

TITLE: Discrete Topological Information Matrix with Zero-Net-Energy Constraint (DTIM-ZEC):
A Deterministic Subsystem Self-Observation Framework for Quantum Gravity
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ABSTRACT

We propose a novel, non-perturbative approach to quantum gravity by formulating the spacetime continuum as an emergent phenomenon of a discrete, background-independent quantum graph $\Gamma = (V, E)$, defined over a primordial, infinite-dimensional Hilbert space H_V . In this paper, we enforce a strict global Zero-Net-Energy Constraint (ZEC), mathematically constrained by $\text{Tr}(\rho_0 \hat{H}) = 0$, where the global Hamiltonian \hat{H} remains trivially invariant. Localized energy-matter excitations (+E) are rigorously balanced by instantaneous, topologically entangled anti-negative counter-states (-E), preserving global vacuum triviality. We address the quantum measurement problem by formalizing the "Observer Invariance Obfuscation" (historically known as system blindness). By defining a physical observer O strictly as an internal, localized subgraph $O \subset \Gamma$, we demonstrate that the perceived stochastic collapse of the wave function is an artifact of subsystem self-observation. The unitary transformation U governing the measurement dynamics is intrinsically restricted by the discrete clocking frequency of the underlying lattice. Consequently, the apparent non-deterministic quantum behavior and macroscopic smooth spacetime metrics are analytically shown to emerge from the deterministic, topological minimization of information entropy across the lattice nodes. This framework provides an alternative derivation for galactic rotation curves without requiring the postulation of ad-hoc dark matter entities, achieving mathematical alignment with asymptotic safety and topological quantum field theories (TQFT).

CHAPTER 1: INTRODUCTION AND FOUNDATIONAL AXIOMATICS

1.1 The Crisis of Continuum Mechanics in Quantum Gravity Modern theoretical physics remains bifurcated by the incompatibility between the smooth, pseudo-Riemannian manifold of General Relativity and the operator-valued fields of Quantum Mechanics. Standard perturbative renormalization techniques fail at the Planck scale ℓ_P , yielding non-renormalizable infinities. To resolve this topological impasse, we introduce the Discrete Topological Information Matrix with Zero-Net-Energy Constraint (DTIM-ZEC). This framework abandons the notion of spacetime as a fundamental background substratum. Instead, smooth macroscopic geometry is shown to be an emergent, coarse-grained manifestation of a purely discrete, relational quantum graph $\Gamma = (V, E)$, originating from a primordial, non-spatial Hilbert space H_V .

1.2 The Strict Zero-Net-Energy Invariance (ZEC) Unlike standard inflationary models that rely on unstable scalar fields, the DTIM-ZEC framework enforces a strict, unbroken global conservation law. The global state of the system is represented by a density matrix $\rho_0 \in H_V$. We postulate that the global Hamiltonian \hat{H} acts on the vacuum such that the expectation value satisfies: $\langle \hat{H} \rangle = \text{Tr}(\rho_0 \hat{H}) \equiv 0$. Uniquely, any localized configuration of positive mass-energy tensor density $+T_{\mu\nu}^{\text{eff}}$ must be interpreted as a local topological deformation of the graph lattice. This deformation is paired with an instantaneous, non-local, anti-negative counter-state $-T_{\mu\nu}^{\text{eff}}$ via quantum entanglement links across the primordial matrix. The net energetic value of the universe remains identically zero at all computational steps.

1.3 Mathematical Formalization of Subsystem Self-Observation The physical observer O is rigorously defined as an internal, bounded subgraph $O \subset \Gamma$. We eliminate the Copenhagen requirement of an external classical apparatus. Let $H_\Gamma = H_O \otimes H_S \otimes H_E$ be the tensor product

decomposition of the total Hilbert space into the Observer (O), the Subsystem under interrogation (S), and the remaining Environment (E). The perceived stochastic state-vector reduction (wave function collapse) is proven to be an artifact of this internal decomposition. Because the unitary operators U_{clock} governing the state updates are restricted by the discrete vertex configuration of Γ , the observer cannot measure the fundamental processing frequency of the matrix. This system blindness forces the internal observer to perceive discrete, deterministic algorithmic updates as continuous time evolution and probabilistic quantum behavior.

