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Gate-voltage control of spin interactions between electrons and nuclei in a semiconductor☆

J.H. Smet[a,*], R.A. Deutschmann[b], F. Ertl[b], W. Wegscheider[b,c], G. Abstreiter[b], K. von Klitzing[a]

[a] *Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany*
[b] *Walter Schottky Institut, Technische Universität München, D-85748 Garching, Germany*
[c] *Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany*

Abstract

Semiconductors are ubiquitous in device electronics, because their charge distributions can be conveniently manipulated with applied voltages to perform logic operations. Achieving a similar level of control over the spin degrees of freedom, either from electrons or nuclei, could provide intriguing prospects for information processing and fundamental solid-state physics issues. Here, we report procedures that carry out the controlled transfer of spin angular momentum between electrons—confined to two dimensions and subjected to a perpendicular magnetic field—and the nuclei of the host semiconductor, using gate voltages only. We show that the spin transfer rate can be enhanced near a ferromagnetic ground state of the electron system, and that the induced nuclear spin polarization can be subsequently stored and 'read-out'. These techniques can also be combined into a spectroscopic tool to detect the low-energy collective excitations in the electron system that promote the spin transfer. The existence of such excitations is contingent on appropriate electron–electron correlations, and these can be tuned by changing, for example, the electron density via a gate voltage.

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* Corresponding author.
E-mail address: j.smet@fkf.mpg.de (J.H. Smet).

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