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Dynamic nuclear polarization with single electron spins[1]

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Hyperfine interactions limit electron spin coherence times in GaAs quantum dots. By separating a spin singlet state on a chip, we measure an ensemble averaged spin dephasing time T_2^* of 10 ns, limited by the contact hyperfine interaction with the GaAs host nuclei[2]. We use electrical control of the exchange interaction to drive coherent spin rotations. Exchange driven spin rotations are used to implement a "singlet-triplet spin echo" pulse sequence, which leads to a spin coherence time, T_2, exceeding 1 microsecond. We show that nuclear spins can be polarized by controlling two-electron spin states near the anti-crossing of the singlet (S) and triplet (T_+). An initialized S state is cyclically brought into resonance with the T_+ state, where hyperfine fields drive rapid rotations between S and T_+, "flipping" an electron spin and "flopping" a nuclear spin[3]. The resulting Overhauser field approaches 80 mT, in agreement with a simple rate-equation model. A self-limiting pulse sequence is developed that allows the steady-state nuclear polarization to be set using a gate voltage.

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[2]J. R. Petta *et al.*, Science **309**, 2180 (2005).

[3]J. R. Petta, J. M. Taylor *et al.*, Phys. Rev. Lett. **100**, 067601 (2008).