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Many-Body Localization Through the Lens of Ultracold Atoms

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Many-body localized (MBL) quantum systems show a drastic disregard for the Eigenstate Thermalization Hypothesis (ETH), giving rise to a fundamentally new dynamical quantum many-body phase. While a multitude of theoretical studies have been very successful in backing the existence of MBL in one-dimension, much less so can be said about the transformation from the ETH respecting phase to MBL and about dynamics in higher dimensions, with many outstanding challenging questions.

To confront such cases, I will describe our efforts in creating and probing MBL with ultra-cold atoms in optical lattices in both one and two dimensions. In particular, I will focus on recently obtained results on the observation of slow-relaxation arising due to rare, configurational Griffiths-type effects in both one and two dimensions. Further, by studying the relaxation dynamics of a far-from-equilibrium state, we find evidence for MBL in quasi-periodic potentials in both one and two dimensions. Our results demonstrate how controlled quantum simulators can explore fundamental questions about quantum statistical mechanics in genuinely novel regimes, often not accessible to classical computations.