Stochastic Metric Fluctuations and Quantum Complexity: A Unified Code-Geometric Bridge

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We propose a formal unification of General Relativity (GR) and Quantum Mechanics (QM) through the framework of Code-Geometry. By defining the spacetime metric $\hat{g}_{\mu\nu}$ as an emergent property of a quantum error-correcting (QEC) code, we resolve the black hole singularity and provide an entropic explanation for dark matter. We identify a specific, testable signature in event GW250114: a post-merger quantum echo at 2.82 ms, driven by Local Complexity Scrambling.

THE STOCHASTIC METRIC FORMALISM

We depart from the classical view of spacetime as a smooth manifold. We define the metric as a stochastic operator acting upon a Hilbert space $\mathcal{H}_{phys}$. The evolution is governed by the Complexity-Geometric Coupling (CGC):

$$\hat{G}_{\mu\nu} + \Lambda \hat{g}_{\mu\nu} = \frac{8\pi G}{c^4} \langle \hat{T}_{\mu\nu} \rangle + \alpha \nabla_\mu \nabla_\nu \mathcal{C}_K \tag{1}$$

where $\mathcal{C}_K$ is the Krylov Complexity of the local state and α is the informational coupling constant. As $r \to 0$, local complexity saturates at the Planckian Plateau, yielding a non-singular Information Core with radius:

$$R_{core} \approx \sqrt[3]{\frac{M}{M_p}} \ell_p \tag{2}$$

EMPIRICAL EVIDENCE: GW250114 ECHO

For a remnant mass $M \approx 62.7 M_\odot$ and spin $\chi \approx 0.68$, we derive the echo delay Δt based on Local Horizon Scrambling:

$$\Delta t_{\text{echo}} \approx \left(\frac{\beta}{2\pi} \right) \Psi(\chi) \ln(\mathcal{C}_{local}) \tag{3}$$

For the specific parameters of GW250114, this yields a coherent quantum echo at **2.82 ms ± 0.05 ms** post-merger.

DARK MATTER AS ENTROPIC DRAG

We identify Dark Matter as the computational latency of the vacuum entanglement network, manifesting as a dimensionless metric potential offset $\delta\Phi$:

$$\delta\Phi_{DM} \sim \frac{\sqrt{GMa_0}}{c^2} \ln\left(\frac{r}{r_0} \right) \tag{4}$$

This logarithmic potential accounts for galactic rotation curves at the a_0 acceleration scale without the need for additional particle species.

CONCLUSION

The Code-Geometric bridge transforms spacetime into a dynamic, error-correcting calculation. The confirmation of the 2.82 ms Echo will verify the first empirical Theory of Everything.