Finite time path field theory perturbative and nonperturbative methods for quantum spin chain quenches

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For paradigmatic Ising an XY spin chains in a transverse magnetic field we discuss local, global and disorder quenches with different types of perturbation switching on protocols, both sudden and non-sudden. We compare results of our previous studies [1, 2] for Loschmidt echo obtained with a full resummation of perturbation series, which uses generalized Schwinger-Dyson equation and certain simple analyticity assumptions, with the nonperturbative approach where Green's functions have shifted poles. Generalized Schwinger-Dyson equations for retarded Green's functions appear in the resummed perturbation series, which at any order consist only of "bubble" type diagrams. By comparing these results obtained using finite time path field theory methods [3] with the exact numerical results, advantages and disadvantages of perturbative and nonperturbative approaches are highlighted. Since different types of perturbation which we have studied include both integrable and nonintegrable ones, perturbative and nonperturbative approaches are benchmarked on such examples. In particular, a newly revealed type of universal behavior [2] of Loschmidt echo that emerges in exponentially short time scale for an important class of quench type protocols is studied in this context, with relevance to potential technological applications in relation to spin chains. They are specially related to topologically frustrated spin chains, i.e. antiferromagnetic spin chains with periodic boundary conditions and an odd number of spins [4, 5]. Our findings [2] about the universal behavior of a large class of non-sudden quench protocols, containing the sudden quench as a special case, imply the robustness of such quantum technology concepts.

References:

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