A study on the universality of the phase transition of the GaAs/AlGaAs system in a magnetic field

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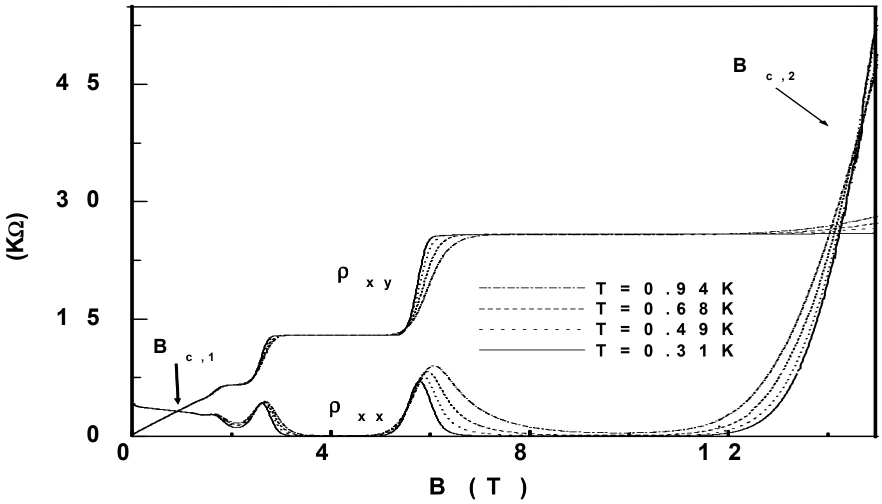
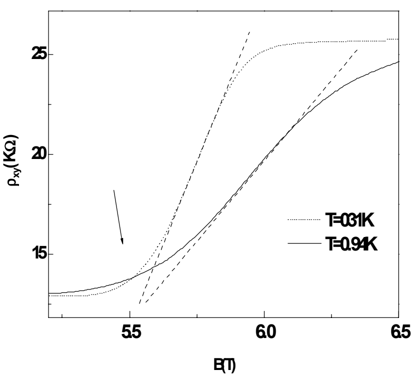
The universality of the quantum Hall effect plateau-plateau transition has been a subject of debate for many years. In this paper, we report the study of the plateau-plateau transition and the insulator -quantum Hall conductor transition of a modulation doped GaAs/AlGaAs system. We found that the universality of the transitions could be established if the data are analyzed correctly. The experiments were performed in the temperature between 0.3 and 1 K and in the magnetic field between 0 and 14 T. All three transitions, the insulator-quantum Hall conductor transition, plateau-plateau transition and quantum Hall conductor-insulator transition could be observed in the magnetic filed sweeps taken at different temperatures. For the 1-0 quantum Hall conductor-insulator transition we found that ρ_{xx} can be scaled with the scaling function, $f((\nu - \nu_c)\, T^{-\kappa})$,with the critical exponent κ=0.38 ±0.05. Here ν is the Landau level filling factor ν_c is the critical filling factor and κ is the critical exponent of the phase transition. For the 1-2 plateau-plateau transition, if we adopt the conventional way of analyzing the data we found that max $|d\rho_{xy}/dB|$ α $T^{-\kappa}$, and κ=0.64 ±0.08. In this method of analysis, the ρ_{xy} vs B curves are approximated by straight lines in the transition region and it is assumed that the transition point is around the middle of the straight line. By plotting the temperature-driven flow diagram we could obtain the transition point directly from the diagram, and we found that, at least in our experiment, the transition point is not near the center of the straight line. We found it is difficult to determine $|d\rho_{xy}/dB|$ near the transition point correctly, and max $|d\rho_{xy}/dB|$ obtained from the slope of the whole is different from $|d\rho_{xy}/dB|$ near the transition point. The validity of the κ obtained from the conventional method is thus questionable. However, by mapping the 2-1 transition to the 1-0 transition with the method suggested by Shahar et al[1], we could obtained a ρ_{xx} -B curve that has a well-defined transition point and could be scaled with $f((\nu - \nu_c)\, T^{-\kappa})$. The scaling exponent obtained with this method is κ = 0.45 ±0.05. Our results demonstrate that for the GaAs/ AlGaAs system, when the data in analyzed correctly, both the quantum conductor-insulator and the plateau-plateau transition have the same critical exponent as the InGaAs/InP system and these transitions are all in the same university class.

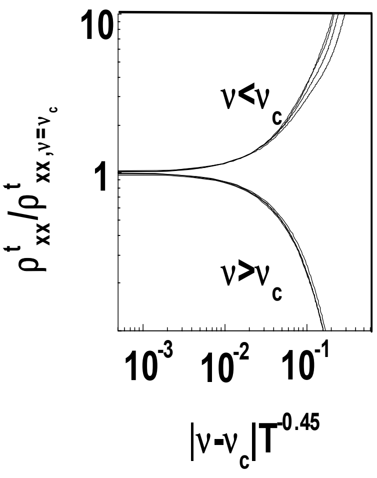
1. D. Shahar et al, Phys. Rev. Lett 79, 479 (1997)



ρ_{xx} and ρ_{xy} of the sample taken between T=0.3 and 1K. The insulator to quantum Hall, plateau-plateau, and quantum Hall to insulator transitions could all be observed.



In the conventional method, max $|d\rho_{xy}/dB|$ are determined by the two straight lines in this figure. The slopes determined this way are obvious different from the slopes determined at the phase transition point which occurs at B=5.5T.



After mapping the 2-1 transition into the 1-0 transition the ρ_{xx} curves collapsed into one curve with scaling exponent κ =0.45 .