

Anderson localization casts clouds over adiabatic quantum optimization.

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Abstract

Understanding NP-complete problems is a central topic in computer science. This is why the idea of adiabatic quantum optimization has attracted so much attention, as it provided a new approach to tackle NP-complete problems using a quantum computer. The idea is to implement a quantum system with the Hamiltonian, which can be adiabatically tuned to the one, whose ground state codes the solution to the computational problem. Interesting computational problems turn out to lead to the Hamiltonians, which can be analyzed by the theoretical methods developed for strongly correlated disordered systems. The efficiency of the adiabatic quantum optimization is limited by small spectral gaps between the ground and excited states of the quantum computer's Hamiltonian. It turns out that close to the end of the adiabatic algorithm the eigenstates of the quantum computer become Anderson-like localized in the space of its final states. As the result for large random instances of NP-complete problems it is impossible to get rid of the exponentially small gaps. This implies that unfortunately, adiabatic quantum optimization fails: the system gets trapped in one of the numerous local minima.

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