Mobility dependence on carrier density of a dilute two-dimensional GaAs electron system in an in-plane magnetic field

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Recently there has been a great deal of interest in transport in dilute two-dimensional (2D) systems. In these studies, there are strong carrier-carrier interactions within the 2D systems. In an in-plane magnetic field. The 2D system shows strong magnetoresistance which appears to be a manifestation of the spin alignment of the free carriers. The suppression of the "metallic-like state" with increasing in-plane magnetic field has now become important in trying to understand the underlying physics of the "metallic-like" conductivity in two dimensions.

It is generally accepted that it is possible to determine the dominant scattering mechanism in a 2D electron system at zero perpendicular magnetic field from the mobility (μ) dependence on carrier density (n). For example, when $\mu \propto n^{\alpha}$ $(\alpha = 1.5)$ then remote ionized impurity scattering dominates. To date, no such study has been conducted for a dilute 2D electron gas in an in-plane magnetic field. In this paper, we present the mobility dependence on carrier density of a dilute two-dimensional GaAs electron system in an in-plane magnetic field. The main finding of our measurements is that the exponent α increases with increasing in-plane magnetic field (see later). We ascribe this effect to the combination of increasing strong localisation at the GaAs/AlGaAs interface and spin polorisation with increasing in-plane magnetic field.

Figure 1 shows the four-terminal magnetoresistivity ρ_{xx} as a function of in-plane magnetic field at various carrier densities n. We see that ρ_{xx} shows a B^2 dependence for $B \leq 5\ T$ and a weaker B^2 dependence for $B \leq 9\ T$. The interception of two parabolic fits is defined as the "crossing field" for a certain 2D electron density. If we take a vertical slice of the data shown in Fig. 1, we can measure the resistivity (mobility) dependence on electron density for a **fixed** magnetic field. For the low ($B \leq 6\ T$) and high $(B \geq 10\ T)$ magnetic field regimes, from the relation $\mu \propto n^{\alpha}$, we can measure the exponent. For the intermediate magnetic field regime $(6.7\ T \leq B \leq 8.3\ T)$, the situation is somewhat complicated and will be described as follows. There are **two** exponents in this intermediate regime. One obtained from the high n side and the other determined from the low n side. In our system, at zero magnetic field, the exponent is, consistent with strong localisation at the GaAs/AlGaAs interface. With increasing in-plane magnetic field, α exhibits a B^2 dependence as shown in figure 2. In the intermediate magnetic field regime, it is better to consider the averaged value of $\alpha \approx 3$. At high magnetic field, α exhibits a linear B dependence. The drastic difference between the exponents measured in two regimes suggests the importance of both strong localisation effects at the interface and possible spin polarisation in a dilute 2D system.

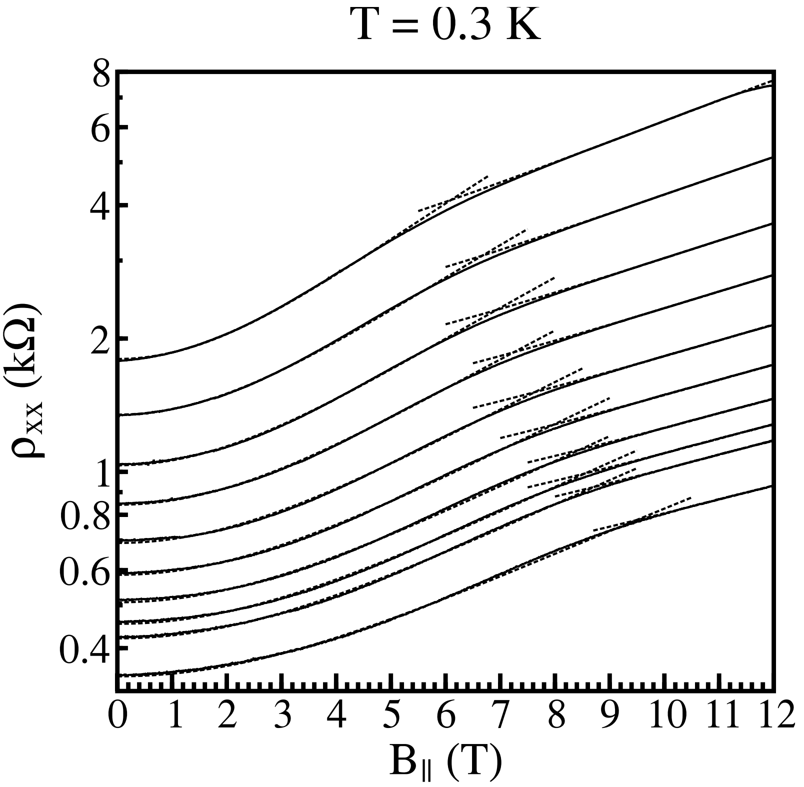

Figure 1 Resistivity as a function of in-plane magnetic field at various carrier density. From top to bottom: 1.379m 1,481m 1.591, 1.688, 1.780, 1.967, 2.036 and 2.076 and 2.226x10^{10} cm^{-2}, respectively.

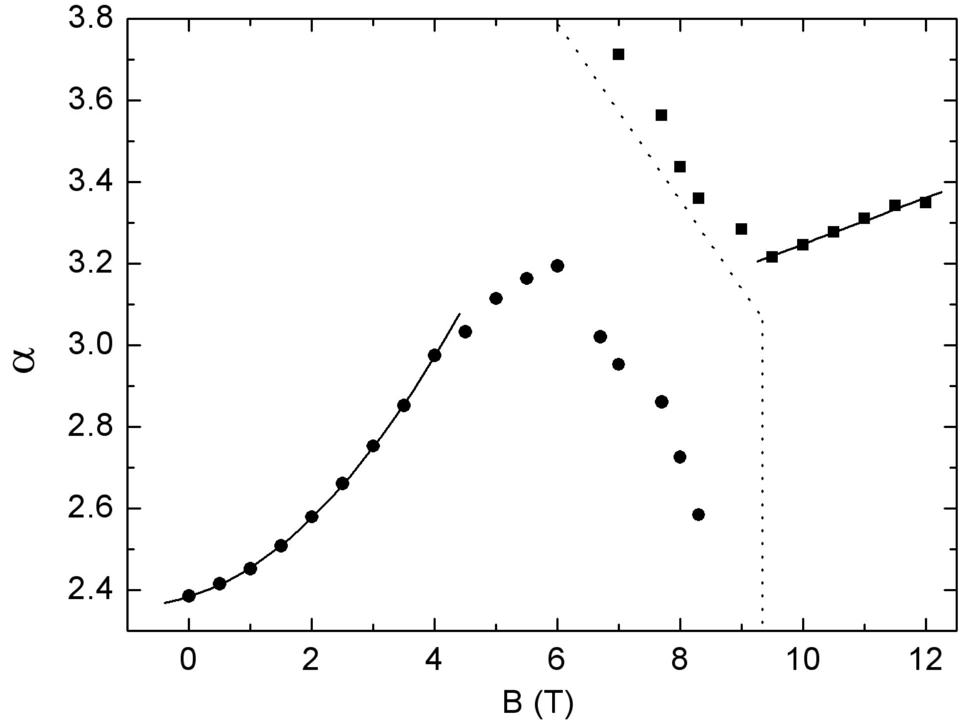

Figure 2 The exponent α determined from the mobility dependence on carrier density. For details, please see the text.