Dynamical signatures of quantum phase transitions for excited states

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Abstract

We study the impact of quantum phase transitions (QPTs) and excited- state quantum phase transitions (ESQPTs) on the validity of the adiabatic approximation for a slowly varying Hamiltonian. We compare two cases, when the initial state is the ground state of the initial Hamiltonian and when the initial state is a statistical mixture of excited states induced by a finite temperature. We use the Lipkin-Meshkov-Glick model of a spin lattice and obtain an abruptly decreasing scaling law of the ground-state population with a growing system size N. We comment on the justifiability of using the Landau-Zener formula to make a quantitative prediction in the case of a first-order and a second-order QPT.

To achieve a truly adiabatic evolution in the thermodynamic limit, one would need to perform the Hamiltonian change during an impossibly long time period. It is possible, however, to obtain the same adiabatic final state in a given finite time period by inducing the quantum evolution with another Hamiltonian specifically devised for this purpose, thus employing the so called adiabatic shortcut. We verify the validity of adiabatic shortcuts in the presence of QPTs and ESQPTs and study the costs of performing such adiabatic shortcuts.

Keywords

Quantum phase transitions, Excited-state quantum phase transitions, Adiabatic approximation, Adiabatic shortcuts, Counter-diabatic driving, Lipkin-Meshkov-Glick model