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Quantum computing with cold atoms and Rydberg blockade[1]

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Optically trapped neutral atoms are one of several leading approaches to scalable quantum information processing. When prepared in electronic ground states in deep optical lattices atomic qubits are weakly interacting with long coherence times. Excitation to Rydberg states turns on strong interactions which enable fast gates and entanglement generation through either coherent evolution or dissipative dynamics. Rydberg interactions can be applied in a variety of ways enabling control of single atom qubits, multi-atom ensemble qubits, and hybrid entanglement between different types of atoms, between atoms and photons, or between atoms and solid state qubits. I will present advances that leverage strong Rydberg interactions for implementation of a small scale quantum computing device. We trap 30 or more atomic qubits in a 2D array of 49 sites. Single qubit gates are performed with fidelities better than 0.999 as characterized by random benchmarking. Two-qubit gates and entanglement are demonstrated between qubit pairs. Experimental gate fidelities are not yet sufficient for reliable error correction and scalable quantum computation. I will describe prospects for reaching the fault tolerance threshold based on new gate protocols with the potential for fast generation of entanglement at fidelities better than 0.9999.

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