

Abstract Submitted  
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**Observation of discrete time-crystalline order in a disordered dipolar many-body system**<sup>1</sup> SOONWON CHOI, JOONHEE CHOI, RENATE LANDIG, GEORG KUČSKO, HENGYUN ZHOU, Harvard Univ, JUNICHI ISOYA, University of Tsukuba, FEDOR JELEZKO, Ulm University, SHINOBU ONODA, Takasaki Advanced Radiation Research Institute, HITOSHI SUMIYA, Sumitomo Electric Industries Ltd., VEDIKA KHEMANI, Harvard Univ, CURT VON KESERLINGK, Princeton University, NORMAN YAO, University of California Berkeley, EUGENE DEMLER, MIKHAIL LUKIN, Harvard Univ — The interplay of periodic driving, disorder, and strong interactions has recently been predicted to result in exotic “time crystalline phases, which spontaneously break the discrete time translation symmetry of the underlying drive. Here, we report the experimental observation of such discrete time crystalline order in a driven, disordered ensemble of dipolar spin impurities in diamond at room temperature. We observe long lived temporal correlations at integer multiples of the fundamental driving period, experimentally identify the phase boundary and find that the temporal order is protected by strong interactions; this order is remarkably stable against perturbations, even in the presence of slow thermalization. We provide a theoretical description of approximate Floquet eigenstates of the system based on product state ansatz and predict the phase boundary, which is in qualitative agreement with our observations. Our work opens the door to exploring dynamical phases of matter and controlling interacting, disordered many body systems.

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