Quantum Hall Ferromagnet effect in CdMnTe

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The presence of magnetic ions in two-dimensional electron gas (2DEG) leads to correlation effects, which modulate Landau levels (LLs) splitting. In particular, LLs corresponding to opposite spin orientations may overlap at the Fermi level. As a consequence spin order is expected in the 2DEG system and such state is called the quantum Hall ferromagnet (QHFM). One of the manifestation of QHFM is the abrupt increase of longitudinal megnetoresistance ($R_{xx}(B)$) at certain B_c[1]. The idea of our experiment came from the opportunity of the manipulation of the 2DEG concentration in wide range (from $3 \times 10^{11}\text{cm}^{-2}$ to $6.4 \times 10^{11}\text{cm}^{-2}$).

We investigated structures with Mn ions uniformly incorporated in the modulation-doped CdTe quantum well. $R_{xx}(B)$ and $R_{xy}(B)$ were measured in magnetic field up to B=8.5 T at temperature T=1.5 K. Sample was illuminated gradually by the green light emitting diode (λ=530 nm). The illumination changed 2DEG concentration and hence position of the Fermi level. Therefore, we observed evolution of the $R_{xx}(B_c)$ cusp related to QHFM: changes of the cusp amplitude and shift of the cusp position. Moreover, we noticed a peculiar behavior of $R_{xy}(B)$: sudden increase or decrease of $R_{xy}(B_c)$ in respect of the filling factor. Deviation from discrete value $R_{xy}(B) = h/ie^2$ were already predicted and observed in Ref.[2,3,4]. However, presented results are the first systematic studies of $R_{xy}(B)$ in CdMnTe with different 2DEG concentration.

We identified that experimental results can not be interpreted as "overshooting". $R_{xx}(B)$ and $R_{xy}(B)$ were analyzed with the proposed model of the moving Fermi level crossing the broadened LLs. Electron-electron interaction and coupling to Mn ions are possible explanations of the observed phenomena.

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