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Enhanced Spin Squeezing in Atomic Ensembles via Control of the Internal Spin States[1] EZAD SHOJAEE, University of New Mexico, LEIGH NORRIS, Dartmouth College, BEN BARAGIOLA, University of New Mexico, ENRIQUE MONTANO, DANIEL HEMMER, POUL JESSEN, University of Arizona, IVAN DEUTSCH, University of New Mexico — Abstract: We study the process by which the collective spin squeezing of an ensemble of Cesium atoms is enhanced by control of the internal spin state of the atoms. By increasing the initial atomic projection noise, one can enhance the Faraday interaction that entangles the atoms with a probe. The light acts as a quantum bus for creating atom-atom entanglement via measurement backaction. Further control can be used to transfer this entanglement to metrologically useful squeezing. We numerically simulate this protocol by a stochastic master equation, including QND measurement and optical pumping, which accounts for decoherence and transfer of coherences between magnetic sub-levels. We study the tradeoff between the enhanced entangling interaction and increased rates of decoherence for different initial state preparations. Under realistic conditions, we find that we can achieve squeezing with a "CAT-State" superpostion |F=4, Mz=4>+ |F, Mz=-4>of $\sim$ 9.9 dB and for the spin coherent state |F=4, Mx=4>of $\sim$ 7.5 dB. The increased entanglement enabled by the CAT state preparation is partially, but not completely reduced by the increased fragility to decoherence.

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