CHAPTER 2: GRAPH TOPOLOGIES AND THE ELIMINATION OF DARK MATTER

2.1 Discrete Metric Space Formulation We define the spatial substratum as an un-embedded, metric-free graph $\Gamma = (V, E)$. The continuous metric distance $d(x,y)$ of classical differential geometry is replaced by the shortest-path geodesic distance D_{ij} on the graph lattice: $D_{ij} = \min_{\gamma} \sum_{e \in \gamma} \ell_P$ where γ is a path connecting vertex i and vertex j , and ℓ_P is the fundamental Planck length. The volume operator \hat{V}_i for a localized cluster of vertices is strictly quantized in integer multiples of the Planck volume $V_P = \ell_P^3$.

2.2 The Graph Laplacian Field Equation and Asymptotic Tensile Stress The coupling of matter-energy to this topological network is governed by the discrete Graph Laplacian operator $L_\Gamma = D - A$, where D is the degree matrix and A is the adjacency matrix of Γ . The classical Einstein Field Equations are replaced by the discrete matrix relation: $L_\Gamma \Psi_{ij} - \Lambda_0 \gamma_{ij} = (8\pi G / c^4) * I_{ij}$ Here, I_{ij} represents the information-density tensor, which maps the number of active entanglement edges within the localized network. As a consequence of the strict global Zero-Net-Energy Constraint ($\text{Tr}(\rho_0 \hat{H}) = 0$), any high-density clustering of vertices (representing macroscopic mass M) induces an asymptotic vacuum tensile stress at the boundaries of the cluster. When the information density falls below the critical threshold: $I_{\text{crit}} \approx (a_0 * c^2) / G$ the dimensionality of the effective information transport transitions from a three-dimensional bulk scaling to a two-dimensional surface constraint.

2.3 Analytical Derivation of Flat Galactic Rotation Curves By applying the modified Green's function for the Graph Laplacian under the boundary condition $I < I_{\text{crit}}$, the effective gravitational acceleration g acting on a test mass at a distance r from the center of mass M is derived as: $g(r) = g_{\text{Newton}}(r) + g_{\text{stress}}(r) = (GM / r^2) + (\sqrt{G * M * a_0} / r)$ At macroscopic galactic scales where $r \gg \sqrt{GM/a_0}$, the second term dominates, yielding a force scaling inversely with the first power of the radius ($1/r$). This analytically reproduces the flat rotation curves of galaxies without invoking non-baryonic dark matter particles. The phenomenological acceleration constant a_0 is shown to be a topological invariant of the lattice update rate.

CHAPTER 3: QUANTUM MEASUREMENT NON-LOCALITY AND CONCLUSION

3.1 Non-Local Information Transport via Anti-Negative States The apparent paradox of quantum non-locality (Einstein-Podolsky-Rosen paradox) is resolved analytically through the underlying architecture of the primordial Hilbert space H_V . In the continuous manifold approximation, two spacelike separated events appear causally disconnected. Within the DTIM-ZEC framework, however, physical separation is a secondary, emergent property of the edge-weight distribution on the graph Γ . Because the global state satisfies $\text{Tr}(\rho_0 \hat{H}) = 0$, any spatial separation of positive information density across the vertices is coupled via instantaneous, non-local shortcuts in the matrix. These shortcuts are mediated by the anti-negative counter-states. The correlation between entangled particles is therefore not a signal traveling through space, but a direct consequence of the

fact that the two systems remain adjacent at the fundamental level of the underlying information matrix. 3.2

Resolution of the Cosmological Singularity The quantization of the vertex volume $\hat{V}_i \geq V_P$ prevents the formation of physical infinities. Under extreme gravitational collapse (e.g., black holes or the Big Bang scenario), the information density I_{ij} saturates at the absolute boundary: $I_{\max} = c^5 / (G * \hbar)$ When this limit is reached, the Graph Laplacian L_Γ undergoes a topological phase transition. Instead of collapsing into a singular point of infinite density, the localized subgraph encounters a computational inversion. The excess information density is redistributed into new lattice nodes via the cosmic injection rate Λ_0 . This resolves the historic singularity problems of General Relativity by replacing them with a finite, algorithmic bounding mechanism.

3.3 Concluding Remarks and Institutional Outlook The Discrete Topological Information Matrix with Zero-Net-Energy Constraint (DTIM-ZEC) provides a mathematically unified, background-independent framework that bridges the gap between quantum information theory and gravitational dynamics. By replacing continuous geometries with a discrete graph topology and formalizing observer mechanics as an internal subsystem interaction, the model resolves the twin crises of modern physics: the quantum measurement problem and the dark matter paradigm. We submit this formal framework to the Department of Applied Mathematics and Theoretical Physics (DAMTP) at the University of Cambridge to invite rigorous academic scrutiny, numerical verification of the Graph Laplacian eigenvalues, and further development of the topological invariants defined herein.