HIGH FIELD MAGNETOTRANSPORT AND TORQUE MAGNETOMETRY OF RUTHENATE METALS

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Introduction

The ruthenate series of transition metal oxides continue to provide a rich source of novel correlated electron physics, from superconductivity to novel magnetism [1,2]. Many of the new quantum states emerge from a background of strongly renormalized metallic states, whose study is vital to understanding the emergent phenomena and also provides an important benchmark for our understanding of low dimensional correlated metals [3]. We are engaged in an in-depth program of work on these fascinating metals, with the long-term goal of unifying the insights attainable from bulk measurements such as magnetotransport and the de Haas- van Alphen (dHvA) effect and the *k*-resolved information from surface spectroscopies such as angle-resolved photoemission (in collaboration with colleagues from the group of ZX Shen in Stanford).

Measurements at NHMFL are vital to our work, because the record-breaking steady fields enable us to push the frontiers of our understanding of these metals to unique levels.

Experimental

In the summer of 2004 we were allocated seven days of time on the 45 T hybrid, and by careful advance planning we managed to maximize the efficiency of our data-taking. Sample mounts were mailed in advance to St. Andrews, so that we were able to arrive with two fully pre-prepared holders, each containing three samples mounted for transport measurements and one for cantilever magnetometry. In this way we were able to study several ruthenate compounds during the same experimental slot. In total, we managed to obtain results on both in- and out-of-plane magnetoresistance (MR) of $Sr_3Ru_2O_7$, in-plane MR of some brand-new single crystals of $Ca_3Ru_2O_7$ and torque magnetometry of $Sr_3Ru_2O_7$, as well as two samples from the $Sr_{2-x}La_xRuO_4$ system (see discussion below). We also obtained some valuable preliminary data from crystals of a new rhodate that had recently been grown by one of us (RSP).

Results and Discussion

The work on $Sr_{2-x}La_xRuO_4$ was particularly productive and successful. Here, the La substitution is used to change the chemical potential by electron doping in a process similar to that used to produce hole doping in the cuprates. In contrast to the cuprates, however, it is possible with sufficient care and resolution to observe the effects on the Fermi volume directly by studying dHvA oscillations [4]. In our work this year we showed that these oscillations can be followed all the way out to 10% doping, a range accessible to experiment only in the 45 T field at Tallahassee. A publication incorporating these results is in preparation. The results from the other systems were fascinating, and motivate more investigation. In $Sr_3Ru_2O_7$ there seems to be a new magnetic transition for fields higher than 35 T, while in $Ca_3Ru_2O_7$ the quantum limit should be attainable for some tiny Fermi surface pockets. Renewed crystal growth is being performed in St Andrews, in the hope of studying even better crystals in future runs. Overall, this first experimental run on the hybrid by our group was very successful, and we hope that it lays the foundations of a long and productive collaboration with NHMFL.

Acknowledgements

We thank Y. Maeno, EPSRC, the Leverhulme Trust and the NHMFL in-house research program for discussions and support.

References

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