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Enhanced Spin Squeezing Through Quantum Control of Qudits
LEIGH NORRIS, Center for Quantum Information and Control, University of New Mexico, COLLIN TRAIL, University of Calgary, IVAN DEUTSCH, Center for Quantum Information and Control, University of New Mexico, POUL JESSEN, Center for Quantum Information and Control, University of Arizona — Spin squeezed states have applications in metrology and quantum information processing. Most spin squeezing research to date has focused on ensembles of qubit spins. We explore squeezed state production in an ensemble of spin f>1/2 alkali atoms (qudits). Collective interactions are achieved through coherent quantum feedback of a laser probe, interacting with the ensemble through Faraday interaction. This process is enhanced with control of the atomic qudits, both before and after the collective interaction. Initial preparation increases the collective squeezing parameter through enhancement of resolvable quantum fluctuations, but comes at the price of increased decoherence. We find an optimal state preparation, achieving an increased squeezing parameter while remaining robust to decoherence. After the collective interaction, qudit control maps generated entanglement to different pseudo-spin subspaces where it is metrologically useful, e.g., the clock transition or the stretched state for magnetometry. These considerations highlight the unique capabilities of our platform: we can transfer correlations between subspaces to explore a wider variety of nonclassical states, with ultimate application in sensors or quantum information processors.

Leigh Norris
Center for Quantum Information and Control, University of New Mexico

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