IN-BAND CONDUCTIVITY OF ORIENTED GRAPHITE IN THE HIGH FIELD ULTRA-QUANTUM REGIME

A. F. Hebard (UF Physics); D. L. Maslov (UF Physics); X. Du (UF Physics)

Introduction

Interest in the electronic properties of graphite has been recently renewed because of the unusual behavior of the magnetotransport. The metallic T-dependence of the in-plane resistivity in zero field turns into an insulating-like one when a magnetic field B is applied normal to the basal plane. Increasing B to near 1 T produces a low-temperature re-entrance of the metallic behavior, which has been attributed in the literature to a manifestation of field-induced superconductivity. To elucidate these phenomena at higher fields, we report here on our use of a two-band model to interpret magnetotransport data on HOPG graphite (<2º mosaic spread) in the ultra-quantum limit (B >8T) where all carriers are in the lowest Landau level. We provide evidence for near perfect compensation and show that the measured 2-band resistivity ρ_{xx} is proportional to the in-band conductivity σ_0, which decreases with increasing field and decreasing temperature.

Experimental Results and Discussion

Data such as shown in the inset of Fig 1 on the in-plane temperature dependence of both the longitudinal ρ_{xx} and transverse ρ_{xy} resistivity were taken in a variety fields directed along the c axis. In strong magnetic fields the multiband model still applies except that we can no longer take the resistivity and the Hall coefficient of each single band to be independent of field. We assume that the system is nearly compensated (i.e., the electron n_e and hole n_h carrier densities are nearly equal) and that the resistivities ρ_0 of each band are very close. We find that when the field dependence of ρ_{xx} is dominated by the off-diagonal Hall resistivity components, then ρ_{xx}/ρ_{xy} becomes a measure of the difference δ of the electron and hole carrier densities. The experimental plot of Fig. 1 shows that for B>8T, ρ_{xx}/ρ_{xy} and hence δ is small, thus confirming our assumption that the system is well compensated ($n_e = n_h$). Accordingly, the in-band conductivity σ_0 is proportional to ρ_{xx}/B^2 and has the temperature dependence shown in Fig. 2 for the indicated fields. In the ultra quantum regime (B>8T) and for T<10 K the data are well described by the dependence $\sigma_0(T,B) \propto \exp(-B/B_0)(T/T_0)^{\alpha}$ where the scaling field B_0 = 26.5 T and the temperature exponent α = 0.3 are determined from experiment. Although this functional form for $\sigma_0(T,B)$ is currently not understood, our analysis demonstrates that, at low temperatures and in the ultraquantum regime, σ_0 is proportional to the measured 2-band resistivity ρ_{xx} and has a T and B dependence reflecting insulating rather than superconducting behavior.

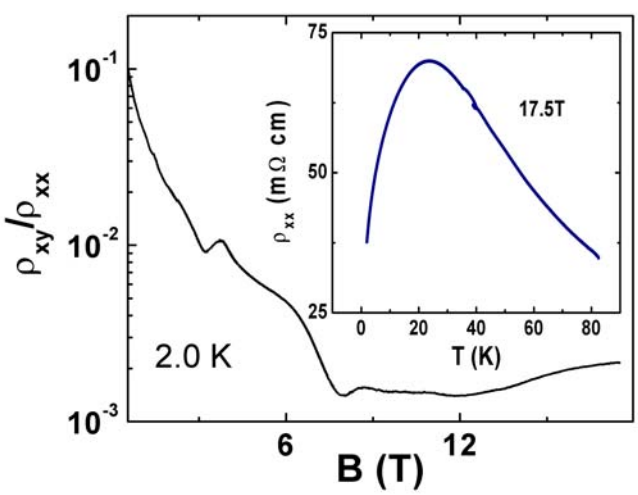

Figure 1

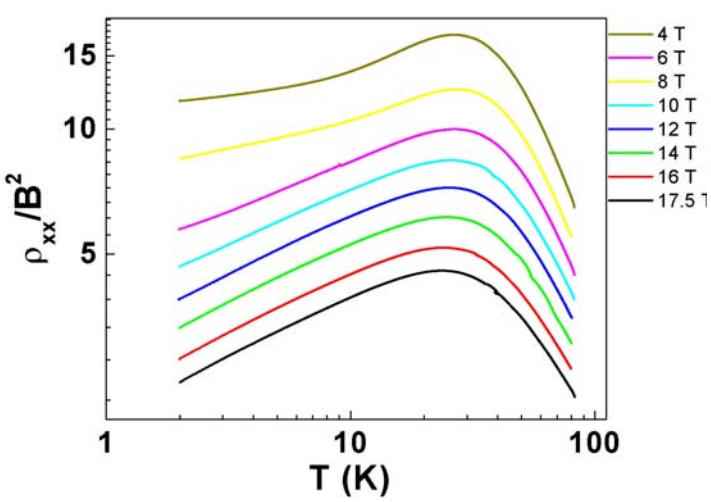

Figure 2

Acknowledgements

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