Quantum Hall Ferromagnet in Magnetically-Doped Quantum Wells[1]

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A giant and nonlinear Zeeman splitting in diluted magnetic semiconductors (DMS) offers a unique opportunity to examine quantum Hall ferromagnetism (QHF) since crossing of Landau levels (LL) can be achieved in moderately strong ($B_{tot} \approx 1$ T) total magnetic fields.

We carried out magnetoresistance studies on a modulation-doped, gated heterostructures of $Cd_{1-x}Mn_xTe/Cd_{1-y}Mg_yTe$:I with peak electron mobility $\mu \approx 25000$ cm^2/Vs and electron density n_s tuned in the range 1.4×10^{11} cm^{-2} $< n_s <$ 4×10^{11} cm^{-2}. We put into evidence observation of the Ising quantum Hall ferromagnet with Curie temperature T_C as high as 2 K. High T_C and low B involved made it possible to collect magnetoresistance data over a wide range of temperatures, magnetic fields, tilt angles, exciting currents, and electron densities.

QHF in our device is manifested by anomalous magnetoresistance spikes, their hysteretic behavior, and time-dependent resistance, similar to earlier observations in III-V heterostructures. However, in our system these phenomena are much stronger, especially when either 2^+ or 1^+, and 0^- LL are brought into coincidence.

The magnitude of the QHF spikes depends dramatically on the history of the sample, shows hysteresis when either B or gate voltage are swept, stretched-exponential time evolution characteristic of glassy systems, and strong Barkhausen noise reflecting the dynamics of ferromagnetic domains. Our study indicates that these metastabilities stem from the electronic systems itself while the nuclear spin polarization play rather a minor role. The results agree with a predicted transition from a QHF to a quantum Hall spin glass phase when disorder is sufficiently strong.

Data are discussed taking into account both Coulomb electron-electron interactions and s$-$d coupling to Mn spin fluctuations. The critical behavior of the resistance spikes at $T \rightarrow T_C$ corroborates theoretical suggestions that the ferromagnet is destroyed by domain excitations.

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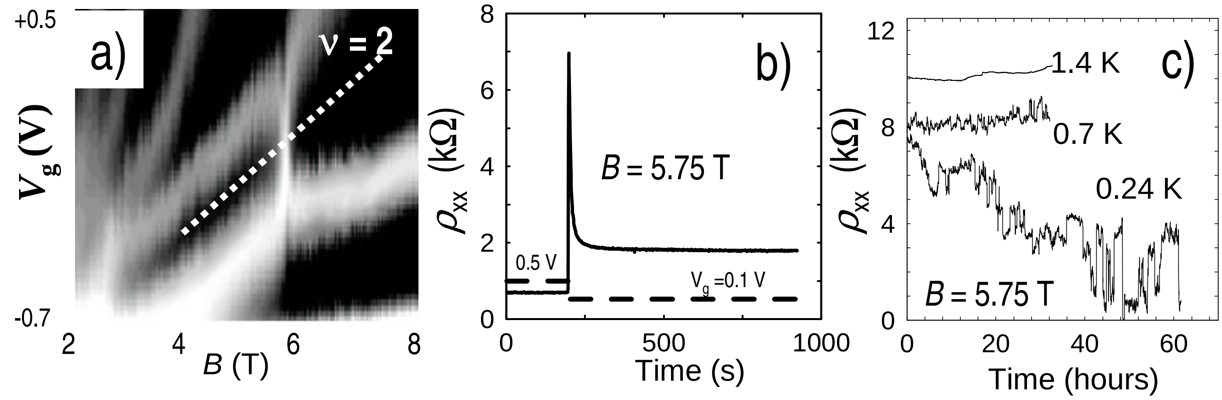

Figure 1: (a) Longitudinal resistivity as a function of the magnetic field and gate voltage. Dark (bright) regions represent low (high) resistivity. (b) Resistance relaxation after instant change of the gate voltage. (c) Resistance evolution in the region of QHF spike.

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