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Relation between quantum fluctuations and the performance enhancement of quantum annealing in a non-stoquastic Hamiltonian

We study the relation between quantum fluctuations and the significant enhancement of the performance of quantum annealing in a non-stoquastic mean-field Hamiltonian. First-order quantum phase transitions were shown to be reduced to second-order by a non-stoquastic term in a mean-field-type many-body-interacting Ising spin system in a transverse field, which means an exponential speedup of quantum annealing by adiabatic quantum computation.
We investigate if and how quantum effects manifest themselves at around these first- and second-order phase transitions to understand if the non-stoquastic term appended to the conventional transverse-field Ising model induces notable quantum effects.
By measuring the proximity of the semi-classical spin-coherent state to the true ground state as well as the magnitude of the concurrence representing entanglement, we conclude that significant quantum fluctuations exist at around second-order transitions whereas quantum effects are much less prominent at first-order transitions.
This result suggests that the non-stoquastic term induces marked quantum effects, and it is likely to be related closely with the significant enhancement of the performance of quantum annealing.