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Understanding the Fong-Wandzura Sequence DANIEL ZEUCH, N.E. BONESTEEL, Department of Physics and NHMFL, Florida State University — In exchange-only spin quantum computation, logical qubits are encoded into the Hilbert space of three or more spin-1/2 particles (e.g. electron spins in quantum dots), and quantum gates are realized by sequences of Heisenberg exchange operations, or "exchange-pulses," acting on pairs of spins. It is easy to obtain pulse sequences for single-qubit gates, but difficult for entangling 2-qubit gates due to the large Hilbert space of six spins. The shortest known 2-qubit gate sequence, obtained by Fong and Wandzura via a numerical search [1], consists of 12 exchange pulses. Unlike a longer 2-qubit gate sequence constructed analytically in [2], this 12-pulse sequence has, until now, escaped intuitive explanation. Here, we analyze this sequence using techniques introduced in [2]. We find the 12-pulse sequence naturally decomposes into three parts, each consisting of the same partial pulse sequence acting on four spins at a time. This reduced sequence preserves certain total spin quantum numbers in a way that naturally suggests how it can be used to construct a leakage free entangling 2-qubit gate.

[1] B. H. Fong and S. M. Wandzura, Quantum Information & Computation 11, 1003 (2011).
[2] D. Zeuch, R. Cipri, and N. E. Bonesteel, Phys. Rev. B 90, 045306 (2014).

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