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Efficiency of Grover's Search Algorithm Implemented on Open Quantum System in the Presence of Drive-Induced Dissipation

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Abstract : Grover's search algorithm is the fastest possible quantum mechanical algorithm to search a certain element from an unstructured set of data of N items. The algorithm can determine the desired result in only O(√N) steps. It has been demonstrated theoretically and experimentally on two-qubit systems long ago. In this work, we investigate the fidelity of Grover's search algorithm by implementing it on an open quantum system. In particular, we study with what accuracy one can estimate that the algorithm would deliver the searched state. In reality, every system has some influence on its environment. We include the environmental effects on the system dynamics by using a recently reported fluctuation-regulated quantum master equation (FRQME). We consider that the environment experiences thermal fluctuations, which leave its signature in the second-order term of the master equation through its appearance as a regulator. The FRQME indicates that in addition to the regular relaxation due to system-environment coupling, the applied drive also causes dissipation in the system dynamics. As a result, the fidelity is found to depend on both the drive-induced dissipative terms and the relaxation terms, and we find that there exists a competition between them, leading to an optimum drive amplitude for which the fidelity becomes maximum. For efficient implementation of the search algorithm, precise knowledge of this optimum drive amplitude is essential.

Keywords : dissipation, fidelity, quantum master equation, relaxation, system-environment coupling
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