Light-induced azimuthal vector potentials for neutral atomic quantum gases

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We demonstrate coupling between the atomic spin and orbital-angular-momentum (OAM) of the atom's center-of-mass motion in an F=1 Rb87 spinor Bose-Einstein condensate. The coupling is induced by Raman-dressing lasers with a Laguerre-Gaussian beam carrying OAM. We further create synthetic azimuthal gauge potentials by adiabatically loading the condensate into the lowest energy Raman-dressed state. The azimuthal gauge potentials act as effective rotations and are tunable by the Raman coupling and detuning. We characterize the spin texture of the dressed states, which agree with the theory. Finally, we employ the azimuthal gauge potential to demonstrate the Hess-Fairbank effect, i.e., we produce dressed atoms in the absolute ground state which have zero quasi-angular momentum when the synthetic magnetic flux is below a critical value. The gauge field in the stationary Hamiltonian allows investigating rotation properties of atomic superfluid under thermal equilibrium.