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Detection of Phase Transition in Quantum Annealing using Fidelity Susceptibility

Understanding phase transitions which occur during Quantum Annealing (QA) has both practical and fundamental importance. It not only provides the physical picture for the obstacle of efficient QA, but also suggests strategies to avoid the phase transition, resulting in speed up of QA.
In this work we focus on fidelity susceptibility (a.k.a., SLD Fisher information) which is a probe to detect drastic changes in the ground state of a varying Hamiltonian. It is known in several quantum spin models, that fidelity susceptibility captures topological phase transitions, where there are no local order parameters.
We study if fidelity susceptibility is useful also for quenched disorder systems, specifically in QA Hamiltonians for NP-hard problems.
NP-hard problems with unique solutions should have exponentially small energy gaps according to the computational complexity conjecture of NP ¥nsubset BQP (or P ¥neq NP, if you believe that stoquastic QA are actually within BPP). In this study, we numerically find that for the NP-hard maximum independent set problem, there is a phase transition that is only detectable by the divergence of the fidelity susceptibility, which leads to exponentially small energy gaps within the novel phase.