Spin Dependent Transport in Diluted Magnetic Heterostructure

G. Karczewski, W. Zaleszczyk, M. Wiater, T. Wojtowicz, (Institute of Physics, Polish Academy of Sciences, Warsaw); J. Jaroszyński, A. Reyes, P. Kuhns, W. Moulton (NHMFL)

Introduction

Diluted magnetic semiconductors (DMS) are currently being heavily researched because of their great potential in spintronics devices. At the same time, DMS offer a worthwhile opportunity to study interplay between charge and spin degrees of freedom. In particular, a giant and nonmonotonic Zeeman splitting leads in 2D DMSs to Landau level (LL) coincidences at *selected* magnetic field B_c without tilting the sample. Previous studies [1] revealed a formation of quantum Hall ferromagnets (QHFM) at crossing of spin subbands belonging to *different* LL (e.g. 0^+ and 1^-). Here we report on the possible formation of QHFM when spin subbands of *the same* LL (e.g. 0^+ and 0^-) are brought into coincidence.

Experimental

Systematic magnetoresistance measurements were carried out in SCM-1 down to T = 20 mK , up to B = 18 T, and for different tilt angles. Modulation doped $Cd_{1-x}Mn_xTe/Cd_{0.8}Mg_{0.2}Te$ heterostructure with electron density n_s=2 $10^{11}/cm^2$ and low Mn content x= 0.002 was grown by molecular beam epitaxy.

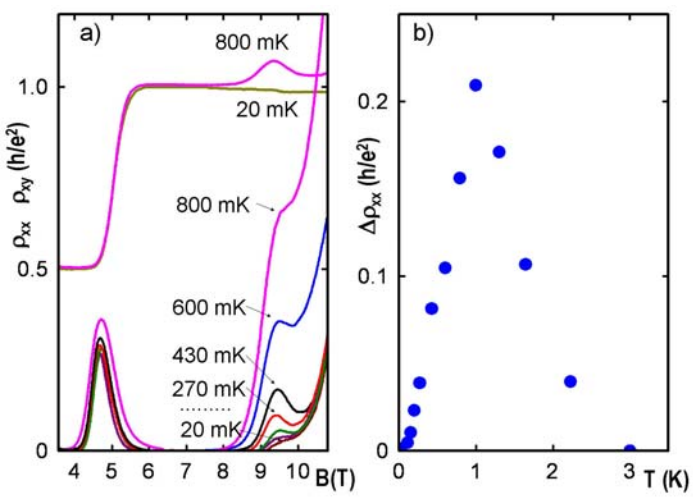

Figure 1 a) Longitudinal and Hall resistivities at different T
b) Amplitude of the anomalous maximum vs. T

Results and Discussion

With such a low Mn content s-d exchange spin-splitting is relatively small and comparable with the intrinsic band splitting, but has opposite sign, thus spin-subbands of the same LL are expected to cross at B ≈ 10 T. Indeed, as it is shown in Fig. 1a an additional maximum of ρ_{xx} is clearly seen in this region. It is distinct from usual Shubnikov-de Haas maxima. Its magnitude changes nonmonotically with T and peaks at T≈ 1 K, as shown in Fig. 1 b. Moreover, its position does not change with the tilt angle. This strongly suggests that it originates from the formation of QHFM. Such additional QHFM maxima are usually understood in terms of transport along domain walls [2]. However, this theory does not expect any anomaly when spin subbands from the same LL cross. In contrast, recent calculations [3] within the spin-density-functional theory, which does not account for domain formation, could explain the observed anomaly.

Conclusions

Our results suggest quantum Hall ferromagnet formation at the coincidence of spin subbands of the lowest LL, strongly supporting recent theoretical studies [3].

Acknowledgements

This work was supported by NHMFL through NSF Cooperative Agreement No. DMR-0084173, by the State of Florida, by the DOE, and by the Ministry of Science and Higher Education (Poland) through the Project N202 05432/1198.

References

[1] Jaroszynski, J., *et al.*, Phys. Rev. Lett., **89**, 266802 (2002)
[2] Jungwirth, T., *et al.*, Phys. Rev. B, **63**, 035305 (2000)
[3] Freire, H.J., *et al.*, Phys. Rev. Lett., **99**, 026801 (2007)