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Quantum Simulation of Frustrated Magnetism with Many Trapped Ions[1]

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A collection of trapped atomic ions is an excellent system for simulating quantum many-body physics, like magnetism, which may be difficult to access via classical computation or traditional condensed-matter experiments. Our large crystals of 10-20 ions comprise a platform to study a long-range quantum Ising model with tunable couplings in a 1D spin chain. State-dependent optical dipole forces exploit the Coulomb interaction to generate the spin-spin couplings, and fluorescence measurements on a camera are used to read out individual spin states. We investigated the spin order resulting from changing the range of antiferromagnetic interactions or the strength of an axial magnetic field, demonstrating our control over the amount of frustration present. We are turning to the study of dynamics in this system, with the aim of exploring topics including adiabaticity, spectroscopy of the Hamiltonian, the emergence of Kibble-Zurek-like behavior in a finite system, thermalization in an isolated quantum system, and nonequilibrium phase transitions. There is great promise in extending the system to 30+ spins, where computations become classically intractable. Co-authors are R. Islam, P. Richerme, W. C. Campbell, S. Korenblit, J. Smith, A. Lee, E. E. Edwards, C.-C. J. Wang, J. K. Freericks, and C. Monroe.

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