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Universal Quantum Computation within the Bose-Hubbard Model[1] MICHAEL S. UNDERWOOD, DAVID L. FEDER, Institute for Quantum Information Science at the University of Calgary — We present a novel scheme for universal quantum computation based on spinless bosons hopping on a two-dimensional lattice with on-site interactions. Our setup is comprised of a $2 \times n$ lattice for an n-qubit system; the two rows correspond to the computational basis states, and a boson in each column encodes a qubit. The system is initialized with n bosons occupying the n sites of the $|0\rangle$ row, and the lattice deep enough to prevent tunneling. Arbitrary single-qubit X rotations are implemented by tuning the tunneling strength between the $|0\rangle$ and $|1\rangle$ sites of the appropriate column, and Z rotations by applying a local potential to the $|1\rangle$ site. Entanglement is generated by hopping between the $|1\rangle$ sites of adjacent qubits; by tuning the on-site interaction strength of the bosons, a non-trivial controlled phase is acquired if these two qubits are in the state $|11\rangle$. Because the quantum information is encoded entirely in the lattice positions of the bosons, the encoded qubits are inherently robust against decoherence. An implementation in terms of ultracold atoms in optical lattices is suggested.

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