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Non-Equilibrium Dynamical Phase Transition with 53 Trapped Ion Qubits[1] P. BECKER, J. ZHANG, G. PAGANO, Joint Quantum Institute and University of Maryland , P. W. HESS, Department of Physics, Middlebury College, A. KYPRIANIDIS, H. B. KAPLAN, A. V. GORSHKOV, Joint Quantum Institute and University of Maryland , Z.-X. GONG, Department of Physics, Colorado School of Mines, C. MONROE, Joint Quantum Institute and University of Maryland — Trapped atomic ions are an ideal platform for constructing interesting quantum systems from the ground up. This system features precise laser control, long qubit coherence times, and individual readout, which together satisfy the requirements for a universal quantum computer. We use this toolbox for quantum simulation by engineering interacting many-body systems, with qubits encoded in the hyperfine states of $^{171}Yb^{+}$ ions and interactions mediated by motional modes in an RF Paul trap. These interactions create an effective long-range transverse-field Ising model. While the dynamics of a system composed of few spins can be easily calculated, exponentially large Hilbert spaces render classical simulation of 50 or more spins intractable without substantial computing resources. Here we present our observation of a non-equilibrium dynamical phase transition after a quench. The signatures of the phase transition are manifested in low order observables such as magnetization and two-body correlators. We scaled up this experiment to 53 qubits, measuring high order correlators, such as formation probabilities, that are not accessible to classical simulation.

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