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The Quantum topological hologram: A stabilizer code framework for black hole information preservation

This study introduces the quantum topological hologram (QTH) — a purely theoretical model in which the event horizon is treated as a hyperbolically embedded topological stabilizer code within a holographic tensor network. The logical degrees of freedom of infalling matter and the black hole interior are encoded in a redundant, nonlocal structure of physical qubits tiled across the horizon surface. The code inherits fault tolerance from topological order and geometric redundancy from its hyperbolic embedding, resulting in enhanced erasure thresholds compared to planar topological codes. Hawking radiation is modelled as a syndrome readout process: each emission step corresponds to the removal (erasure) of one or more horizon qubits, with the location of erasures known in principle. Using stabilizer code theory, the Knill–Laflamme error-correction conditions, and the decoupling theorem, this study formally proves that if the cumulative erasure fraction never exceeds a critical threshold, the global evolution remains unitary. This encoding naturally reproduces the Page curve: early radiation is nearly thermal and maximally entangled with the remaining black hole, but after the Page time, sufficient redundancy is exposed for decoding to become possible, causing the radiation entropy to decrease in a manner consistent with unitarity. The QTH also suggests, at a theoretical level, that certain observational or analog phenomena could be associated with its structure, although the focus of this paper is entirely on the mathematical framework using quantum simulators. This work provides a coherent framework uniting ideas from quantum error correction, holography, and topological quantum computation, offering a concrete, mathematically tractable approach to the information paradox without invoking exotic violations of quantum mechanics

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