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Quantum Simulation of Frustrated Ising Spins with Trapped Ions[1]

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We experimentally simulate the quantum Ising spin model with a transverse field using a collection of trapped atomic 171Yb+ ions [1,2]. The spins are initially polarized along a transverse effective magnetic field. The Ising interactions are switched on, while the transverse field adiabatically reduced. The state of each spin is measured through state-dependent fluorescence. The resulting ground-state spin order depends upon the signs and strengths of the long-range Ising couplings, which are precisely controlled through the detuning of bichromatic Raman laser beams from the motional modes [3,4]. In cases where the interactions are frustrated, we observe a higher level of degeneracy in the ground state and directly show that an extra degree of entanglement emerges. Because the interaction is mediated through closely-spaced transverse modes of motion, this system is scalable to much larger numbers of spins where classical simulations of the Ising model are intractable. This work is supported by the Army Research Office (ARO) with funds from the DARPA Optical Lattice Emulator (OLE) Program, IARPA under ARO contract, the NSF Physics at the Information Frontier Program, and the NSF Physics Frontier Center at JQI.

[1] D. Porras, et al., Phys. Rev. Lett. 92, 207901 (2004).
[2] A. Friedenauer, et al., Nature Physics 4, 757 (2008).
[3] K. Mølmer and A. Sørensen, Phys. Rev. Lett. 82, 1835 (1999); G. J. Milburn, et al., Fortschr. Phys. 48, 801 (2000).
[4] K. Kim, et al., Phys. Rev. Lett. 103, 120502 (2009).

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