Abstract Submitted
for the DAMOP14 Meeting of
The American Physical Society

Robust and Inhomogeneous Quantum Control of Cold Atom Qudits HECTOR SOSA MARTINEZ, POUL JESSEN, University of Arizona, IVAN DEUTSCH, University of New Mexico — Quantum control over complex systems plays an important role in quantum information science. The use of large state space systems (qudits) may prove advantageous for quantum information tasks if good laboratory tools for qudit control can be developed. We have implemented a protocol for arbitrary unitary transformations in the 16 dimensional hyperfine ground manifold of Cesium 133 atoms, driving the system with phase modulated rf and microwave magnetic fields and using the tools of optimal control to find appropriate control waveforms. Robustness against imperfections in the applied fields can be built into the control waveforms by averaging the cost function over a suitable ensemble, e. g., a distribution of static and dynamical variations in bias field strength. Suppression of dynamical errors may prove helpful for qudit control in less than ideal environments such as atoms moving around in the light shift potential of a dipole trap. We have also begun to explore inhomogeneous quantum control, with the goal of performing different unitary transformations on qudits that see different light shifts from an optical addressing field. Ultimately this could lead to addressable unitary control similar to that demonstrated for qubits in optical lattices.

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Date submitted: 30 Jan 2014 Electronic form version 1.4