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Quantum critical behavior at the many-body localization transition JULIAN LEONARD, MATTHEW RISPOLI, ALEXANDER LUKIN, ROBERT SCHITTKO, SOOSHIN KIM, ERIC M. TAI, MARKUS GREINER, Harvard University — Phase transitions are driven by collective fluctuations of a system's constituents that emerge at a critical point. This mechanism has been extensively explored for classical and quantum systems in equilibrium, whose critical behavior is described by a general theory of phase transitions. The many-body localization (MBL) transition, however, occurs out-of-equilibrium and presents a fundamentally different type of phase transitions that defies this description and is not well understood. We present studies on the quantum critical behavior at the MBL transition and characterize its entanglement properties via its quantum correlations. We observe strong correlations, whose emergence is accompanied by the onset of anomalous diffusive transport throughout the system, and verify their critical nature by measuring their system-size dependence. The correlations extend to high orders in the quantum critical regime and appear to form via a sparse network of many-body resonances that spans the entire system. Our results unify the system's microscopic structure with its macroscopic quantum critical behavior, and they provide an essential step towards understanding criticality and universality in non-equilibrium systems.

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