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Critical Properties of the Many-Body Localization Transition

VEDIKA KHEMANI, Harvard, SAY-PENG LIM, DONNA SHENG, Cal. State, Northridge, DAVID HUSE, Princeton — The transition from a many-body localized phase to a thermalizing one is a dynamical quantum phase transition which lies outside the framework of equilibrium statistical mechanics. We provide a detailed study of the critical properties of this transition at finite sizes in one dimension. We find that the entanglement entropy of small subsystems looks strongly subthermal in the quantum critical regime, which indicates that it varies discontinuously across the transition as the system-size is taken to infinity, even though many other aspects of the transition look continuous. We also study the variance of the half-chain entanglement entropy which shows a peak near the transition, and find that the sample-to-sample variations in this quantity are larger than the intra-sample variations across eigenstates and spatial cuts. We posit that these results are consistent with a picture in which the transition to the thermal phase is driven by an eigenstate-dependent sparse resonant "backbone" of long-range entanglement, which just barely gains enough strength to thermalize the entire system on the thermal side of the transition as the system size is taken to infinity. This discontinuity in a global quantity — the presence of a fully functional bath — in turn implies a discontinuity even for local properties. We discuss how this picture compares with existing renormalization group treatments of the transition.

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