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Finite temperature criticality in a quantum annealer

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Commercially viable **quantum annealers** have proven as reliable tools to seek the groundstates of disordered many body systems mappable to an Ising spin-glass Hamiltonian. An advantage over simulated annealing techniques is given by the intrinsic quantum nature of the spins (superflux qubits) which, thanks to a **transverse magnetic field**, can more easily and quickly escape metastable configurations and provide solutions closer to the true groundstate. Potentially, they can also be used as samplers for classical equilibrium (Boltzmann) configurations at finite temperatures. However, their reliability as such a tool is subject to several issues, mainly due to the temperature fluctuations of the QPU, analogical implementation errors, and freezouts of the relaxation dynamics for large networks.
We have investigated the potential use of **D-Wave** quantum annealers as **finite-temperature** Boltzmann samplers through an embedding of the **2D Ising ferromagnetic model**. This paradigmatic model exhibits a continuous phase transition at a finite temperature, which can be used to benchmark the performance of D-wave in these difficult scenarios –both in the neighborhood of the critical region and when quenching through the phase transition.
To underpin criticality, we developed an **experimental protocol** that allows us to account for systematic biases and temperature fluctuations of the QPU. This allowed us to perform reliably and consistently experiments across different system sizes making use of the whole qubits network ($\sim$ 3000 spins), ultimately pinning criticality in the thermodynamic limit and recovering the universal critical exponents of a 2D classical ferromagnet. On one hand, these results set the grounds for **reliable Boltzmann sampling** on these experimental devices, while also offering the 2D Ising ferromagnet as a tool to finely benchmark the features of D-Wave quantum anneler s. As a case in point, we are able to prove and quantify an explicit **advantage provided by the transverse field** in finding true Hamiltonian's groundstate throughout an annealing schedule.

Theme

Theme 1. Energy advantage and cost of quantum technology

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