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Dynamical phase transitions in a collective Heisenberg model simulated with harmonically trapped ultracold fermions SCOTT SMALE, University of Toronto, PEIRU HE, JILA, NIST, and University of Colorado, Boulder, BEN A. OLSEN, KENNETH G. JACKSON, University of Toronto, JAMIR MARINO, ANA MARIA REY, JILA, NIST, and University of Colorado, Boulder, JOSEPH H. THYWISSEN, University of Toronto — The collective Heisenberg spin model is a textbook model for magnetism and superconductivity. It describes localized spins interacting via long-range exchange interactions. We discuss a quantum simulation of this model using tens of thousands of potassium atoms trapped in a three-dimensional harmonic oscillator, without an optical lattice. Using a Feshbach resonance to tune the interactions between spin-up and spin-down potassium atoms to be weak, mode-changing collisions can be suppressed during the time of the experiment. Atoms remain in their initial single-particle eigenmodes, which form a lattice in mode space. We study spin dynamics initiated with a $\pi/2$ pulse, and observe competition between interactions and an inhomogenous effective magnetic field (due to a real-space field curvature, which maps onto a mode-space field gradient). Varying both the strength of interactions and of inhomogeneity, we observe a dynamical phase transition between ferromagnetic dynamics and ungapped paramagnetic dynamics. We find excellent agreement with calculations based on a mean-field treatment of a collective Heisenberg model, with all-to-all couplings.

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