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Title: Non-Markovian Quantum Mpemba Effect

Abstract:

Since its rediscovery in the twentieth century, the Mpemba effect, where a far-from-equilibrium state may relax faster than a state closer to equilibrium, has been extensively studied in classical systems and has recently received significant attention in quantum systems. Many theories explaining this counter-intuitive behavior in classical systems rely on memory effects. However, in quantum systems, the relation between the Mpemba effect and memory has remained largely unexplored. Here, we consider general non-Markovian open quantum systems and reveal new classes of quantum Mpemba effects, with no analog in Markovian quantum dynamics. Generically, open quantum dynamics possess a finite memory time and a unique steady state. We show that, due to non-Markovian dynamics stemming from system-bath correlations, even if the system is initialized in a state identical to the steady state, it can take a long time to relax back. Contrarily, it is possible to find other initial states that reach the steady state much faster. Most notably, we demonstrate that there can be an initial state in which the system reaches the steady state within the finite memory time itself, therefore giving the fastest possible relaxation to stationarity. We verify the effect for quantum dot systems coupled to electronic reservoirs in equilibrium and non-equilibrium setups at weak, intermediate and strong coupling, and both with and without interactions. Our work provides new insights into the rich physics underlying accelerated relaxation in quantum systems.

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