Transport Properties of the Quantum Hall Ferromagnet in a Parabolic Wells

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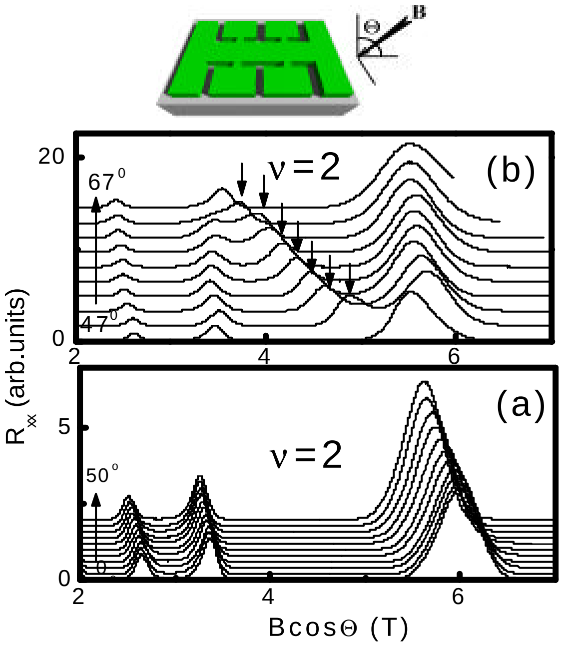
Two-dimensional (2D) states in the quantum Hall regime at Landau filling factors ν=2,4,6... undergoes the unpolarized-ferromagnetic transitions in the limit of vanishing effective Lande **g** factor [1], when electron exchange-correlation energy becomes larger than cyclotron energy. Properties of such quantum Hall ferromagnet (QHF) have been a subject of recent theoretical and experimental works. The best candidate for the study of the transport anomalies in QHF is a wide width well with several subbands, because the energy gap between Landau levels in a strong magnetic field is determined by the energy-level spacing ΔE_{ij} at zero field, which is much smaller than $\hbar\omega_c$ (ω_c is the cyclotron frequency). Since the exchange -correlation energy E_{exc} increases with magnetic field, it is expected that $E_{exc} > \Delta E_{ij}$ at some crytical magnetic field, and magnetic transition occurs. Such coincidence can be tuned in the tilting magnetic field experiments, because ΔE_{ij} decreases with tilt angle.

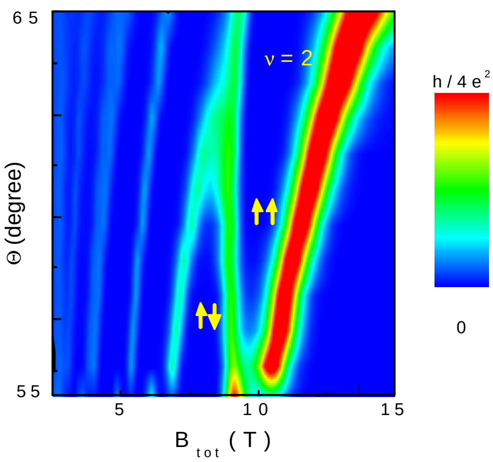
We observed an anomalous magnetoresistance peak in tilted magnetic field corresponding to the filling factor 2 and 4 in parabolic wells with widths ranging from 1000 to 3000 Å The position of the peak is determined by the bare width of the parabolic potencial : peak moves to the lower magnetic field with increasing of the width. We attribute this peak to unpolarized-ferromagnetic transition in quantum Hall ferromagnet. As has been argued by Falko and Iordanskii [2], disorder arising from the density inhomogeneities produces a multidomain structure. Therefore, transport in a QHF is attributed to the diffusion along the network formed by the domain walls in analogy with transport in integer quantum Hall effect. We found that the behavior of the anomalous peak resembles the typical behavior of the magnetoresitance peak in a quantum Hall insulator-Hall metal transition. This behavior can be explained by percolation along the domain walls with an Ising-like structure. It is supported by the absence of the temperature dependence of the anomalous peak. We did not find hysteresis behaviour which usually associated with domain formation. We proposed, that the domains are stabilized by the random impurity potential. We also found that the anomalous peak moves from low filling factor to high ν with increasing tilt angle Θ. Qualitatively, it can be explained by the increase of the exchange-correlation energy with perpendicular component of the magnetic field $B_\perp$. Since the Zeeman splitting in our system is very small, the exchange energy is comparable with the energy-level separation in our PQWs. Therefore we have demonstrated that a parabolic quantum well is a promising system for understanding the physics of quantum Hall ferromagnets.

References

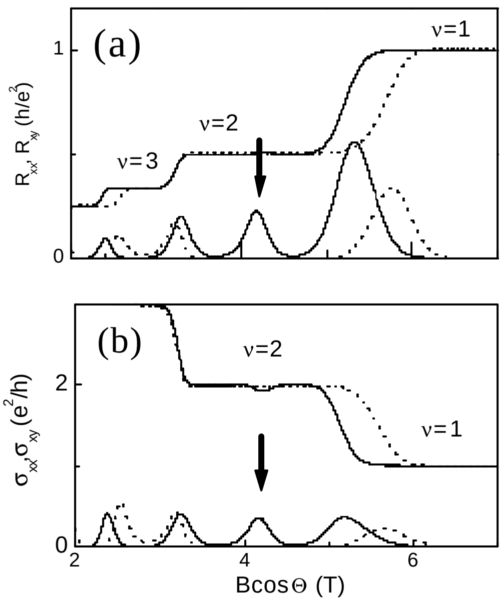
1. The quantum Hall effect, edited by R.E.Prange, S.M.Girvin, New York, 1990.
2. V.I.Falko, S.V.Iordanskii, Phys.Rev.Lett., **82**, 402 (1999).



Magnetoresistance of a 2000 Å PQW as a function of the normal component of the magnetic field for different tilt angles Θ between the applied magnetic field and the plane of the substrate at T = 50 mK (a-0°<Θ<50°; b- 47°<Θ<67)°. The in-plane magnetic-field component is directed along the x axis, parallel to the current flow. Top - schematic view of the sample and experiment geometry.



Magnetoresistance of a 2000 Å PQW as a function of the total magnetic field for different tilt angles Θ between the applied magnetic field and the plane of the substrate at T = 50 mK



Longitudinal R_{xx} and transverse R_{xy} resistance (a) and longitudinal σ_{xx} and transverse σ_{xy} conductance (b) of a 2000 Å PQW as a function of the magnetic field at Θ=0° (dashes) and Θ = 60°, T=50 mK. Arrows indicate anomalous peak.