MAR11-2010-004358

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

Realization of an SU(6) invariant Fermi system

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We report the realization of a novel Fermi system with an enlarged spin symmetry of SU(6) in a cold atomic gas of ytterbium ^{173}Yb with nuclear spin I=5/2, which will open up a new opportunity for exotic many-body physics . While the achievement of quantum degeneracy of ^{173}Yb with 6 spin components was already reported three years ago, an important technique of the separate imaging of the nuclear spin components was not developed. Recently we have made this possible by exploiting an optical Stern-Gerlach effect using a spatially inhomogeneous laser beam. The metallic state to Mott insulator transition for SU(6) Fermi gas is also investigated by loading ^{173}Yb atoms into a 3D optical lattice. We find some results suggesting the formation of SU(6) Mott state at low lattice temperatures expected for SU(N) systems. The similar adiabatic cooling effect is also observed in the Bose-Fermi mixture of spinless boson of ^{174}Yb and the SU(6) Fermi system of ^{173}Yb. In addition, an all-optical sympathetic evaporative cooling method is applied to the two fermionic isotopes of ytterbium ^{171}Yb with the nuclear spin I=1/2 and ^{173}Yb, and we successfully cool the mixture below the Fermi temperatures. The same scattering lengths for different spin components make this mixture featured with the novel SU(2) x SU(6) symmetry. The mixture is loaded into a 3D optical lattice to implement the SU(2) x SU(6) Hubbard model. In particular, we find interaction-induced suppression of Bloch oscillations for the mixture in the 3D lattice.