The influence of the edge effects on the Hall resistance anomaly

E. M. Kendirlik[1], S. Sirt[1,2], S. B. Kalkan[1] and A. Siddiki[1]

[1] *Department of Physics, Istanbul University, 34134 Istanbul, Turkey*

[2] *Department of Physics, Mimar Sinan Fine Arts University, 34360 Istanbul, Turkey*

At low temperatures and in strong magnetic fields, it is found that the Hall resistance of a two dimensional electron system has plateaus as a function of the number of electrons or magnetic field, and is quantized [1]. However, under these conditions, an unexpected non-monotonic magnetic field B dependence of the Hall resistance at the low-field-end of the quantized plateaus, known as the overshoot effect, remains a puzzle despite both theoretical and experimental efforts. The challenge to utilize the integer quantized Hall effect (IQHE) as a resistance standard would be hindered by such anomalies, especially their physical mechanism is not well understood. This effect had been attributed to the decoupling of the spin-split states within the same Landau level (LL) at odd filling factors by Richter and Wheeler [2] and the scattering between edge states, together with spin-orbit interaction by Komiyama and Nii [3].

In this work,it is reported on systematic experimental findings considering smooth edge defined narrow Hall bars. The overshoot effect observed at the intermediate mobility 2D electron systems are scrutinized and analyzed within the screening theory of the IQHE. We contributed to the understanding of the overshoot effect by performing magneto-transport measurements and investigated the scattering between the edge-edge and edge-bulk evanescent incompressible strips. Unexpectedly, the overshoot effect becomes more pronounced at elevated temperatures, where the Hall bars are defined by shallow chemical etching. In addition, we observe the overshoot effect also at even integer plateaus, which rules out a possible spin dependent explanation, commonly discussed in the literature. All the effect can be elucidated taking into account direct coulomb interaction, namely the screening theory of the IQHE.

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