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Title: Many-body physics in the NISQ era: quantum programming a discrete time crystal

Abstract: Given recent progress in the realm of noisy, intermediate scale quantum (NISQ) devices, we explore their implications for quantum many-body physics in a practical sense: we ask which *physical phenomena* in the realm of quantum statistical mechanics can these devices realize better than any other experimental platform. As a target, we identify discrete time crystals (DTCs), novel out-of-equilibrium phases of matter that break time translation symmetry, and are realized in the intrinsically nonequilibrium setting of periodically driven quantum systems stabilized by disorder and many-body localization. While precursors of time-crystals have been observed across a variety of experimental platforms - ranging from trapped ions to nitrogen vacancy centers - each of these lacks one or more of the necessary ingredients for realizing a true incarnation of this phase, and detecting the long-range spatiotemporal order that is its defining feature. We show that a new generation of quantum simulators, such as Google's Sycamore processor, can be programmed to realize the DTC phase and to experimentally verify its dynamical properties using a wide range of observables and initial states. We also discuss the effects of environmental decoherence, and show that already with existing technology one could observe the persistence of DTC spatiotemporal order over hundreds periods, with parametric improvements to come as the technology advances in the future.