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Entanglement Negativity Islands and Communicating Black Holes

We advance two alternative proposals for the island contributions to the entanglement negativity of various pure and mixed state configurations in quantum field theories coupled to semiclassical gravity. The first construction involves the extremization of an algebraic sum of the generalized Renyi entropies of order half. The second proposal involves the extremization of the sum of the effective entanglement negativity of quantum matter fields and the backreacted area of a cosmic brane spanning the entanglement wedge cross section which also extremizes the generalized Renyi reflected entropy of order half. These proposals are utilized to obtain the island contributions to the entanglement negativity of various pure and mixed state configurations involving the bath systems coupled to extremal and non-extremal black holes in JT gravity demonstrating an exact match with each other. Furthermore, the results from both the proposals match precisely with the island contribution to half the Renyi reflected entropy of order half providing a strong consistency check. We then allude to a possible doubly holographic picture of our island proposals and provide a derivation of the first proposal by determining the corresponding replica wormhole contributions.

In this context, utilizing the first proposal, we obtain the holographic entanglement negativity for bipartite mixed states at a finite temperature in baths described by conformal field theories dual to configurations involving two communicating black holes in brane world geometries. We analyse the mixed state entanglement structure characterized by the information transfer between the black holes for two separate models. The first model involves communicating black holes in a Karch-Randall braneworld with $BCFT_2$ s with two boundaries serving as a common bath system for the radiation flux. The second model corresponds to a configuration of two dimensional eternal JT black holes in a braneworld geometry involving two Planck branes coupled through a shared bath system described by a CFT_2 . For both the models our results reproduce analogue of Page curves for the entanglement negativity obtained earlier in the context of random matrix theory and from geometric evaporation in standard JT black hole configurations.

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