Many-body Quantum Control of a Spin-1 BEC

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Spin-1 condensates provide a useful platform for investigations of atom squeezing,\(^1\) generation of non-Gaussian states,\(^2\) and dynamical control.\(^3\) We demonstrate dynamic control of a quantum many-body spin-1 system that is enabled by strong collisional interactions. In contrast to the usual single-particle quantum control techniques, the method demonstrated here is intrinsically many-body, exploiting the strong collisional interactions. The experiment uses a spin-1 \(^{87}\text{Rb}\) condensate initialized in the \(|F = 1, m_F = 0\rangle\) polar state at a high magnetic field above the quantum phase transition, and then prepared in a coherent state using a rf rotation. The many-body control is implemented by time-varying the relative strength of the Zeeman and spin interaction energies of the condensate at multiples of the natural coherent oscillation frequency of the system. This is a parametric excitation method relying on time varying changes to the Hamiltonian. We will present our experimental results, which compare well to theory, and will discuss future directions and applications.

\(^1\)C.D. Hamley, \textit{et al.}, Nat. Phys. 8, 305 (2012)