Nuclear spin diffusion in double quantum wells
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When we think about nuclear manipulation in semiconductor nanostructures, it is essential to understand the nuclear spin diffusion. We have studied the nuclear spin diffusion in double quantum wells (QWs) by using dynamic nuclear polarization (DNP) at a Landau level filling factor ν=2/3 spin phase transition (SPT). The longitudinal resistance increases during the DNP of one of the two QW (the "polarization QW") by means of a large applied current and starts to decrease just after the termination of the DNP. On the other hand, the longitudinal resistance of the other QW (the "detection QW") continuously increases for approximately 2 h after the termination of the DNP of the polarization QW. It is therefore concluded that the nuclear spins diffuse from the polarization QW to the detection QW. The time evolution of the longitudinal resistance of the polarization QW is explained mainly by the nuclear spin diffusion in the in-plane direction, which is roughly estimated to be 4 nm^2/s. In contrast, that of the detection QW manifests much slower nuclear diffusion, 0.07 nm^2/s, in the perpendicular direction through the AlGaAs barrier. One possible explanation of such strong anisotropic diffusion might be the modified quadrupole couplings produced by the slight lattice mismatch between the GaAs wells and AlGaAs barriers. In addition, the spin-lattice relaxation times, T_1, is estimated to be about 5 ×10^4 sec. This value is much longer than the usually estimated relaxation time of 1000 sec, which is still determined by the nuclear spin diffusion.

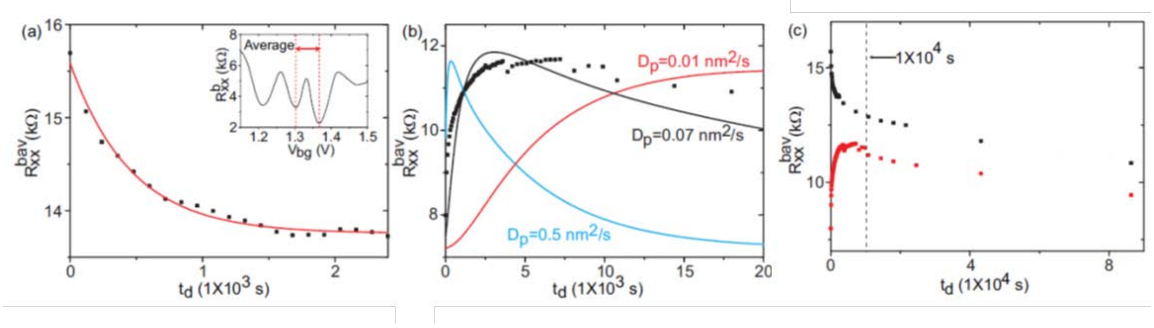

Fig. 1 (a) Averaged value of the back QW SPT peak R_{xx}^{bav} as a function of t_d (duration of full depletion) after nuclear polarization of the back QW. The SPT peak is averaged between the two red dashed lines in the inset. The time evolution is mainly determined by the in-plane nuclear diffusion. (b) R_{xx}^{bav} as a function of t_d after nuclear polarization of the front QW. Here, the time evolution is determined by perpendicular nuclear diffusion with the best fit of D_p = 0.07 nm^2/s. (c) R_{xx}^{bav} as a function of long t_d after nuclear polarization of the back (black squares) and front QWs (red squares). The long tail of the time evaluation reflects true T_1 of nuclear spins.

Representative publication:

1. T. Hatano, W. Kume, S. Watanabe, K. Akiba, K. Nagase, and Y. Hirayama, "Anisotropic nuclear-spin diffusion in double quantum wells", Phys. Rev. B91, 115318 (2015).