Charge Order and Anomalous Hall Effect in $Na_{0.5}CoO_2$ Under High Magnetic Field

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Introduction

We study magnetotransport properties of $Na_{0.46}CoO_2$ (NCO) under high magnetic field. This composition exhibits a weakly insulating state, with a frustrated local spin texture. Previous low-field measurements [1] have revealed a large Hall effect for this composition, and prior high-field studies [2] have found the existence of a small Fermi surface in the system and a two-fold angular magnetoresistance. To date however, the Hall-conductivity has not been investigated in magnetic fields strong enough to suppress the charge-order. Herein, we investigate the role of local spin-texture (in the charge-ordered state) on the Hall conductance in strong magnetic fields.

Experimental

We mapped a complete *H-T* phase diagram by measuring transport properties using 65 T short pulse magnet at Los Alamos and 45 T hybrid magnet in Tallahassee. Transport measurements were done using an AC method with *f*~200 kHz & 10 kHz for pulse magnet and hybrid magnet, respectively. The contour plot is drawn from the pulse field data. *T*-sweeps at fixed field are performed in the hybrid magnet with typical sweep rate of ~2 K/min.

Results and Discussion

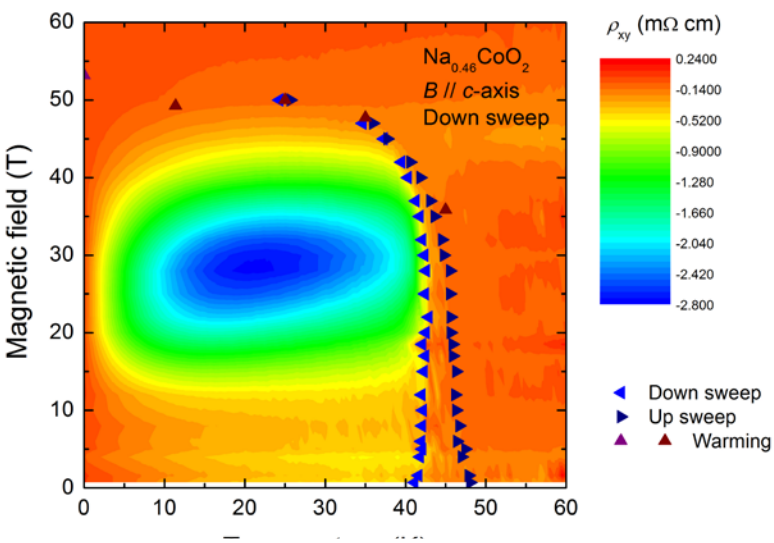

Figure 1. Contour plot of ρ_{xy} in *H-T* phase space. Symbols note the phase boundary where first derivative of ρ_{xy}-*H* shows a maxima.

Figure 1 shows the contour plot of ρ_{xy} in the *H-T* phase space. The phase boundary is marked by symbols where ρ_{xy} values changes to a constant value. Above 51 K, NCO is in a low resistive state. Below 51 K, it undergoes a charge order (CO) transition with high ρ_{xx} values and very large increase of ρ_{xy}. We find that the CO state is suppressed and returns to low resistive state by magnetic field applied along the *c*-axis. The hysteresis exists in both ρ_{xx} and ρ_{xy} vs. *H* curves and the hysteretic region increases at lower *T*.

On cooling, $|\rho_{xy}|$ increases and shows a maximum at 30 K but decreases when cooled further. By mapping out the contour, we find that the maximum position of $|\rho_{xy}|$ is located at *T*=25 K and *H*=28 T.

Conclusions

While such effect can be explained by temperature dependence of multiple carriers, we found that it requires more than two carriers to fit given field dependent data. Instead, we argue that the spin texture naturally acquires a Berry's phase by chiral ordering of spins that gives rise to the anomalous Hall effect. The temperature dependence can be explained by the coupling-decoupling of the interplanar interactions.

Acknowledgements

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References

[1] M. Foo *et al.*, Phys. Rev. Lett. 92, 247001 (2004).
[2] L. Balicas *et al.*, Phys. Rev. Lett. 94, 236402 (2005).