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Dipolar Exchange Quantum Logic Gates Using Polar Molecules
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A current challenge in quantum computing is efficiently scaling ensembles of qubits without sacrificing fidelity and experimental simplicity. We propose a two-qubit gate based on the dipolar exchange interaction between ultracold polar molecules trapped in an array of optical tweezers. This proposal uses two long-lived nuclear spin states as storage qubits, while a third rotationally excited state with rotation-hyperfine coupling enables switchable exchange interactions between molecules to generate an iSWAP gate. We simulate the dynamics of this system using the full Hamiltonian of NaCs and demonstrate a potential two-qubit gate fidelity of $> 99.99\%$ in a coherent system that can be scaled by purely optical means.

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