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Probing the quench dynamics of antiferromagnetic correlations in a 2D quantum Ising system of 200 spins

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Simulating the real-time evolution of quantum spin systems far out of equilibrium poses a major theoretical challenge, especially in more than one dimension. Here, we experimentally explore quench dynamics in a two-dimensional Ising spin system with transverse and longitudinal fields - a system that is well-suited for scalable quantum computing. We prepare a near unit-occupancy atomic array of over 200 atoms by loading a spin-polarized band insulator of fermionic lithium into an optical lattice and induce nearest-neighbor interactions by direct excitation to a low-lying Rydberg state. Using site-resolved microscopy, we probe antiferromagnetic correlations in the system after a sudden quench from a paramagnetic state and compare our measurements to exact calculations in the regimes where it is possible. We achieve many-body states with longer-range antiferromagnetic correlations by implementing a near-adiabatic quench of the longitudinal field and study the buildup of correlations. The coherence is limited by anomalous dephasing that we attribute to motion of the atoms caused by the strong interactions.