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Entanglement Properties and Quantum Phase Transitions in Interacting Disordered One Dimensional Systems

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Abstract:

Interacting disordered one-dimensional fermionic systems are an ideal test ground in order to investigate the interplay between properties of the entanglement and quantum phase transitions. Although 1D systems with uncorrelated disorder are always localized, they may exhibit a quantum phase transition to a metallic phase as function of disorder strength if the disorder is correlated (e.g., the Harper model). Once attractive interactions are considered, a transition to a metallic/superconducting phase is predicted. Even for repulsive interactions a transition at higher temperatures/excitation energies to a metallic regime is predicted. This is the celebrated many-body localization (MBL) transition, which has far reaching consequences on a wide range of subjects, from quantum information to biological processes. We will argue that entanglement properties are an ideal tool to investigate these phase transitions. We shall show that entanglement properties, such as the typical entanglement entropy, the statistics of the entanglement entropy, the statistics of the entanglement spectrum, are a powerful tool to characterize these phase transitions and may provide a way to characterize unconventional regions of the phase space such as the non-ergodic region of the MBL phase diagram.