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Spin interactions in ultra-cold many-body systems SEBASTIAN HILD, PETER SCHAUSS, JOHANNES ZEIHER, TAKESHI FUKUHARA, MARC CHENEAU, MANUEL ENDRES, CHRISTIAN GROSS, Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany, STEFAN KUHR, University of Strathclyde, Department of Physics, SUPA, Glasgow G4 0NG, United Kingdom, IMMANUEL BLOCH, Fakultät für Physik, Ludwig-Maximilians-Universität München, 80799 München, Germany & Max-Planck-Institut für Quantenoptik, 85748 — Spin Hamiltonians are used to explain a variety of different phenomena in solid state physics. Quantum simulation of such systems with ultracold gases promises deeper insight in the emerging physics. Here we report on the realization of two kinds of effective spin Hamiltonians with ultracold Rubidium atoms in optical lattices. Single site resolved detection enabled the direct measurement of a single spin impurity immersed into a bath of opposite spins. The measurement revealed coherent superexchange dynamics in the Heisenberg regime as well as evidence for polaronic behavior in the superfluid regime. In a second experiment we used Rydberg atoms to realize long-range interacting effective spin systems. By high resolution optical detection we observed the emergence of spatially ordered patterns upon laser excitation of a dense 2D gas. The results pave the way towards quantum simulation of novel long-range interacting quantum systems with ultracold atoms.

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