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Robust and High Fidelity Quantum Logic with the Rydberg-Dressed Blockade TYLER KEATING, ROBERT COOK, IVAN DEUTSCH, University of New Mexico, AARON HANKIN, National Institute of Standards and Technology, YUAN-YU JAU, GRANT BIEDERMANN, Sandia National Laboratories — We study a scheme for implementing a controlled-Z (CZ) gate between two neutral-atom qubits based on the Rydberg blockade mechanism in a manner that is robust to errors caused by atomic motion. By adiabatically dressing the ground electronic state, we can protect the gate from decoherence due to random phase errors that typically arise from atomic thermal motion. The adiabatic protocol also allows for a Doppler-free configuration with counterpropagating lasers in a σ_+/σ_- orthogonal polarization geometry that further reduces motional errors due to Doppler shifts. The residual error is dominated by dipole-dipole forces acting on doubly-excited Rydberg atoms when the blockade is imperfect. For reasonable parameters, with qubits encoded into the clock states of 133Cs, we predict that our protocol could produce a CZ gate in $<10\ \mu$s with error probability of order 10^{-3}[1]. We generalize this protocol to exploit the multi-body nature of the Rydberg blockade and go beyond two qubits. We show how one can implement a three-qubit Toffoli gate in a single-step. Finally, we consider encoding in collective states of small ensembles of atoms, and show how such a scheme can allow for scalable, robust, quantum logic.

[1] T. Keating et al., Phys. Rev. A 91, 012337 (2015).

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