Quantum Annealing and Information Encoding in the Transverse Ising Model

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Why climb mountains when you can tunnel through them? Harnessing quantum tunneling holds great promise to speed up solutions for a broad range of optimization problems. I will present experiments on the disordered Ising ferromagnet, $L(Ho,Y)F_4$, that quantitatively compare quantum and classical annealing protocols, and demonstrate quantum speedup for reasons that can be understood at a microscopic level. In the dilute limit, the Ho dipoles form clusters of several hundred spins that bind together and can be excited resonantly. By analogy to laser excitation of atoms, we use a pump-probe magnetic technique to drive the system out of the linear regime, and study both the nature of the excitations and the coupling of the excitations to the spin bath. By applying a magnetic field transverse to the Ising axis, we are able to tune the dynamics of the quantum degrees of freedom such that localized clusters (the "qubits") essentially decouple from their environment.