Magnetism, Transport and Fermi Surface Topology in Na Ordered Cobaltates Na_xCoO_2

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Introduction

The sodium cobaltates Na_xCoO_2 are layered materials with a Co triangular lattice in the CoO_2 layers. They display many unexpected emergent metallic and magnetic properties. While the Co magnetic response has been often considered as uniform, we have evidenced by NMR that a Co charge disproportionation is concomitant with the Na atomic ordering achieved out of the CoO_2 planes(1-2). The incidence on the physical properties is still an important pending question. Here we consider a specific Na ordered phase with x=0.77 which displays an A type AF order (3) below T_N=22K.

Experimental Results and Discussion

We took advantage of the successful efforts done in Kazan to synthesize single crystals with controlled alkali contents and orderings (4). Reproducible transport properties on phase pure *x*=0.77 samples were obtained in small applied fields and we measured their field variation in cell 9 in the Maglab up to 31 T in a He3 cryostat.

We could detect (Fig.1) reproducible Shubnikov de-Haas quantum oscillations (QO) that differ from all previously published QO observed in samples of uncontrolled quality (5). Their Fourier analysis suggests a single carrier pocket with a 143T frequency, with a slight asymmetry or possibly a second lower frequency of 110T (Fig.2). The angular dependence (not shown) did not indicate whether the main pocket is cylindrical or whether it is elongated with necks and bellies. The Lifshitz-Kosevitch fit of the *T* variation of the QO allows us to deduce an effective mass of 2.45m_e (Fig.2 inset). Assuming a cylindrical 2D Fermi Surface (FS) allows us to extract the carrier density n=2.4 10^{-3}/Co, much smaller than the hole carrier density (n_h=0.23/Co) expected from the chemical formula unit.

Conclusions

The various pending experimental questions might be solved by taking higher field data. The detected pocket(s) correspond to a small number of carriers and are at odds with the large hole pockets seen in ARPES experiments (6) with uncontrolled surface Na order for similar Na content. These results, together with the disproportionation evidenced by NMR establish that the Na order and/or the magnetic ordering induces a FS reconstruction. The actual topology of the FS might be resolved by band structure computations taking into account the electronic correlations. The occurrence of anomalous contributions to the Hall effect in the AF state also requires a careful experimental study of its dependence on the magnetization to relate the normal Hall effect with the FS topology in the AF sate. .

Acknowledgements

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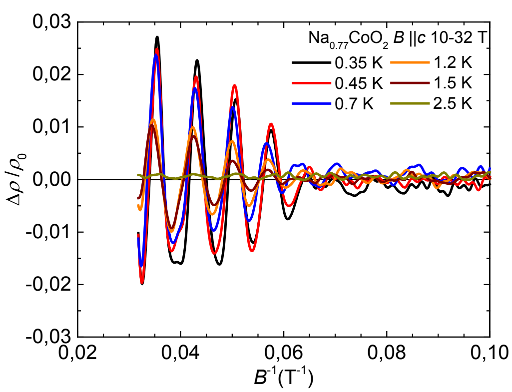

Fig.1 Relative variation of the resistivity versus the inverse applied field after background subtraction.

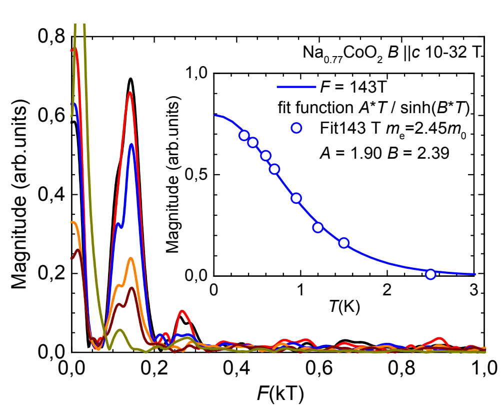

Fig.2 Fourier transform of the QO signal of Fig 1 and its *T* dependence (inset)