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Quantum state control of atoms in microscopic optical traps

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University of Wisconsin — We present recent progress in loading and manipulation of neutral atoms in microscopic optical traps. Single Rb atoms are loaded into far-off resonant optical traps from a background vapor of cold atoms. Tightly focused optical beams are used to perform two-photon stimulated Raman rotations between hyperfine qubit states. We demonstrate qubit rotations at a rate of 1.4 MHz, 1 ms coherence time, and individual site addressing with crosstalk at the level of $10^{-3}$. These results are a significant step towards quantum computing using optically trapped neutral atoms. We discuss work in progress aimed at observing strong, angle independent dipole-dipole interactions for fast two-qubit gates using microwave dressing of Rydberg states. We demonstrate two-photon coherent excitation of Rydberg levels by a $5s_{1/2} - 5p_{3/2} - nd_{5/2}$ sequence. The possibility of dipole-dipole interactions without angular zeroes will be important for gates, as well as for coupling to mesoscopic qubits to enable transmission of quantum states.

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