New Insights into the Plateau-Insulator Transition in the Quantum Hall Regime

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Despite its relatively long history of study, the exact nature of the transitions between adjacent quantum Hall states is still a subject of debate. In the framework of the scaling theory of the quantum Hall effect [1], the plateau transitions are interpreted as quantum phase transitions with an associated universal critical exponent κ. Initial pioneering experiments by Wei *et al.* [2] on the plateau-plateau (PP) transitions of an InGaAs/InP heterojunction resulted in a numerical value of κ = 0.42 which has generally been interpreted in terms of ordinary Fermi-liquid principles. However, more recently, in experiments [3] conducted on the plateau-insulator (PI) transition of a very similar InGaAs/InP sample, a slightly different, non-Fermi-liquid value of the exponent (κ= 0.57) has been observed. It turns out that the PP transitions suffer from systematic errors that are inherently due to macroscopic sample inhomogeneities. On the contrary, PI transition data have been shown to be more robust against sample imperfections, resulting in a more reliable determination of the critical exponent than in the case of PP transition. Furthermore, the PI transitions display all the fundamental features sought in the PP transitions that previously remained concealed.

In this contribution we report the results of transport experiments conducted on an $In_{0.2}Ga_{0.8}As$/GaAs quantum well with variable carrier density. Whereas the sample was insulating when cooled down, the density of the sample could be increased by illumination with a LED. Because of the additional electrons and ionized donors, illumination also slightly alters the disorder potential and the interaction between the electrons. We have measured the resistance components for magnetic field strengths up to 20 T, in the temperature range T = 0.08 - 1.07 K for different densities. For one density n_{2D}=2.03x10^{11} cm^{-2} the magnetoresistance curves are presented in Fig 1. The data show a fixed point indicating the transition between the quantum Hall and insulating state. In Fig. 2 we have plotted the results for two different values of the electron density. The data clearly shows scaling behavior within the experimental range of temperature. The extracted values for the critical exponents, κ_1 = 0.54 and κ_2 = 0.58, are close to the value κ = 0.57 which was obtained previously [3], making the case for having a non-Fermi liquid critical exponent stronger. The effects of sample inhomogeneities will be discussed, as well as the corrections to scaling.

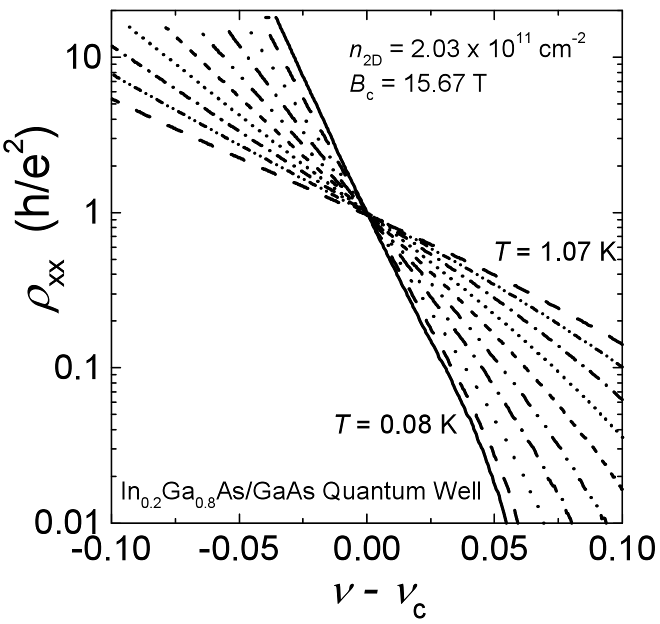

FIG 1. Longitudinal resistivity curves ρ_{xx} as function of filling factor ν near the critical value ν_c, for temperatures T = 0.08, 0.107, 0.142, 0.189, 0.253, 0.337, 0.449, 0.6, 0.8 and 1.07 K. The fixed point occurs at $h/e^2 \pm 0.5\%$. The curves follow the empirical law $\rho_{xx} \propto \exp[-(\nu-\nu_c)/\nu_0(T)]$ [3] from which the critical exponent can be extracted.

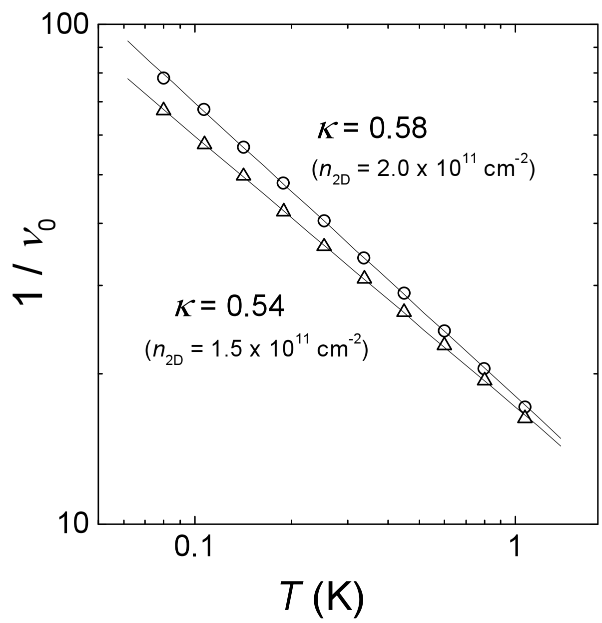

FIG 2. Temperature dependence of slopes of $\ln(\rho_{xx})$ for two different carrier densities of the sample. A straight line on a log-log plot indicates scaling behavior $1/\nu_0 \propto T^{-\kappa}$ with critical exponent κ. Both exponents are similar to the previously obtained non-Fermi liquid value of $\kappa = 0.57$ [3].

References:

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