Soliton Lattice Phase and Anisotropic Transport in ν_T=1 Bilayer Quantum Hall State

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The bilayer quantum Hall (QH) state at the total Landau level filling factor $\nu_T = 1$ is the most simple system, yet it still shows various fascinating quantum phenomena due to the layer degree of freedom called 'pseudospin'. This state is described as a broken-symmetry state with a spontaneous interlayer phase coherence or as a Bose-Einstein condensate of composite bosons.

In this work we report on our experimental results on the commensurate (C)-incommensurate (IC) transition at $\nu_T = 1$, which occurs in association with the change of the pseudospin symmetry induced by the in-plane magnetic field ($B_{//}$). Our new finding is a broad maximum in the magnetoresistance (R_{xx}) between the C and IC phases around the C-IC transition point. Qualitatively the same results have been obtained for two different samples with tunneling energy of 11 K and 33 K. The temperature dependence of R_{xx} showing the maximum remains finite down to 50 mK. This fact indicates that there is a dissipative phase between the C and IC phases. We also found that the R_{xx} maximum disappears for larger layer imbalance of charge density, indicating that the pseudospin plays an important role. Accordingly, we conclude that this phase corresponds to the theoretically predicted soliton lattice (SL) phase. As far as we know, it is the first observation of the pseudospin domain structure, which affects the quantum transport phenomena. The SL phase consists of numbers of pseudospin domain walls, which should align parallel to $B_{//}$. Domain walls are expected to act as the line defects against the electric current flow (I) in the two-dimensional system.

To investigate the effect of domain walls to magnetotransport, R_{xx} that depends on the direction of $B_{//}$ was also measured for various relative angles (ϕ's) between $B_{//}$ and I near the bilayer $\nu_T = 1$ QH system. We found that the longitudinal resistance strongly varies when we changed ϕ. The anisotropy becomes remarkable at the phase transition point between the C and IC phases. The observed anisotropy is most strong when the charge density of each layer is balanced and vanishes at the monolayer point. We make a qualitative argument on the theoretically predicted 'rippled state' which is considered to be one of the candidates for this anisotropy. Though the exact relationship between the observed anisotropy and the SL phase is unclear, we can conclude that two-dimensional pseudospin textures strongly affect the anisotropic quantum transport phenomena.