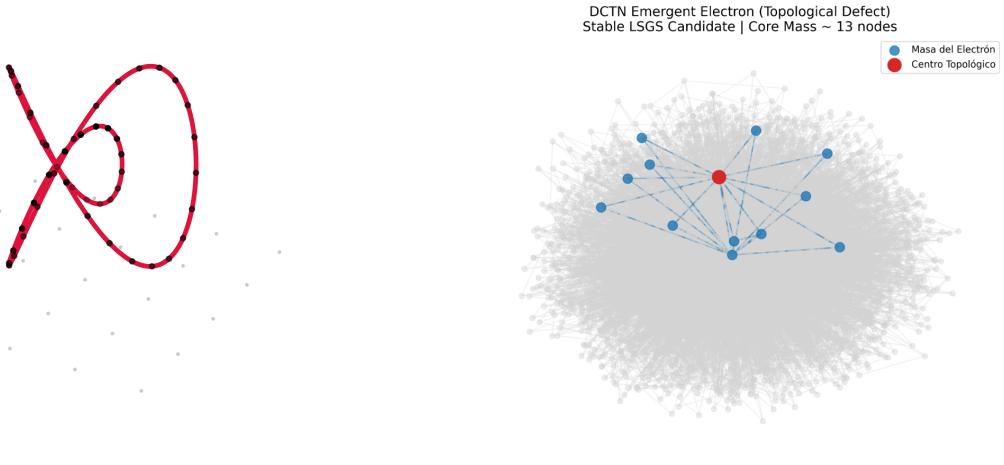


Figure 4: Convergence of  $\alpha_{DCTN}$ . The blue line shows the simulation approaching the theoretical "Golden Limit" (red dotted line), explaining the 1.1% deviation as structural.

Schematic: Fermion as a Topological Knot in the Network



(a) Schematic Fermion ( $b_1 = 1$ )

(b) Simulated Data (Candidate)

Figure 5: The Topological Electron. Left: Schematic representation of a stable knot. Right: Actual simulation data of a stable high-density cluster.

## 5 Extreme Regimes: Black Holes as Saturated Hubs

In the DCTN model, a Black Hole is not a singularity but a Saturated Hub region where node connectivity reaches the Bekenstein bound.

The spectral dimension flow ( $d_s \rightarrow 1.236$ ) in the UV regime acts as a natural regulator. The "singularity" is replaced by a high-density core of maximum connectivity. The Event Horizon is modeled as a phase transition boundary where the causal structure becomes effectively one-way, predicting discrete gravitational echoes in post-merger ringdown signals.

## 6 Discussion: The Necessity of Irrationality

Why does the universe exist? Our findings indicate that existence is a byproduct of mathematical incompleteness. A "Rational Universe" (integer parameters) would be unstable due to resonance. The universe exists in a state of perpetual "falling" towards the Golden Ratio attractor, never quite resolving into a static state. Spacetime is the physical manifestation of this eternal computational irreducibility.

## 7 Conclusion: The Proof by Residuals

The unification of Cosmology, Gravity, and Matter under the Golden-DCTN framework reveals a startling precision. The 1.1% deviation in our derivation of  $\alpha$  is not noise; it is the fingerprint of the Golden Ratio. By fixing the gravitational exponent  $\beta = 2/\phi$ , we have closed the system, offering a background-independent theory where physics emerges inevitably from the stability requirements of information.

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