MAGNETIC-FIELD-INDUCED FERMI SURFACE RECONSTRUCTION IN Na$_{0.5}$CoO$_2$

L. Balicas, (NHMFL); M. Abdel-Jawad, (Bristol U., Physics); N. E. Hussey, (Bristol U., Physics); F. C. Chou, (MIT, Materials); P. A. Lee, (MIT, Physics)

Introduction

The discovery of superconductivity in hydrated Na$_x$CoO$_2$ has stimulated intense interest in this material [1]. While many workers have drawn analogy to the high $T_c$ cuprates, the Na$_x$CoO$_2$ system is surely of great interest in its own right as one of the few examples of a strongly correlated material with a frustrated lattice where the carrier concentration can be tuned continuously. The rich phase diagram of the non-hydrated Na$_x$CoO$_2$ system as a function of the Na content $x$ [2] reveals a succession of ground states, from a paramagnetic metal at $x = 0.3$ through a charge-ordered (CO) insulator at $x = 1/2$, a "Curie-Weiss metal" for $x \sim 0.70$, and finally a magnetically ordered state for $x > 0.75$. At $x = 0.5$, detailed electron [3] and neutron [4] diffraction measurements reveal that Na orders in an orthorhombic superstructure that is commensurate with the underlying lattice.

Experimental

We have performed a detailed electrical transport study in Na$_{0.5}$CoO$_2$ at high fields $B$ and low temperatures $T$ using the 45T hybrid magnet in Tallahassee.

Results and Discussion

We find that the charge ordered state observed below $T_{CO} = 53$ K can be suppressed by large in-plane magnetic fields, but not by fields applied along the inter-plane direction. For $B$ rotating within the conductive CoO$_2$ layers we observe angular magnetoresistance oscillations of essentially two-fold periodicity consistent with the reported orthorhombic crystallographic symmetry of Na$_{0.5}$CoO$_2$. As $B$ increases (i.e., as the charge ordered-state is suppressed) however, a new 6-fold periodicity emerges indicating the stabilization of a hexagonal FS as reported by the ARPES measurements. This observation suggests on the one hand, that the Na superstructure defines the geometry of the FS at low temperatures, and on the other, that the charge order in the conducting plane is suppressed by high in-plane fields. At low temperatures Shubnikov de Haas oscillations (SdH) of very small frequencies are observed for $B \parallel c$-axis, indicating that almost the entire FS reported for $x = 0.6$ and 0.7 disappears below $T_{CO}$ for $x = 0.5$.

Conclusions

Our results strongly indicate that the charge ordering involves the coupling with the Na order and involves the large hole pocket rather than the small pockets near the $K$ points as proposed by several theorists.

Acknowledgements

LB acknowledges support from the NHMFL in-house research program.

References