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Spin Squeezing and Superradiance with a Collective Cavity QED System JOSHUA WEINER, KEVIN COX, MATTHEW NORCIA, JILA and University of Colorado at Boulder, JUSTIN BOHNET, JAMES THOMPSON, NIST, JILA, and University of Colorado at Boulder — We present experiments that utilize cavity-mediated interactions between an ensemble of $\sim 10^6$ ^{87}Rb atoms to create conditional spin squeezing and steady state superradiance. In one set of experiments, we employ quantum non-demolition measurements to obtain collective information about the pseudo-spin projection J_z of the atoms and generate an improvement of 10.2(6) dB in quantum phase estimation relative to the standard quantum limit for a coherent spin state. A method for reducing the effects of microwave rotation errors on the observed spin noise reduction through controlled dephasing with a far off-resonant laser beam is also discussed. In separate experiments, we establish steady-state superradiance (or bad-cavity lasing) using a Raman transition between hyperfine ground states of rubidium. We present studies of active and passive sensing of external fields with a superradiant laser, amplitude stability, and phase synchronization between two spatially distinct ensembles emitting into a single optical cavity. These techniques could enhance future precision measurements in optical atomic clocks, atom interferometry, and long-baseline interferometry.

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