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**Quantum State Reconstruction of a Large Angular Momentum by Continuous Weak Measurement** POUL JESSEN, GREG SMITH, University of Arizona, ANDREW SILBERFARB, IVAN DEUTSCH, University of New Mexico — We show experimentally that an optical probe measurement can be used to acquire complete information about the angular momentum density matrix for an ensemble of Cs atoms in the  $F = 3$  hyperfine ground manifold. We do this by measuring a single atomic observable (e. g. a spin component), while driving the system so that it explores the entire spin state space. The quantum state can then be estimated from the measurement record in the presence of the known system dynamics. We show that high fidelity estimates can be achieved for a wide variety of test states, including squeezed- and similar non-classical states generated by the action of the tensor light shift. The procedure is non-destructive, in the sense that the ensemble is available in a known quantum state at the end of the estimation. It can also – in principle – be performed in real time, though our implementation does not reach that limit. This suggests that the procedure may serve as the starting point for a new type of feedback that involves partial or complete knowledge of the ensemble quantum state.

Poul Jessen  
University of Arizona

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