Specific Heat and Shubinikov-de Haas Measurements in High fields on $YBa_2Cu_3O_{7-x}$

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Introduction

The behavior of metals is characterized by a few manifestations thought to be unique. These behaviors are the hallmark of what is known as Fermi liquid. One of these is quantum magneto-oscillations in nearly all the physical properties of a material which follow a form first described by Lifshitz and Kosevich. $YBa_2Cu_3O_{7-x}$ has recently been shown to exhibit behaviors which describe Fermi liquids and non-Fermi liquids, as well as superconductivity. The motivation for research by this collaboration was to determine if such behaviors came from the same system, or separate phases within a single sample, as well as the details of the correct scenario. The overarching goal of this research is to contribute to a full understanding of cuprate systems, including the superconductivity which can exist to temperatures of order 100 K.

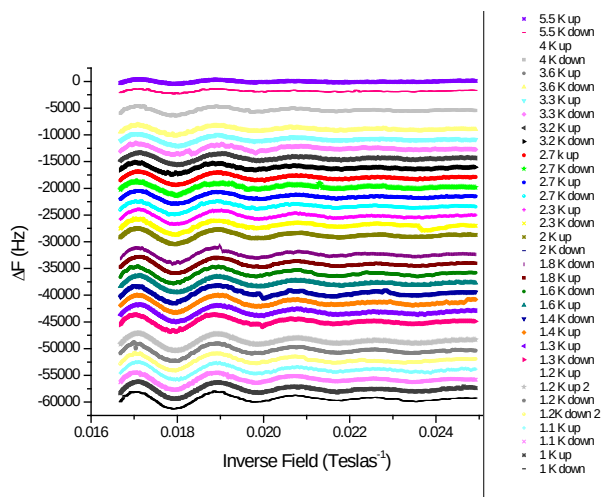
Experimental

The plan for 2012 included two types of experiments on one pair of crystals: specific heat up to 45 Teslas making use of the DC facility including the hybrid magnet, and proximity detected oscillations (PDO) to measure skin depth of the samples in pulsed fields up to 65 Teslas at the LANL pulsed field facility. Calibrations for the specific heat thermometry utilized the pulsed field facility as well.

Results and Discussion

The experiments showed results consistent with previous publications and somewhat in line with expectations. The specific heat was successful up to 35 Teslas, showing the evolution of the zero-temperature extrapolation of the electronic specific heat to increase in a precise way with field. The Shubinikov-de Haas measurements in the 65 T short pulse and 60 T controlled waveform magnets at the pulsed field facility generated high quality results allowing the determination of the electron effective mass for comparison to the specific heat.

Figure 1. SdH oscillations at temperatures from 1 K to 5.5 K (bottom to top)



Conclusions

High field measurements on $YBa_2Cu_3O_{7-x}$ have proved extremely valuable since the discovery of the material, and these experiments follow that trend. The comparison between high field measurements where superconductivity is suppressed by the magnetic field, and those which show the evolution of the system from vanishing field to high field can demonstrate much about the formation of superconductivity.

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