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Quantum Simulations in Ion Traps[1]

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When Richard Feynman famously proposed a quantum computer, his intended application was to simulate quantum dynamical systems. This is a hard problem because as the number of elements of a quantum system linearly increases, the complexity of the equations modeling it grows exponentially. Feynman's proposed solution to this problem was to simulate one quantum mechanical system with another. Such quantum simulators can solve only a limited set of problems, but building one would represent an important milestone in the road to universal quantum computation. At LANL we use an array of strontium ions confined in a linear rf trap to build a multi-body quantum simulator. Each ion simulates a single spin system, while Coulomb and optical forces simulate spin-spin interactions and magnetic fields. This system can simulate the most basic models of condensed matter physics, the Ising model and the Heisenberg XY model, in addition to more complex physical systems. We have modeled the basic interactions in this system and are starting to demonstrate the interactions central to the simulations.

[1]In collaboration with Malcolm Boshier, John Chiaverini, David Lizon, Warren Lybarger, Robert Scarlett, and Rolando Somma, Los Alamos National Laboratory.