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A generalized phase space approach for solving quantum spin dynamics[1] BIHUI ZHU, ITAMP, Harvard University, ANA MARIA REY, JILA, University of Colorado Boulder, JOHANNES SCHACHENMAYER, IPCMS, Universit de Strasbourg — Numerical techniques to efficiently model nonequilibrium dynamics in quantum many-body systems are crucial for advancing our capability to harness and understand complex quantum matter. Here we propose a new numerical approach based on a discrete semi-classical phase space sampling, which allows to investigate quantum dynamics in lattice spin systems with arbitrary spin S. We refer to this approach as generalized discrete truncated Wigner approximation (GDTWA). We show that the GDTWA can accurately simulate dynamics of large ensembles in arbitrary dimensions, by applying it to study S>1/2 spin-models with dipolar long-range interactions, a scenario arising in recent experiments with magnetic atoms. We compute experimentally accessible observables such as spin populations, spin coherence, spin squeezing, and entanglement quantified by single-spin Renyi entropies, and reveal features in large S systems different from conventional S-1/2 systems. We further discuss potential applications of GDTWA for studying other systems with discrete local Hilbert space. Our analysis demonstrates that the GDTWA can be a powerful tool for modeling complex spin dynamics in regimes where other state-of-the art numerical methods fail.

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