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Ensemble Quantum Control of Neutral Atoms Qudits[1] BRIAN MISCHUCK, University of New Mexico, SETH MERKEL, IQC, IVAN DEUTSCH, University of New Mexico, POUL JESSEN, University of Arizona — Atomic spins are robust and highly controllable, making them an excellent platform for quantum information processing. In addition, the large number of magnetic substates in the electronic ground state of heavy alkali atoms makes them natural candidates for encoding qudits. In previous work we showed that the complete hyperfine manifold is controllable through the application of oscillating radio and microwave frequency magnetic fields. In the present work we show how such control waveforms can be designed to be robust to inhomogeneities such as spatio-temporal variations of the fields. Borrowing on ideas originally developed for NMR, we show how to drive an inhomogeneous ensemble of Cs-133 atoms through a given desired evolution. By appropriate choice of rf power and phase, we can limit the dynamics to remain in the lower hyperfine manifold (F=3) plus an additional auxiliary state in the upper manifold, an 8 dimensional Hilbert space that is controllable. By brute force optimization, we find waveforms that act for a time of 500 μs and will achieve an average fidelity of greater than 0.99 for a 5% variation in all of the parameters . We also show how to synthesize different states in different spatial regions by using a spatially varying magnetic field.

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