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Zero-field optical manipulation of magnetic ions in semiconductors[1]

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For coherent spin information processing, spin coherence times must be long enough to perform multiple state operations, thus requiring a balance between gating time and spin lifetime. Because single magnetic spins in semiconductors can be strongly coupled to both itinerant carriers and to other magnetic ions, these interactions can be rapidly manipulated optically and electrically. We show that small numbers of magnetic spins in III-V GaAs quantum wells can be polarized by optical spin injection without the need for applied magnetic fields, and exhibit unusually long coherence times [3]. Mn ions provide acceptor states within the bandgap of GaAs [4], enabling optical readout and control of the magnetic ions in a manner distinct from paramagnetic II-VI materials. Spin polarized electrons created within the quantum well dynamically orient the Mn spins in a manner analogous to dynamic nuclear polarization, generating a dynamic exchange splitting of the magnetic spins. The Mn ions are manipulated at zero field solely by changing the excitation helicity or energy. Ion spin lifetimes increase sharply as the concentration is reduced exhibiting T_2^* times exceeding 6 ns at the lowest doping, longer than is typically observed in other magnetic semiconductors. These results indicate that hole-mediated Mn-Mn interactions dominate the decoherence, and suggest that long lifetimes may be expected for single Mn spins in GaAs.

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[2]In collaboration with M. H. Mikkelsen, J.-M. Tang, M. E. Flatté, A. C. Gossard, and D. D. Awschalom.
[3]R. C. Myers, M. H. Mikkelsen, J.-M. Tang, M. E. Flatté, A. C. Gossard, and D. D. Awschalom, *submitted* (2007).
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