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Adiabatic quantum computation in a dissipative environment

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Quantum annealing (QA) is getting more and more relevant as powerful solver of optimization problems. Thanks to the availability of“commercial”adiabatic quantum computers, based on QA, there is plenty of proposals both on the fundamental and on the applied side. In QA a target ground state encodes the solution of a computationally hard problem. Such ground state is approached exploring the energy landscape, employing quantum flutcuations that are adiabatically decreased towards to zero. Annealing machines are made by arrays of superconducting quantum interferometric devices embedded in classical circuits. They act as a dissipative environment, that is well known to modify the dynamics of any quantum two level system, affecting in a detrimental way the annealing performances. I will review some recent results regarding the role of dissipation in adiabatic quantum computation, discussing a simple model i.e. the ferromagnetic p-spin model that, in the large p limit, encodes in its ground state the solution to the Grover’s algorithm for searching in unsorted databases (that is known to provide a quadratic speed-up with respect to its best classical counterpart). Unexpectedly, under some particular conditions, the system-bath coupling can improve the annealing performances. I will discuss the role of pausing as well as the problem of the embedding on real devices. To conclude, in the presence of a dissipative bath, the question whether the dynamics has driven the system to the target state through a quantum or a classical path, up to now, remained unanswered and only partially addressed in the literature, and the question is still controversial. Hence I will describe a new method that we have proposed to assess the quantumness of the system during its adiabatic dynamics, based on the Leggett Gargs inequalities (LGI), evaluated in the framework of weak measurements.

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