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Quantum logic in Group-II neutral atoms via nuclear-exchange interactions DAVID HAYES, University of New Mexico, IVAN DEUTSCH, PAUL JULIENNE, NIST — The spin exchange-interaction generates an entangling quantum-logic gate, the square-root of SWAP, at the heart protocols employing single electron quantum dots. This is typically accompanied by strong Coulomb interactions and commensurate decoherence due to strong coupling of charge degrees of freedom to the noisy environment. We propose a protocol utilizing a *nuclear-exchange* interaction that occurs through ultracold collisions of identical spin $1/2$ Group-II *neutral* atoms. A natural advantage is gained by storing the quantum information in nuclear spin states with long coherence times. Unlike NMR protocols based on weak magnetic dipole-dipole interaction, the nuclear exchange interaction stems from strong s-wave scattering of electrons. Nuclear exchange is ensured by the Fermi symmetry of the overall wave function. We have studied this protocol in the context of ^{171}Yb atoms trapped in far-off resonance optical dipole traps. Using quantum control analysis, high-fidelity operation is possible through controlled collisions in dynamically varied double-well trapping potentials.

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