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Quantum magic in permutationally invariant systems

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Nonstabilizerness, also known as quantum magic, quantifies the deviation of a quantum state from the set of stabilizer states and has emerged in recent years as an information-theoretic quantity to measure the true power of quantum computation beyond entanglement. Simulating and manipulating volume-law entangled quantum states with extensive magic is widely believed to pose considerable challenges for classical algorithms. Thus, numerical experiments have predominantly focused on systems with few qubits. Conventional methods for assessing the nonstabilizerness of an N-qubit system necessitate the computation of 4^N expectation values of Pauli strings over a state with a dimension of 2^N. Permutationally invariant systems are the perfect playground to overcome this limitation. For permutationally invariant systems, the exponential computational overhead of computing the quantum magic can be significantly reduced to $O(N^3)$ expectation values on a state of dimension $O(N)$. This reduction allows exploring not only nonstabilizerness phase transitions in the ground states of this class of models but also across the entire many-body spectrum, paving the way to studying excited-state quantum phase transitions and magic dynamics in nonequilibrium (closed and open) settings in systems comprising hundreds of qubits.

Title

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