Dynamics and quantum information studies of quantum many body systems

Abstract

This thesis can be divided into two general parts. In first part, we focus on studying some quantum information theoretic measures for quantum spin models in the context of characterizing quantum phase transitions. We here propose a new method for calculating the ground state fidelity susceptibility and the Loschmidt echo (LE) for a generic path and verified our method considering a one-dimensional (1D) three-spin interacting transverse field Ising model which has a rich phase diagram consisting of isolated critical points, multicritical points and quasicritical points. We then extend the study of the LE considering a two-dimensional Kitaev model on a honeycomb lattice which has a gapless phase. The LE here successfully detects the gapless phase of the Kitaev model on a honeycomb lattice. We also study the effect of two simultaneous local quenches on the evolution of the LE and the entanglement entropy of the 1D transverse field Ising model.

In second part, we consider a $p$-wave superconducting chain and study the dynamics of an edge Majorana after suddenly quenching the system from one topologically non-trivial phase to another (or to the topologically trivial phase) and also to the quantum critical point (QCP) separating these phases. We find that for the quenching up to the QCP separating the two topological phases (or separating one topological phase from the non-topological one), the Majorana survival probability shows a collapse and revival as a function of time. In the context of slow quenching dynamics of the $p$-wave superconducting chain with a complex hopping term, we show that there exists a non-zero probability that an edge Majorana can be adiabatically transported from one topological phase to the other across the gapless region. We then present a quantum annealing study of the Sherrington-Kirkpatrick spin glass model by tuning not only the transverse field but also a longitudinal field and reduce them both eventually to zero. At the end of annealing we obtain the final state having high overlap with the exact ground state(s) of classical spin glass system.

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