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The emergence of chaos in a single nuclear spin of a donor in silicon[1] SERWAN ASAAD, VINCENT MOURIK, HANNES FIRGAU, University of New South Wales, JEFFREY MCCALLUM, University of Melbourne, GERARD MILBURN, CATHY HOLMES, The University of Queensland, ANDREA MORELLO, University of New South Wales — Classical conservative systems usually exhibit rapid dispersion of initial conditions chaos while the corresponding quantum equivalent system exhibits quasi-periodicity, localization, and tunneling through classically forbidden regions in phase space. How to reconcile these strikingly different behaviours has been the topic of active theoretical debate, but accompanied by few experimental results. We propose an experiment aimed at realizing the real-time experimental observation of a single quantum system whose dynamics is classically chaotic a periodically-driven nonlinear top. Our experimental proposal builds upon the existing infrastructure of the 31-P donor qubit in purified 28-Si, which shows record-long coherence times and high-fidelity single-shot readout. Replacing the 31-P donor with 123-Sb, which has a larger nuclear spin of 7/2, its nuclear quadrupole interaction adds the necessary nonlinearity to implement the periodically-driven nonlinear top. We show how the resulting enlarged nuclear Hilbert space is sufficient to observe signatures of classical chaos, allowing us to study the quantum-classical crossover in the nuclear spins dynamics.

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