Authors: Rafail Frantzeskakis, John Van Dyke, Sophia Economou and Edwin Barnes

Title: Time-crystalline behavior in central-spin models with Heisenberg interactions

Abstract:

Time crystals, non-equilibrium phases of quantum matter induced by periodic driving and many-body interactions, have been experimentally realized recently in trapped ion systems and superconducting circuits [1,2]. Such phases can also occur in solid-state spin systems, including ensembles of NV centers [3] or nuclear spins [4] in diamond and quantum dot spin chains [5-7].

Here, we show how to create time crystal phases in central-spin models with Heisenberg interactions, which can describe a single dot or defect system or star-shaped dot arrays. Such interactions are generally present in electron-nuclear spin systems due to hyperfine couplings [8,9]. We show how to use time crystal physics to stabilize multi-qubit short-range correlated states in the presence of Heisenberg interactions by using either magnetic field gradients or additional pulses on the central spin. Both approaches effectively convert the Heisenberg interactions into Ising form [5,10], enabling the subharmonic response characteristic of time crystalline behavior to emerge. Our results can be used to design new schemes for state preservation or robust quantum information processing in quantum dot and defect systems that exploit periodic driving and many-body interactions [7].

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