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Coherent control of donor states in Si[1]

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The spin degrees of freedom of group V donors in Si satisfy many of the criteria required for qubits [1,2]. The orbital Rydberg states of group V donors can also be used to control these spins coherently [3,4]. Critical to such schemes are the population (T_1) and dephasing (T_2) lifetimes of these Rydberg states. We describe the use the free electron laser FELIX [5] to perform pump-probe experiments to measure T_1 [6] and photon echo experiments to measure T_2 [7]. The lifetimes we obtain from a theoretical analysis of the experiments are $\sim$ 200 ps, which is long enough for orbital excitation to be a practical control mechanism for 2-qubit quantum gates. The experimental and theoretical analysis of these gates is also described.

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