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# Non-Markovianity of a qubit probe as a detector of phase transitions in ion crystals and Ising chains

Quantum probes interacting with complex system can be used, under certain conditions, to extract information on the system they are interacting with, ideally in a nondestructive way. In an open quantum system approach, the interaction of the qubit probe with the complex environment gives rise to decoherence phenomena affecting the qubit dynamics. Due to the nontrivial structure of the environment, the qubit time evolution is usually characterised by partial recoherence and information backflow, i.e. non-Markovianity [1]. It has been shown that the non-Markovianity measure [2] of a qubit probe is a useful characterisation of the complex system state and dynamics in the context of ultracold gases, allowing to monitor, e.g., the change of dimensionality of a Bose-Einstein condensate [3].

Here we focus on two new examples. In the case of an Ising model in a transverse filed coupled to a central spin (Heppman-Coleman model), we show that the non-Markovianity measure vanishes exactly only at criticality, for any value of the number of spins in the chain [3]. We also show that, for any dephasing model, the non-Markovianity measure is simply related to the Loschmidt echo. For the case of an ion crystal undergoing a second order phase transition from a linear to a zigzag structure, we show that the non-Markovianity measure decreases monotonically as we move towards the critical value of the trap frequency.

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