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OBSERVATION AND CHARACTERIZATION OF MANY-BODY LOCALIZATION OF INTERACTING FERMIONS IN A QUASI-RANDOM OPTICAL LATTICE

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Abstract:

Many-body localization (MBL), the disorder-induced localization of interacting particles, signals a breakdown of conventional thermodynamics, as isolated MBL systems do not thermalize and show non-ergodic time evolution. We experimentally observe this non-ergodic evolution for interacting fermions in a one-dimensional quasi-random optical lattice and identify the many-body localization transition through the relaxation dynamics of an initially-prepared charge density wave. For sufficiently weak disorder the time evolution appears ergodic and thermalizing, erasing all initial ordering, whereas above a critical disorder strength a significant portion of the initial ordering persists. The critical disorder value shows a distinctive dependence on the interaction strength, in agreement with numerical simulations.

Furthermore, we study the effects of coupling one-dimensional MBL systems with identical disorder and find a strikingly different behavior between MBL and Anderson Localization. While the non-interacting Anderson case remains localized, in the interacting case any coupling between the tubes leads to a delocalization of the entire system.