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Non-extremal Island in de Sitter Gravity

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In this talk, I will present our recent approach to calculating the entanglement entropy for quantum field theories coupled to de Sitter (dS) gravity along a timelike boundary. Traditional techniques, such as the island formula—originally developed for non-gravitational systems coupled to AdS gravity—encounter significant challenges when extended to a de Sitter gravitational setting, where no physically consistent extremal island solution emerges. We propose a doubly holographic framework to address these limitations by embedding a dS_2 braneworld within an AdS_3 bulk spacetime. Thanks to the higher-dimensional holographic duality, this configuration allows us to circumvent the constraints of the island formula. We show that the correct recipe for calculating entanglement entropy in the presence of dS gravity involves the non-extremal island, whose boundary is instead defined at the edge of the dS gravitational region. Our findings indicate that, during the island phase, the entanglement wedge of the non-gravitational bath encompasses the entire dS gravitational region. Using the second variation formula, we further show that the existence of a locally minimal surface anchored on the gravitational brane is intrinsically linked to the extrinsic curvature of the brane.

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