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Designing Two-Qubit Gates for Exchange-Only Quantum Computation

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In exchange-only quantum computation, qubits are encoded using three or more spin-1/2 particles and quantum gates can be performed by switching on and off, or pulsing, the isotropic exchange interaction between spins. Finding efficient pulse sequences for realizing two-qubit gates in this way is complicated by the large search space of sequences and has typically involved numerical brute force search. Here I will give a simple analytic derivation of the most efficient known exchange-pulse sequence for carrying out a controlled-NOT gate [1], originally found numerically by Fong and Wandzura [2]. I will then show how the ideas behind this derivation can be used to analytically find new pulse sequences for two-qubit gates beyond controlled-NOT [3]. [1] D. Zeuch and N.E. Bonesteel, PRA 93, 010303 (2016). [2] B.H. Fong and S.M. Wandzura, Quantum Inf. Comput. 11, 1003 (2011). [3] D. Zeuch and N.E. Bonesteel, PRB 102, 075311 (2020).