NUCLEAR SPIN MANIPULATION IN MAGNETICALLY DOPED QUANTUM WELLS

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Introduction

Magnetotransport study in diluted magnetic semiconductor (DMS) modulation doped $Cd_{1-x}Mn_xTe/Cd_{0.8}Mg_{0.2}Te$ quantum wells (QW) reveals slow dynamics at Landau level coincidence which reflects changes of nuclear spin polarization and/or reconfiguration of magnetic domain in the regime of the quantum Hall ferromagnet.

Experimental

We have measured 3 samples with electron density n_s= 5.5, 4.5, and 3 $10^{11}/cm^2$ and Mn content x= 0.02, 0.006, and 0.02, respectively. The samples were measured down to T = 20 mK , up to B = 18 T, under excitation currents up to 1 μA, and under radio frequency (1 – 500 MHz) radiation.

Results and Discussion

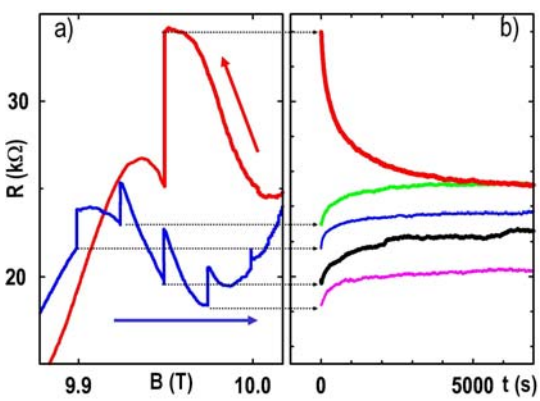

Fig. 1 Hysteresis in the region of the QHFM spike (a). The field is swept at 0.004 T/min. Sweeps are interrupted and slow resistance relaxation is recorded (b). This relaxation may reflects slow reconfiguration of the ferromagnetic domain and/or changes in nuclear spin polarization.

Samples show high quality, well resolved Hall plateaux at integer filling factors ν and typical Shubnikov-de Haas maxima in longitudinal resistance. Also, additional anomalous resistance spikes are observed at ν ≈ 2,5,8 where Landau levels cross (e.g. 0↓ with 1↑ at ν ≈2), a sign of Ising quantum Hall ferromagnetism (QHFM) , where domains with different electronic spin orientation coexist and additional conductance along their walls breaks the quantum Hall regime. If, as some theories claim, nuclear spin polarization is involved in the QHFM formation, one should expect resistance variation when nuclear polarization changes either with time, or under conditions of nuclear spin resonance (NMR), or when it is dynamically induced by DC currents.

We observed resistance hysteresis at QHFM spike as well as slow resistance relaxation after interrupting the B sweep (Fig 1). We possibly observed resistively detected NMR in our heterostructures in the QHFM regime. Moreover, an apparent influence of DC current on the resistance probably reflects dynamic nuclear polarization. In the latter case slow relaxation is accompanied by sudden jumps. Such jumps have been observed previously in GaAs devices [1] and interpreted as an evidence for domains flips. However, striking regularity of the resistance jumps in our case may suggests a different explanation.

Conclusions

Our preliminary results suggest at least some influence of the nuclear spin polarization on QHFM formation in (Cd,Mn)Te quantum wells. However, more work is needed to clarify a microscopic mechanism of the observed phenomena.

Acknowledgements

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References

[1] Smet J. *et al.* , Phys. Rev. Lett. **86**, 2412-2415 (2001).