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Harvesting Information Across the Horizon

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The effect of black holes on entanglement harvesting has been of considerable interest over the past decade. Research involving stationary Unruh-DeWitt (UDW) detectors near a (2+1)-dimensional Bañados-Teitelboim-Zanelli (BTZ) black hole has uncovered phenomena such as entanglement shadows, entanglement amplification through black hole rotation, and differences between bipartite and tripartite entanglement. For a (1+1)-dimensional Schwarzschild black hole, it has been shown that two infalling UDW detectors can harvest entanglement from the scalar quantum vacuum even when separated by an event horizon. In this paper, we calculate the mutual information between two UDW detectors coupled to a massless quantum scalar field, with the detectors starting at rest and falling radially into a non-rotating (2+1)-dimensional BTZ black hole. The trajectory of the detectors includes regions where both detectors are switched on outside of the horizon; where one detector is switched on inside of the horizon while the other switches on outside; and where both detectors switch on inside of the horizon. We investigate different black hole masses, detector energy gaps, widths and temporal separations of the detector switching functions, and field boundary conditions. We find that black holes–even the simplest kind having constant curvature–significantly affect the correlation properties of quantum fields in the vacuum state. These correlations, both outside and inside the horizon, can be mapped out by infalling detectors.

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