Magneto-resistance Anomalies at Level Crossing in Double Layer Quantum Hall Systems

K. Kodera, **A. Endo, K. Kobayashi, S. Katsumoto, and Y. Iye**

Institute for Solid State Physics, University of Tokyo, Kashiwa, Chiba 277-8581, Japan

The quantum Hall effect in double layer two-dimensional electron gas (2DEG) systems has attracted much attention in recent years. The bilayer (pseudospin) degree of freedom introduces an extra complexity in the Landau level scheme in addition to the ordinary spin degree of freedom. Depending on the relevant parameter values, various situations of level scheme and crossing of the Landau levels can occur and they leads to novel electronic states dictated by interplay between the interlayer tunneling and the intra- and interlayer Coulomb interactions.

We have investigated the magneto-resistance features of bilayer 2DEG systems in quantum Hall regime under asymmetric conditions where the electron densities of the two layers are off-balance. The sample employed here is a gated GaAs/AlGaAs double quantum well structure consisting of two 200Å GaAs quantum wells separated by a 50 Å $Al_{0.33}Ga_{0.67}As$ barrier. A front gate was used to control the carrier density. Figure 1 shows the characteristics of carriers in each of the two layers a function of the front gate bias V_g. Here, n_f and μ_f (n_b and μ_b) represent the electron density and mobility in the front (back) layer. The relatively large barrier layer thickness and the asymmetric condition make the interlayer coupling unimportant except for the regions of level crossing.

Figure 2 shows the Landau level scheme and the magneto-transport data for an extremely asymmetric case, n_f/n_b~0.1 realized at V_g=-0.5V. The solid (dashed) curves in the lower panel are the data taken by down- (up-) sweep of the magnetic field. The filling factors of the front and back layers for each quantum Hall states are given in the figure. A distinct hysteresis is observed at B~6T, where the N=0 Landau level in the front layer and the N=3 Landau level in the back layer are close to each other. The quantum Hall state ν_{total}=7 (ν_f=1, ν_b=6) is fount to be more stable when the magnetic field is down-swept. A similar phenomenon is observed for the ν_{total}=5 state (ν_f=2, ν_b=3) in Fig.3 (n_f/n_b~0.55).

Figure 4 shows magnetotransport data obtained in measurements after a different cool down. The resistance peak at B~9T (marked by the arrows) is peculiar in that the corresponding Hall resistance remains unchanged on both sides of the resistance peak. The position of this anomalous peak is insensitive to the front gate bias. Although this seems to suggest that the anomalous peak is primarily attributed to the electron system in the back layer, the interlayer charge redistribution must be playing a role in this phenomenon.

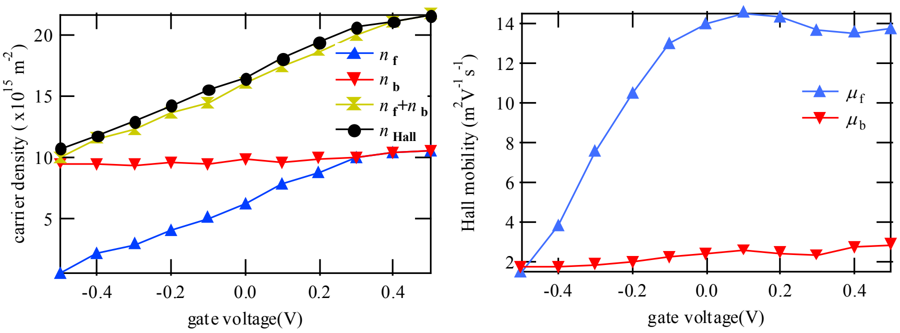

Fig.1: The electron density and mobility in the front and back layers as a function of the front gate bias.

