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Progress in entangling atoms in 3D for quantum computation[1]

TSUNG-YAO WU, FELIPE GIRALDO, PENG DU, The Pennsylvania State University, AISHWARYA KUMAR, The University of Chicago, DAVID S. WEISS, The Pennsylvania State University — We will report our recent progress towards implementing entangling operations in our 3D neutral atom quantum computer. To date, we have demonstrated deterministic preparation of qubits through 3D sorting and cooling [Nature 561, 83 (2018)], high-fidelity single qubit gates [Phys. Rev. Lett. 115, 043003 (2015)], and high-fidelity state measurement [Nature Physics 15, 538 (2019)]. We are developing two types of entangling operations. The first is the creation of cluster states (in 1D, 2D and 3D) through cold atom collisions [Phys. Rev. Lett. 86, 910 (2001)]. We are currently improving our cooling by temporarily transferring atoms to a closer-detuned, deeper trap. Preliminary results show a 3D vibrational ground state occupation >98%. By using this enhanced cooling and our state-dependent lattices, we will prepare all the atoms in a superposition and entangle them all together through controlled collisions with neighboring atoms. This will enable us to create cluster state of up to 50 qubits in 3D. The other entangling operation currently being developed is a site-addressable Rydberg gate within the 3D, which we project can exceed 99.9% fidelity.

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