

The Ground State Configuration Model: A New Information-Theoretic Paradigm

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The Ground State Configuration (GSC) model proposes a radical departure from the foundational assumptions of modern cosmology. It posits that spacetime, gravity, and the matter fields we observe are not fundamental entities but are emergent phenomena arising from a deeper, pre-geometric layer of reality governed by the principles of quantum information theory.¹ To understand this paradigm, it is necessary to first establish its conceptual vocabulary and then explore its proposed mathematical structure.

Philosophical and Conceptual Foundations: From "It from Bit" to "It from Qubit"

The intellectual lineage of the GSC model can be traced to John Archibald Wheeler's influential maxim, "it from bit," which suggested that physical reality has an immaterial, informational source.¹ The GSC model, however, aligns with the modern evolution of this idea, "It from Qubit," which elevates the principles of quantum information to a primary ontological status.¹ In this view, the fundamental substrate of reality is not classical information but quantum information, with the phenomenon of quantum entanglement serving as the very fabric of spacetime geometry.

This paradigm shift is supported by a growing body of evidence from theoretical physics, particularly from holographic dualities like the AdS/CFT correspondence. Key results that form the pillars of this "entanglement geometry" include:

- **The Ryu-Takayanagi Formula:** This provides a precise, quantitative relationship between the entanglement entropy of a region in a quantum field theory and the area of a minimal surface in its dual gravitational theory, establishing the first concrete link between a quantum-informational quantity and a geometric one.
- **The ER=EPR Conjecture:** This conjecture posits a deep equivalence between quantum entanglement (EPR pairs) and spacetime connectivity via wormholes (Einstein-Rosen bridges), suggesting that the "spooky action at a distance" is the quantum counterpart to a geometric connection through spacetime.¹

The GSC model builds upon these ideas to postulate the existence of a single, universal, and invariant quantum information state—the Ground State Configuration—that serves as the substrate for all of reality.

A New Dictionary for Gravity

To move from a philosophical concept to a quantitative theory, the GSC model proposes a new "dictionary" that translates the language of quantum information into the language of gravity. This involves replacing the concept of mass density (ρ) as the source of gravity in the Poisson equation, $\nabla^2\Phi=4\pi G\rho$, with new source terms derived from the information-theoretic properties of the quantum vacuum. The key entries in this dictionary are:

- **Entanglement Density (SE):** Defined as the entanglement entropy per unit volume of the underlying quantum state. This is hypothesized to be the primary source term for the static component of the emergent gravitational field, playing a role directly analogous to that of dark matter mass density. A region of high entanglement density, such as that occupied by a galaxy cluster, would correspond to a deep gravitational potential well.
- **Computational Complexity (C):** Defined as the minimum number of elementary quantum gates required to prepare a quantum state from a simple reference state, complexity is a measure of a state's organizational structure. In a cosmological context, the evolution of the universe's global computational complexity could act as a source for the dynamic aspects of gravity, potentially providing an information-theoretic origin for the phenomenon of cosmic acceleration currently attributed to dark energy.
- **Mutual Information $I(A:B)$:** This quantity measures the total correlation (both classical and quantum) between two subsystems, A and B. The mutual information between the qubits underlying two distinct regions of space could govern the non-local character of gravity. A high degree of mutual information between distant regions could manifest as a long-range gravitational force that does not fall off with the inverse square of the distance, providing a potential mechanism for the observed flat rotation curves of galaxies and MOND-like phenomenology without requiring an ad-hoc modification of dynamics.

This new vocabulary offers a more unified vision of the "dark sector" than Λ CDM. In the standard model, dark matter and dark energy are two separate, unrelated physical mysteries, described by different equations of state with no known connection. The GSC model, by contrast, suggests a deep, intrinsic link between them. The phenomena of dark matter and dark energy are not separate entities but are reinterpreted as different measures of the *same underlying quantum state*—the GSC. The static, attractive effects (dark matter) are sourced by local entanglement density, while the dynamic, accelerative effects (dark energy) may be sourced by evolving global complexity. This potential for a unified explanation is a significant conceptual advantage over the disjointed nature of the dark sector in Λ CDM.