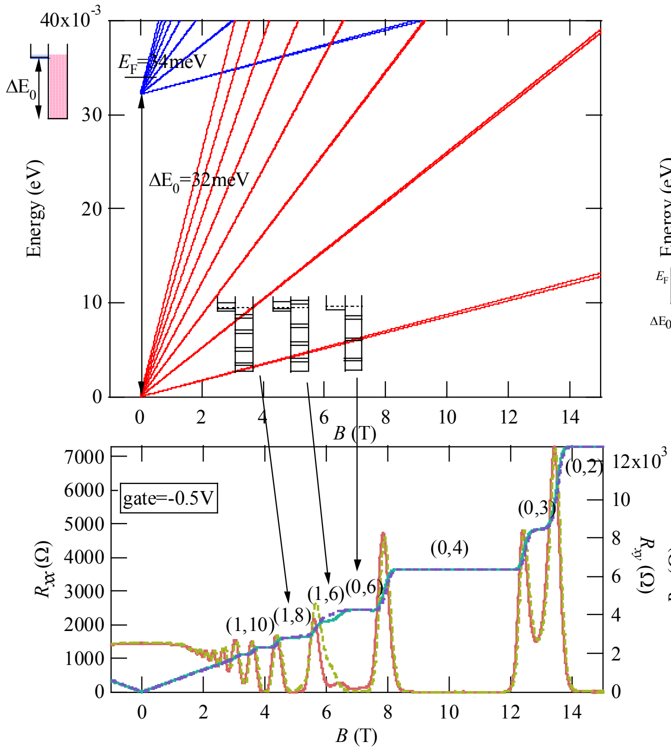

Fig.2: The Landau level scheme and the magneto-transport data for an extremely asymmetric case, gate bias = -0.5V. The filling factor of each layer (ν_f, ν_b) is given.

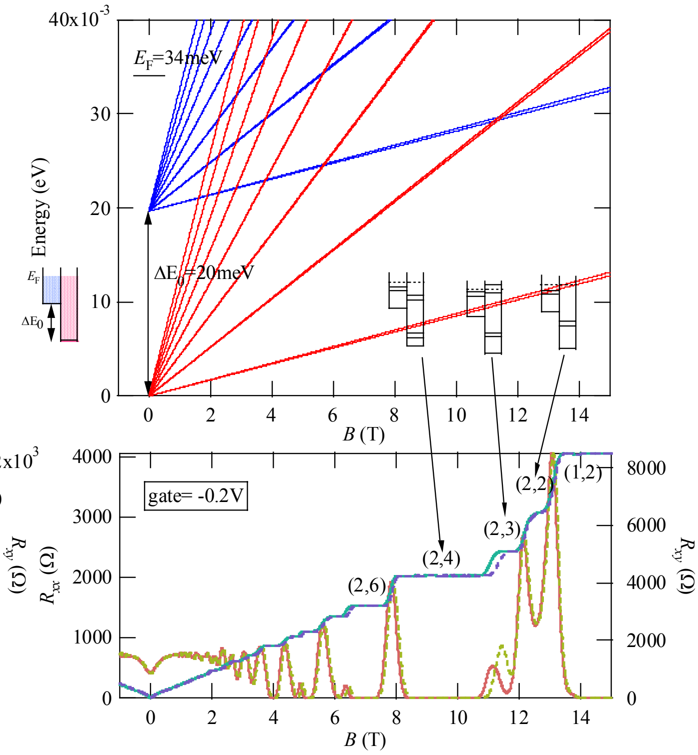

Fig.3: The Landau level scheme and the magneto-transport data for an asymmetric case, gate bias = -0.2V. The filling factor of each layer (ν_f, ν_b) is given.

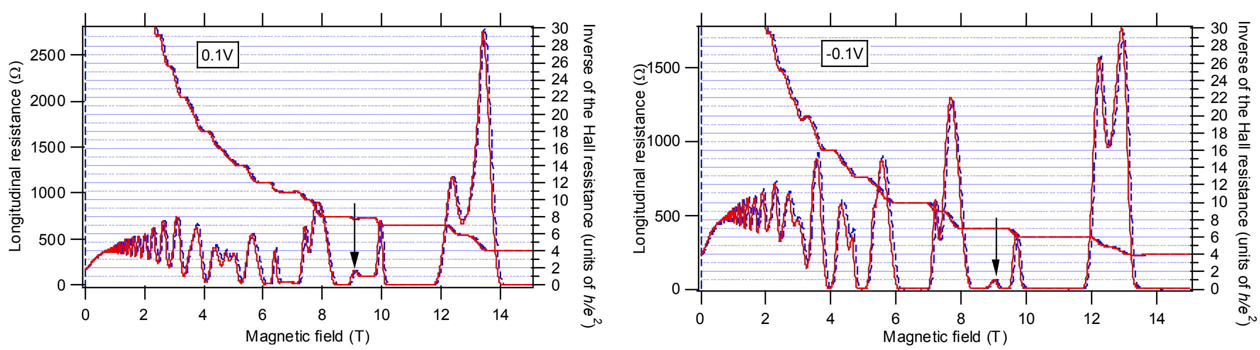

Fig. 4: The magnetoresistance and the inverse Hall resistance (filling factor) of the same sample after a different cooldown. The peak at B~9T (indicated by the arrow) is peculiar in that the corresponding Hall resistance remains unchanged on both sides of the resistance peak.