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**Quantum State Tomography of Cold Atom Qudits** HECTOR SOSA MARTINEZ, NATHAN LYSNE, POUL JESSEN, University of Arizona, CHARLES BALDWIN, AMIR KALEV, IVAN DEUTSCH, University of New Mexico — Accurate and robust control over quantum systems plays a key role in quantum information science. The use of systems with large state spaces (qudits) may prove a useful resource for quantum information tasks if good laboratory tools for qudit manipulation and measurement can be developed. Over the past few years we have developed and experimentally implemented a protocol to perform high-fidelity unitary transformations in the 16 dimensional hyperfine ground manifold of Cesium-133 atoms, driving the system with phase modulated radio-frequency and microwave magnetic fields and using the tools of optimal control to find appropriate control waveforms. We have recently extended our protocol to investigate quantum state tomography based on a combination of unitary transformations and Stern-Gerlach analysis. Experimental results shown that optimal tomography based on mutually-unbiased-bases (MUBs) can be implemented, with reconstruction fidelities on the order of 99% for arbitrarily chosen test states in a 16-dimensional Hilbert space. We are also interested in the characterization of our measurement detector for which we plan to perform POVM tomography. Ultimately, successful implementation of this kind of state tomography may prove very valuable, greatly reducing the required data for more complex procedures such as quantum process tomography.

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