

# Reaching states below the threshold energy in spin glasses via quantum annealing

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Quantum annealing is a quantum-mechanical analogue to the classical optimization algorithm called simulated annealing, wherein one uses tunable quantum fluctuations to guide a collection of qubits into the ground state of a target spin-glass Hamiltonian. Although the vast majority of work has focused on the time required to reliably prepare the ground state, the complementary question --- how low in energy can be reached in a fixed amount of time --- is equally important. The traditional (mean-field) theory of spin glasses makes a very underwhelming prediction, that there exists a unique "threshold" energy which all classical and quantum annealing protocols converge to on  $O(1)$  timescales. However, recent work by Folena et al (PRX 2020) has shown that this prediction is generically incorrect as far as simulated annealing is concerned. Here we examine the consequences of this surprising result for **quantum** annealing, using the well-known mixed p-spin model as a tractable case study. We show that in certain cases, quantum annealing can in fact perform better than simulated annealing: not only can it reach states as far below the naive threshold, but it can do so significantly faster.