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Trapped-Ion Quantum Simulations of Spin Systems: From Two Qubits to Thousands WARREN LYBARGER, Los Alamos National Laboratory, DANA BERKELAND, IARPA, JOHN CHIAVERINI, Los Alamos National Laboratory — Due to the exponential growth of a quantum system's state-space with its size, the current technological limit for simulating the evolution of many-quantum-spin systems with classical computers (CC) is 36 spin-$\frac{1}{2}$ particles. While CC's cannot be scaled to meet the exponentially increased demand in computational resources, mapping the Hamiltonians of such problems onto that of a quantum simulator (QS) completely avoids this exponential scaling problem, allowing for efficient simulations of much larger systems. QS may be the first attainable application of quantum information processing, enabling exploration of parts of the phase space not accessible in the original system and possibly providing an exponential speedup of computations for even just a few tens of interacting qubits when compared to CC methods. Following the work of Porras and Cirac [Phys. Rev. Lett. 92, 207901-1 (2004)] we discuss the status of an experiment at Los Alamos for demonstrating a proof of principle QS of an Ising-like spin-spin interaction in a transverse magnetic field. We also discuss a novel architecture for microfabricated ion trap arrays geared toward enabling large scale QS and one-way quantum computing with potentially thousands of ions [arXiv:0711.0233].

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