Coherent control of donor states in Si

THORNTON GREENLAND, London Centre for Nanotechnology and Department of Physics and Astronomy, University College London, WC1H 0AH, England

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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