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Improved Apparatus to Study Matter-Wave Quantum Optics in a Sodium Spinor Bose-Einstein Condensate SHAN ZHONG, ANITA BHAGAT, QIMIN ZHANG, ARNE SCHWETTMANN, University of Oklahoma — We present and characterize our recently improved experimental apparatus for studying matter-wave quantum optics in spin space in ultracold sodium gases. Improvements include our recent addition of a 3D-printed Helmholtz coil frame for field stabilization and a crossed optical dipole trap. Spin-exchange collisions in the $F = 1$ spinor Bose-Einstein condensate can be precisely controlled by microwave dressing, and generate pairs of entangled atoms with magnetic quantum numbers $m_F = +1$ and $m_F = -1$ from pairs of $m_F = 0$ atoms. Spin squeezing generated by the collisions can reduce the noise of population measurements below the shot noise limit. Versatile microwave pulse sequences will be used to implement an interferometer, a phase-sensitive amplifier and other devices with sub-shot noise performance. With an added ion detector to detect Rydberg atoms via pulse-field ionization, we later plan to study the effect of Rydberg excitations on the spin evolution of the ultracold gas.

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