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Scalable Quantum Information Processing with Ultracold Neutral Atoms ARJUN SHARMA, KATHY-ANNE BRICKMAN SODERBERG, KARA LAMB, PETER SCHERPELZ, NATHAN GEMELKE, CHENG CHIN, The Department of Physics and The James Franck Institute, The University of Chicago — Remarkable experimental progress has been made over the last decade in realizing the necessary requirements for quantum information processing. Of all the approaches, cold atoms are at the forefront due to the precise control possible over both the external trapping potential and the atoms' internal structure. Two key issues are scaling up the number of quantum bits (qubits) and individually addressing qubits for targeted operations. We present an experiment able to overcome these difficulties. Two species of ultra cold neutral atoms confined in independent, overlapping optical lattices are the basis of our computer. One atomic species is loaded into a lattice with unit filling and act as qubits. The other species, less densely populated in a second lattice, are messenger atoms that allow for individual qubit addressing and aid in entangling operations. By translating the lattices, the messenger and qubits are brought into contact for qubit operations. This makes the scheme scalable to entangle any two distant qubits.

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