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Prethermal Dynamics of Trapped Ion Discrete Time Crystals[1]

P.W. HESS[2], P. BECKER, A. KYPRIANIDIS, H.B. KAPLAN, G. PAGANO, W.L. TAN, J. ZHANG, C. MONROE, Joint Quantum Institute and University of Maryland Department of Physics, C. NAYAK, University of California, Santa Barbara, F. MACHADO, N. YAO, University of California, Berkeley — Periodically driving a quantum system can generate phases of matter without analog in stationary systems. Discrete time crystals (DTCs) are one such case, where the spontaneous breaking of a time translational symmetry is forbidden in the time-independent case. Previous observations of this effect relied on strong disorder to stabilize the discrete time crystal's temporal oscillations. Here, we report on the generation of DTC like behavior in a disorderless regime over finite length prethermal timescales. A 1D chain of up to 30 trapped ions is used to simulate a periodically driven long-range interacting spin model, with an individual addressing laser to prepare arbitrary initial spin configurations. The stability of the prethermal time crystal regime is probed by varying the drive frequency and choosing different initial states with varying energy densities. We observe that both low frequency drives and high energy density initial states destroy the periodic time dynamics. Moreover, the single site resolution of this experiment allows us to confirm that the motion of individual domain walls contributes to the decay of the spin order.

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