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Simulation of a 3-dimensional transverse Ising system with a D-Wave quantum annealing processor

A prototype quantum annealing processor has been used to simulate an 8x8x8 cubic lattice of Ising spins subject to a transverse magnetic field Ht. The lattice was formed by representing the individual Ising spins using strongly coupled chains of flux qubits and choosing a subset of interqubit couplers to represent the nearest neighbour couplings of the cubic lattice. The low energy Hamiltonian of the processor then mapped onto that of the desired system. The ground state of the Ht=0 Ising spin system was tuned by choosing a fraction 1-p of the nearest neighbour interactions to be antiferromagnetic (AFM) and the remaining fraction p to be ferromagnetic (FM). Measurements of the antiferromagnetic order parameter, dc magnetic susceptibility, and hysteresis were used to identify paramagnetic (PM) to AFM and PM to spin glass (SG) phase transitions. The measurements were used to map the p-Ht phase diagram for this system. Quantitative agreement between key points in the experimentally determined phase diagram and numerical results found in the literature has been demonstrated. These results support the hypothesis that D-Wave quantum annealing processors can be used to perform quantum magnetism simulations.