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Spin relaxation of exchange-coupled donors in silicon A.M. TYRYSHKIN, S. SHANKAR, S.A. LYON, Princeton University — The exchange interaction (J-coupling) between electron spins provides a natural way to accomplish two-qubit operations in a spin-based, solid-state quantum processor. The J-coupling, because of its electrostatic (Coulombic) nature, is susceptible to charge noise in the environment, and hence turning on the J- coupling may cause fast decoherence of the interacting spin qubits. To clarify the effect of J-coupling on spin coherence, we performed spin relaxation measurements for exchange-coupled donors in dimers and trimers randomly formed in bulk-doped natural silicon and isotopically-purified ^{28}Si. The longitudinal relaxation time, T_1, for donors in exchange- coupled dimers is found to be identical to that of isolated donors at temperatures 8-15K, solely determined by a two-phonon Orbach mechanism. The transverse relaxation time, T_2, for dimers is even longer than that of isolated donors because of the lower density of the dimers in our samples and thus substantially reduced dipole-dipole interactions. In natural silicon containing 5% ^{29}Si magnetic nuclei, an additional decoherence results from the nuclear-induced spectral diffusion. The spectral diffusion decoherence of J-coupled dimers and trimers is also identical to that of isolated donors. We conclude that J-coupling does not induce any additional decoherence in bulk donors in Si. However, the situation may change for donor dimers placed closer to the surface where more charge noise is expected. Supported by LPS/ARO.

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