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A coherent beam splitter for electronic spin states[1] J. R. PETTA, H. LU, A. C. GOSSARD — Energy level crossings, where two quantum states cross in energy as a function of an external parameter, are ubiquitous in quantum mechanics. We demonstrate coherent control of electronic spin states in a double quantum dot by sweeping an initially prepared spin singlet state through a singlet-triplet anti-crossing in the energy level spectrum. The anti-crossing serves as a beam splitter for the incoming spin singlet state. Consecutive crossings through the beam splitter, when performed within the spin dephasing time, result in controllable coherent quantum oscillations between the singlet state and m_s=+1 triplet state, T_+. The observed quantum interference patterns are in good agreement with a theoretical model of consecutive Landau-Zener tunneling events. This all-electrical method for quantum control relies on electron-nuclear spin coupling and drives single electron spin-flip transitions on nanosecond timescales without electron spin resonance fields, which are difficult to localize on the nanometer scale.

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