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Entanglement in the many-body localized phase and transition

JENS H. BARDARSON, Max Planck Institute for the physics of complex systems, Dresden

The study of entanglement, both in eigenstates and its evolution after quenches, has been instrumental in advancing our understanding of many-body localized phases—the interacting analogs of the Anderson insulator. In this talk I will discuss in detail three observations related to the entanglement properties of many-body localized systems: (i) A global quench within the many-body localized phase gives rise to a slowly (logarithmically) increasing entanglement entropy. This is due to interaction induced dephasing that is absent in the Anderson insulator and therefore serves as a unique signature of the many-body localized phase. (ii) A local quench from an eigenstate leads to an extensive increase in the entanglement entropy only at the many-body localization transition itself. And (iii) at the many-body localization transition the distribution of entanglement entropies becomes extensively broad, while it vanishes both in the extended metallic phase and in the localized phases. The width of the entanglement distribution, like the long time limit of the local quench, is therefore a useful diagnostic for a many-body localization transition. I explicitly demonstrate how all these features are observed in microscopic spin chain models of many-body localization, and, in particular, discuss how they can be used to detect a many-body mobility edge.

[1] Jens H. Bardarson, Frank Pollmann, and Joel E. Moore, Phys. Rev. Lett. 109, 017202 (2012).
[2] Jonas A. Kjall, Jens H. Bardarson, and Frank Pollmann, Phys. Rev. Lett. 113, 107204 (2014).