Adiabatic spin-dependent momentum transfer in an SU(N) degenerate Fermi gas

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Abstract

For the study of strongly correlated fermionic systems, ultracold alkaline-earth atoms offer original possibilities with their large ground-state spin and spin-independent collisions (SU(N) symmetry). The nuclear nature of the spins is both a strength and a complication – for example as it prevents the simple use of magnetic forces as in a Stern-Gerlach measurement. Nevertheless, the narrow lines associated with their singlet-to-triplet transitions can be used for novel spin-sensitive manipulations schemes, e.g. effective magnetic fields as in the "Optical Stern-Gerlach" (OSG) scheme [1], and spin-orbit coupling with low levels of spontaneous emission [2].

In our experiment [3], we introduce a spin-orbit coupling scheme where a retro-reflected laser beam selectively diffracts two spin components of a degenerate Fermi gas in opposite directions. Spin sensitivity is provided by sweeping through a magnetic-field sensitive transition: the intercombination line of strontium 87. The atoms follow adiabatically dark states, which significantly suppresses spontaneous emission. The adiabaticity of the scheme makes it inherently robust. We furthermore demonstrate a generalization of the scheme, and diffract in a single shot four spin states with four different momentum transfers. The spin-orbit coupling is associated with well-defined momentum transfers, set by the two-photon recoil, such that, unlike in OSG, momentum distortion is negligible. Thus, this scheme allows simultaneous measurements of the spin and momentum distributions of a strontium degenerate Fermi gas, opening the path to momentum-resolved spin correlation measurements [4] on SU(N) quantum magnets.

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