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THE ROLE OF EDGE CURRENTS IN DISSIPATIVE TRANSPORT AT STRONG MAGNETIC FIELDS .

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Effect of ohmic contacts on both the Hall resistance and magnetoresistance is observed. This result proves an existence of the edge currents in a dissipative regime at noninteger filling factors. Experimental curves can be quantitatively explained in terms of a model considering a finite length for equilibration between the upper and lower Landau levels.

Effect of voltage probes on measured resistances provides an unambiguous evidence that edge currents are of importance. Introduced for the quantum Hall regime, ideas of the edge states apparently have to be reconsidered in a dissipative regime corresponding to transitions between successive Hall plateaus. The main complication is that in this case the edge states are no longer stationary. In this paper we present experimental results which clearly demonstrate the effect of the potential probes in the dissipative regime and discuss these results in terms of different approaches [1-3].

We have investigated two samples of GaAs/AlGaAs heterojunctions with electron concentration about $1.6*10^{11}$ cm^{-2} and mobility about $4*10^{5}$ cm^{2}/V s. The layout of our samples is sketched in the inset to Fig.1. The doped regions of the ohmic contacts are dotted and the Schottky gates are shaded. Application of a gate voltage allows to vary the filling factor in the sample regions underneath the gates. The same voltage V_g was applied to both gates. Magnetoresistance R_{xx} and Hall resistance R_{xy} were measured between contacts A and D, B and C, respectively. Typical experimental traces are shown in Fig.1. The experimentally observed effects have been predicted by the authors [2] on the basis of a simple model considering macroscopic dissipationless edge currents. Unfortunately, the model [2] gives only some relations between R_{xx} and R_{xy} but not their accurate absolute values. Results of quantitative comparison with models [1,3] are shown in Fig.2. For both models all contacts have been included into consideration and a corresponding system of linear equations has been solved. A negative gate voltage was considered to prevent from penetration of the upper Landau level into reservoirs in the central Hall probes.

All material parameters in the sample body were assumed to be independent of the gate voltage. These parameters were chosen for each value of the filling factor. The model [3] introduces a finite equilibration time between the upper Landau level and other levels and uses a magnetoconductivity tensor with components σ_{xx} and σ_{xy} to describe the current flow through the upper level. So it operates with three unknown material parameters. The model [1] neglects the equilibration and uses only one material parameter to describe backscattering of the edge states. The model [1] can not definitely describe our results with reasonable accuracy while the model [3] demonstrates much better agreement with four experimental curves using only three fitting parameters whose values lie within the expected ranges. We believe the success of the model [3] is a result of taking into consideration the main physical phenomena involved.

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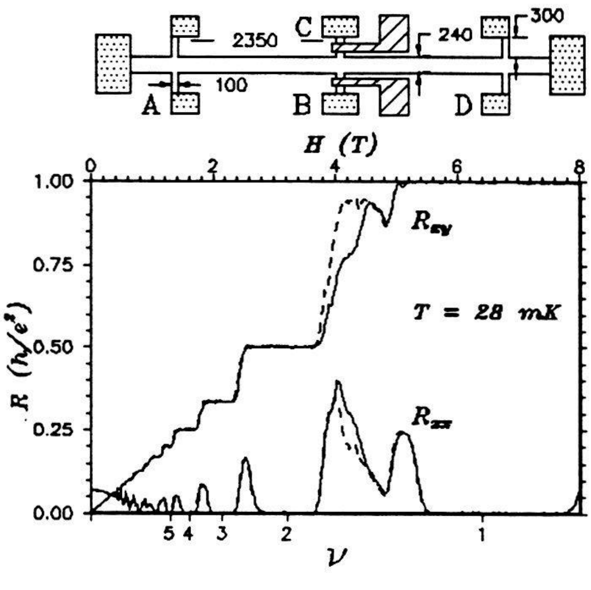

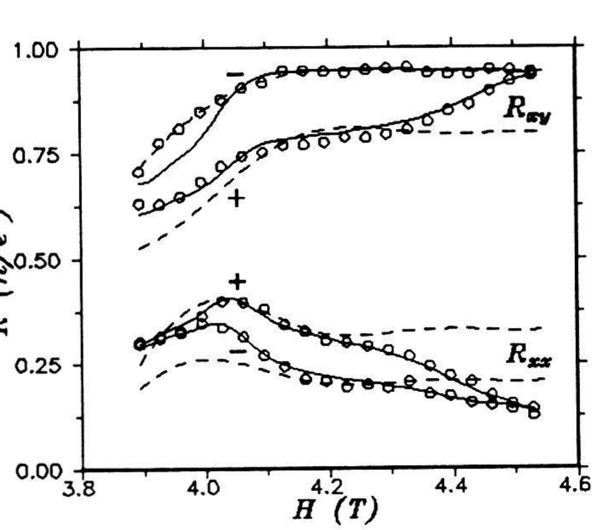

FIG.1. Magnetoresistance R_{xx} and Hall resistance R_{xy} at V_g=+0.1V (solid lines) and negative V_g (dashed lines, for R_{xy} V_g=-0.1V and for R_{xx} V_g=-0.4V). Sample 1. Temperature T=28mK. Inset: Schematic of the devices used in these experiments, all sizes are given in μm.

FIG.2. Experimental values of R_{xy} and R_{xx} at filling factors between ν=1 and ν=2 (circles). Sample 1, T=28mK. Dashed and solid lines are the results of calculations based on models [1] and [3], respectively. Groups of curves are marked by plus or minus in accordance with perfect connection or isolation of the upper magnetic level from the central Hall probes. Corresponding experimental results have been obtained at V_g=+0.1V and V_g=-0.1V, respectively.