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Daine Danielson - Horizon Algebras and Soft Quantum Information

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We consider a thought experiment in which an experimenter, Alice, creates a spatial superposition of a charged (or massive) particle in the vicinity of a Killing horizon. This gives rise to a superposition of soft electromagnetic (or gravitational) field configurations on the black hole horizon, in a direct analog to the memory effect at null infinity. We use the quantum fidelity to compute the distinguishability of the resulting states of the black hole interior. The analysis of this—which has historically been obstructed by infrared divergences—can be carried out by extending the algebra of observables beyond the usual algebra of compactly supported observables, to include unitary algebra elements that produce noncompact field configurations on the horizon. In fact, we find that certain quantum information theoretic quantities are generically easier to compute in this enlarged algebra, and that analogous "horizon algebras"arise on de Sitter horizons and at null infinity. After Alice has held her superposition open for a given proper time, we compute the distinguishability of the resulting interior states, according to any spacelike observer Bob (or family of observers) allowed to carry out optimal measurements in the black hole interior. The resulting distinguishability is shown to be precisely equal to the decoherence of Alice's superposition in the exterior.

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