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Demonstration of metrologically relevant spin-squeezing in free space with an ensemble of ^{87}Rb atoms YUNFAN WU, ONUR HOSTEN, Stanford Univ, RAJIV KRISHNAKUMAR, Caltech/INQNET, JULIAN MARTINEZ, BENJAMIN PICHLER, MARK KASEVICH, Stanford Univ, CQED TEAM — Entangled atomic states such as spin-squeezed states can overcome the atomic projection noise that limits the precision of atomic sensors. Various experiments have successfully demonstrated such states. For precision sensing applications requiring the atoms to be freely moving, such as fountain clocks and atom interferometers, the homogeneity of the prepared squeezed states is crucial for their successful retrieval. In this work, we initially generated 12dB spin-squeezed states using an optical-cavity that uniformly interacts with 500,000 ^{87}Rb atoms trapped in an optical lattice. Then we released these atoms into free space and recaptured them back into the lattice after a variable duration. The final state of the atoms was then measured with the help of the cavity. We characterized the degradation in squeezing as a function of release time, and modeled it including the effects of atom loss and loss in atom-cavity coupling homogeneity. We demonstrated the retrieval of spin-squeezing in free space for up to 2ms limited by our ability to recapture the atoms. This result is a crucial step towards implementing metrologically relevant spin-squeezed atomic sensors in free space.

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