The Quantum Event Horizon: A Dual-Layer Boundary of Perception, Entropy, and Decoherence

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Abstract

This paper introduces the notion of a dual-structured event horizon, distinguishing between the classical (physical) event horizon and a quantum event horizon. While the classical event horizon is defined by the speed-of-light boundary around a black hole, the quantum event horizon is a non-observable, information-theoretic threshold where wavefunctions oscillate indefinitely. This boundary marks the onset of decoherence and defines a zone where microstate resolution becomes maximally uncertain. We argue that this quantum boundary, encoded through nonlocal interference, gauge redundancy, and observer complementarity, constitutes a fundamental threshold of perceptual and informational collapse.

1. Introduction

Event horizons have traditionally been treated as absolute boundaries in spacetime, marking the point beyond which no classical information escapes. However, quantum systems suggest the existence of a subtler, non-classical boundary--one defined not by energy or velocity, but by entanglement, measurement, and perception. We propose a dual-horizon structure to reconcile classical and quantum observational limits.

2. The Physical Event Horizon

The classical event horizon is the limit beyond which no signal, even light, can escape a gravitational singularity. It is defined in terms of escape velocity and energy curvature. This boundary is static, global, and measurable--visible in the warping of spacetime itself. It is the horizon of physical observation.

3. The Quantum Event Horizon

The quantum event horizon, in contrast, defines the limit at which the wavefunction remains uncollapsed but begins to interact with external degrees of freedom. This is the pre-decoherence interface: a regime of indefinite oscillation and phase interaction. It is not locally measurable but globally consequential.

4. Entropy, Microstates, and Irreducibility

Within the quantum horizon, the decomposition of states reaches maximal complexity. Microstates become irreducible--not because they are inherently chaotic, but because observer-dependent resolution becomes impossible. This threshold marks the divergence between subjective perception and objective measurability.

5. Complementarity and Gauge Redundancy

The quantum horizon varies across observers. It is a relativistic perceptual boundary, informed by complementarity and shaped by the gauge freedom of the observing frame. What is entangled from one perspective may appear collapsed from another. The horizon is not a fixed wall, but a phase-dependent interface.

6. Conclusion

The dual-horizon model provides a richer framework for interpreting the boundary between information and collapse. The quantum event horizon is not the end of perception--it is its maximum. It is the edge of uncertainty, the phase wall of awareness, and the last rhythm before silence.

Keywords

quantum event horizon, decoherence, wavefunction, microstates, gauge symmetry, observer complementarity, entropy, perception