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Many-body dynamics and entanglement in Rydberg atom arrays

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Programmable arrays of neutral atoms provide an exciting avenue for quantum simulations and quantum information processing. We employ a 1D array of neutral atoms coupled to Rydberg states to simulate a transverse-field Ising model with long-range interactions. This system can undergo quantum phase transitions breaking different spatial symmetries, which we study in detail. I will present our studies of non-equilibrium dynamics across these phase transitions, which yields universal scaling laws consistent with the quantum Kibble-Zurek mechanism. Furthermore, I will describe a method we developed to rapidly and deterministically entangle a full chain of atoms using local engineering of the many-body spectrum and adiabatic transitions. The ability to reliably produce large-scale entanglement in neutral atom systems opens up a new route towards scalable quantum processors.