Determining the Fermi Surface of Colossal Magnetoresistive Materials

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Introduction

The rare earth manganites have been the subject of a high level of research activity for many years [1]. Their rich temperature/doping phase diagram, strongly-correlated properties and the colossal magnetoresistance (CMR) that they display have made them extremely important materials in the field of condensed matter physics and are of interest to theoreticians and experimentalists alike. Despite all this attention many questions still remain, especially regarding the origin of the ferromagnetic, CMR phase. Having an unprecedentedly high response to external stimuli, this phase is of great significance to technologists for use in actuators and other electronic devices. In particular, the Fermi surface has yet to be satisfactorily mapped out. Positron annihilation experiments have been successful in some manganite materials {2,3], but magnetic quantum oscillations (QOs), the most established and reliable method for determining the bulk Fermi surface, have yet to be observed in these materials.

Experimental

Single crystal samples of $La_xSr_{1-x}MnO$ were mounted for quantum oscillation measurements in the 65 T short-pulse magnets at NHMFL, LANL. One crystal was placed directly inside the 1500-turn measurement coil of a compensated-coil magnetometer optimized for de Haas-van Alphen measurements. Two further samples had 6 to 8-turn coils wrapped around them, which were used as the inductive part of an LCR circuit driven by a proximity detector oscillator at around 30 MHz. The frequency at which the circuit oscillates is known follow changes in the skin-depth of the material inside the coil, and hence is sensitive to Shubnikov-de Haas oscillations [4]. Both experiments were placed inside a ^{3}He cryostat so that temperatures as low as 500 mK could be achieved.

Results and Discussion

In both experiments a large signal was observed at low fields due to the alignment of ferromagnetic domains. There was hysteresis between up and down sweeps, the size of which was reduced in the smallest sample indicating a level of sample heating. The magnetic-field dependent data were Fourier transformed. At the lowest temperatures this revealed a number of small peaks in the region of 2000 to 7000 T, the exact positions varying between experimental techniques and as a function of the field window over which the transform was applied.

Conclusions

The results are promising but so far inconclusive. Further measurements are warranted, particularly in higher fields and with smaller samples to alleviate the effects of heating due to d*BI*/d*t.*

Acknowledgements

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References

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