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Direct observation of interacting Magnons in optical lattices

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The quantum simulation of spinful many-body systems with ultracold atoms in optical lattices promises novel insight into fundamental aspects of magnetism. Here we report on the direct observation of coherent Magnon propagation after a local spin flip in the isotropic Heisenberg regime. Using our quantum gas microscope we track the position of the flipped spins during their propagation in the bath of opposite spins. When the local quantum quench is realized by flipping two adjacent spins the subsequent dynamics shows clear signatures of a stable Two-Magnon bound state propagating through the lattice. We extract the propagation velocity of the bound state and find slower dynamics due to the larger effective mass of the compound object. Tuning the system from the Mott insulating into the superfluid regime, we observe polaronic features in the non-equilibrium dynamics of a single spin impurity. Our results show the potential of local manipulation and detection for the study of correlations in magnetic quantum systems.