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**Progress towards entangling neutral atom ensemble qubits using Rydberg interactions**[1] MINHO KWON, CHRIS YOUNG, MATT EBERT, THAD WALKER, MARK SAFFMAN, Department of Physics, University of Wisconsin-Madison — We report on progress towards higher fidelity preparation and control of ensemble qubits using Rydberg blockade. The scalability and strong coupling to photons of ensemble qubits make them promising building blocks for quantum networks. Our previous demonstration of the preparation of ensemble qubits was limited to moderate fidelity $< 60\%$, possibly due to the presence of atom pairs with small separations leading to Rydberg blockade leakage. In order to suppress unwanted Rydberg interaction channels we add a blue-detuned 1-D lattice on top of the existing red-detuned dipole trap, thereby imposing constraints on the minimal atom separations. We study the effect of lattice insertion on the fidelity of ensemble state preparation and Rydberg-mediated gates. Cooperative scattering from a 1D atomic array is also studied. An automatic alignment system to improve the pointing stability of the tightly focused Rydberg excitation beams is also presented.

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