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Replica analysis of entanglement properties and conditions for islands

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Entanglement entropy quantifies the degree of entanglement between two quantum systems or between two subregions in a QFT and hence is an important tool to understand the quantum system. However, its study in dimensions > 2 has been mostly limited to flat backgrounds and CFT vacuum states in specific subregions due to technical as well as conceptual difficulties. In this talk, I will present a systematic analysis of the properties of entanglement entropy in curved backgrounds using the replica approach. We will explore the analytic $(q-1)$ expansion of Rényi entropy S_q and its variations; the setup applies to generic variations, from symmetry transformations to variations of the background metric or entangling region. Our methodology elegantly reproduces and generalises results from the literature on entanglement entropy in different dimensions, backgrounds, and states. We will then use this analytic expansion to explore the behaviour of entanglement entropy in static black hole backgrounds under specific scaling transformations. We will show that certain conditions on this quantity and hence the QFT spectrum have to be satisfied for the presence of islands of entanglement, which provide enough quantum corrections to restore unitarity in black hole evaporation.

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