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Experimental signatures of quantum annealing[1]

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Quantum annealing is a general strategy for solving optimization problems with the aid of quantum adiabatic evolution. How effective is rapid decoherence in precluding quantum effects in a quantum annealing experiment, and will engineered quantum annealing devices effectively perform classical thermalization when coupled to a decohering thermal environment? Using the D-Wave machine, we report experimental results for a simple problem which takes advantage of the fact that for quantum annealing the measurement statistics are determined by the energy spectrum along the quantum evolution, while in classical thermalization they are determined by the spectrum of the final Hamiltonian only. We establish an experimental signature which is consistent with quantum annealing, and at the same time inconsistent with classical thermalization, in spite of a decoherence timescale which is orders of magnitude shorter than the adiabatic evolution time. For larger and more difficult problems, we compare the measurements statistics of the D-Wave machine to large-scale numerical simulations of simulated annealing and simulated quantum annealing, implemented through classical and quantum Monte Carlo simulations. For our test cases the statistics of the machine are - within calibration uncertainties - indistinguishable from a simulated quantum annealer with suitably chosen parameters, but significantly different from a classical annealer.

[1]Work in collaboration with T. Albash, N. Chancellor, S. Isakov, D. Lidar, T. Roennow, F. Spedalieri, M. Troyer and Z. Wang.