Two-Fold Fermi-Surface Anisotropy Revealed by Angle-Dependent Magneto-Resistance Measurements in $YBa_2Cu_3O_{6.58}$

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Introduction

The discovery of a coherent Fermi surface in the underdoped high-temperature superconductor $YBa_2Cu_3O_{6.58}$ (YBCO)[1] has garnered much interest over the past five years, kick starting a renewed search for broken-symmetries in YBCO, and changing the way we think about the underlying metallic state of this system. To date these Fermi surface determinations have come from quantum oscillation measurements, and the complementary technique of angle-dependent magneto-resistance (AMR) has remained unexplored due to the requirements of ultra-clean samples and high signal-to-noise in a high DC-field magnet. AMR experiments are vital to a full understanding of YBCO because they provide more detailed geometric information about the Fermi surface, and because they are sensitive to 1-dimensional pieces of Fermi surface which are out of reach of quantum oscillation measurements [2].

Experimental

Single-crystal $YBa_2Cu_3O_{6.58}$ samples were prepared at the University of British Columbia with evaporated gold-contacts in a geometry for c-axis transport. These samples were screened for strong quantum oscillation signals at the NHMFL-PFF in a 65 T short pulse magnet. Using the 45 T hybrid at the NHMFL, c-axis resistance was measured using a lock-in amplifier as a function of field angle at 45 T. Using a dual-axis rotator, θ angle sweeps were made from 0 (field parallel to c-axis) to 90 degrees (field in the a-b plane), repeated at several different φ angles (the in-plane field angle, i.e. a-c plane θ sweeps at φ=0, b-c plane sweeps at φ=90).

Results and Discussion

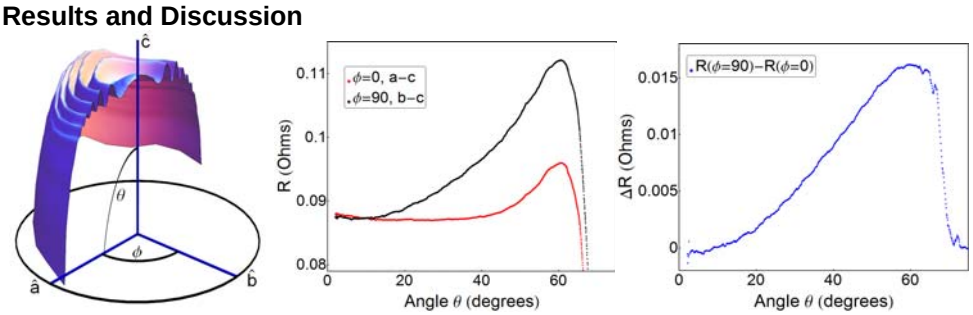

Figure1: Left: c-axis resistance data at 1.5 K plotted as a function of θ and φ, showing clear quantum oscillations. The magnitude of the magneto-resistance is larger when the field is along the b-axis then when along the a-axis. Middle: At 15 K the oscillations are suppressed, clearly showing the enhanced magneto-resistance with the field along the b-axis. Right: the difference between the a and b-axis 15 K data.

The figure above shows the magnetoresistance data as a function of θ and φ. The structure of the oscillations near zero angle (the "bump" when the field is along the c-axis) provides important information about the Fermi surface warping.
Additionally, at 15 K the oscillations can be suppressed, revealing an anisotropy in magnetoresistance between the a and b-axes.

Conclusions

We have measured AMR in $YBa_2Cu_3O_{6.58}$, and in addition to finding new geometric information about the established quasi-2D pockets, we have found a strong anisotropy in the magnetoresistance between the a and b-axes. A comparison between the highly anisotropic AMR data shown here and the results of numerical simulations is underway. This will establish the likely topology of the underlying Fermi surface, and brings us closer to a complete picture of the reconstructed Fermi surface in YBCO.

Acknowledgements

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References

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