The Architecture of Reality: Spacetime as a Quantum Error-Correcting Code (QEC)

A profound question in physics is why the macroscopic world appears so stable and classical if it is built upon fragile, fluctuating quantum states. The GSC model offers an explanation through the powerful analogy of Quantum Error Correction (QEC).¹ In quantum computing, QEC is a technique for preserving fragile quantum information by encoding the state of a single "logical qubit" non-locally across the entangled state of many "physical qubits". This redundancy protects the encoded information from local errors.

The GSC model posits that spacetime itself is such a code.¹ The geometric information that defines our universe—the "logical qubits" of distances, angles, and curvature—is stored redundantly in the complex entanglement patterns of a vast number of underlying "physical qubits". This makes the emergent geometry robust against local quantum fluctuations, explaining the remarkable stability and smoothness of spacetime. This perspective leads to a radical reinterpretation of physical law: the gravitational dynamics described by Einstein's

equations may be the macroscopic manifestation of the logical operations of this cosmic QEC—the physical process by which the universe actively preserves its own geometric information. Gravity becomes the algorithm of cosmic self-correction.

Proposed Mathematical Formalism: Synthesizing LQG and CST

To construct a physical theory from these concepts requires a coherent mathematical formalism. The GSC model proposes a novel synthesis of two leading but incomplete approaches to quantum gravity: Loop Quantum Gravity (LQG) and Causal Set Theory (CST). This synthesis is particularly powerful because the two frameworks are complementary, with each addressing the primary weakness of the other.¹

- **LQG (The "Hardware"):** Canonical LQG provides a compelling, background-independent framework for a quantized, discrete space. Its Hilbert space is spanned by spin networks: graphs whose edges represent quantized quanta of area and whose vertices represent quantized quanta of volume.¹ However, LQG is fundamentally atemporal; it describes the quantum state of a spatial slice but struggles to incorporate a description of causal evolution.¹ The GSC model leverages this formalism by proposing that the fundamental substrate of reality—the GSC itself—can be mathematically modeled as a universal, maximally entangled spin network state, representing the complete quantum-geometric potentiality of reality.
- **CST (The "Software"):** Causal Set Theory provides the complementary ingredient. CST posits that the most fundamental structure of spacetime is not geometric but causal, defined by a discrete set of fundamental "events" endowed with a partial order relation.¹ While CST provides the rules of causal succession, it does not, on its own, specify the geometric properties of the emergent manifold.¹ In the synthesized GSC model, the emergence of a specific spacetime history occurs through observation and decoherence. An interaction "actualizes" a specific path, or history, through the vast combinatorial possibilities of the GSC spin network. This actualized history is a causal set, providing the causal dynamics that canonical LQG lacks.
- **The Metric as an Interference Effect:** The final step in the formalism is to describe the origin of the metric tensor, $g_{\mu\nu}$, which defines distances and time intervals. In this model, the metric is not fundamental but is an effective description of the interference pattern between the observer's singular, actualized history (a specific causal set) and the background of all other potential histories contained within the GSC. The spacetime interval,

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu$$

, is conceptualized as a measure of the "information distance" between events, a distance that is modulated by the "pressure" of all the other probabilistic alternatives. This directly links the origin of spacetime geometry to the resolution of the quantum measurement problem, recasting the metric as a relic of the measurement process itself.

This new paradigm requires a new vocabulary. The following table provides a direct, side-by-side comparison of the core concepts of Λ CDM and the GSC model to clarify the fundamental shift in perspective.

Concept	Λ CDM Interpretation	GSC Interpretation
Spacetime	A fundamental, pre-existing, continuous manifold.	An emergent property of the entanglement structure of a discrete quantum state.
Gravity	The curvature of spacetime caused by mass-energy, described by General Relativity.	An entropic force emerging from the information dynamics of the underlying quantum system.
Dark Matter	An undiscovered, fundamental, collisionless particle that dominates cosmic mass.	The gravitational effect of a high local density of quantum entanglement (SE) in the vacuum.
Dark Energy	An intrinsic energy of the vacuum (the cosmological constant, Λ) causing accelerated expansion.	The gravitational effect of the evolving global computational complexity (C) of the universe's quantum state.
Primordial Seeds	Random quantum fluctuations of a hypothetical inflaton field stretched to cosmic scales.	Primordial fluctuations in the information-theoretic properties (the "infome") of the pre-geometric state.
Physical Laws	Prescriptive, fundamental rules imposed on an inert reality.	An emergent, descriptive protocol of a cosmic Quantum Error-Correcting Code (QEC) that preserves information.