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Long-lived spin and valley states in silicon for quantum information processing CHARLES TAHAN, MARK FRIESEN, ROBERT JOYNT, University of Wisconsin-Madison — Quantum electronics in silicon offers both challenges and opportunities for information technology. Here we take a challenge, the doubly degenerate conduction band minima of silicon quantum wells, and make it into an opportunity, stable valley states for quantum storage and control. We calculate the coupling between the two valley states using both tight-binding and approximate-analytic techniques for a lateral quantum dot. This determines the valley relaxation and optical excitation rates. Not only are the relaxation times uncharacteristically long for excited orbital states, but we find that for finite quantum wells there are 'magic' electric fields where the coupling goes to zero, suppressing valley relaxation and excitation. In the process we derive new expressions for single-valley orbital relaxation (which is very fast) and qubit spin-flip times (due to spin-orbit coupling) and compare them to valley state relaxation. We discuss important implications for 'valley qubits' in silicon quantum information processing and technology.

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