Magnetization Measurements Using a Piezoresistive Cantilever in Pulsed Magnetic Fields

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Introduction

The cantilevers used for this experiment are commercially available in Japan from Seiko Instruments (Model PRC120) and are produced for atomic force microscopy. Using these cantilevers for magnetization measurements in pulsed magnetic fields was first suggested by Ohmichi and Osada [1], where the method proved sensitive enough to observe quantum oscillations in Sr_2RuO_4 and κ-(BEDT-TTF)$_2$KHg(SCN)$_4$.

Experimental

The organic superconductor (T_c ~ 10K), κ-(BEDT-TTF)$_2$Cu(NCS)$_2$, was chosen for this experiment because the Fermi surface has been well studied since the first Shubnikov de Haas (SdH) measurements 20 years ago [2] and subsequent refinements using higher magnetic fields [3]. The cantilever consists of a sample lever and reference lever of equal resistance, which are used as part of a resistance bridge. The sample is attached to the longer lever using vacuum grease, allowing a single cantilever to be used numerous times. A reference signal of ~ 98 kHz was provided with a SRS830 lock-in, and at low temperatures, before the magnetic field is swept, the bridge circuit is balanced to zero. The measurements were conducted using the mid-pulse magnet, which has the slowest sweep rate of the capacitor driven magnets available (~ 100 ms rise time and ~ 400 ms decay). The cantilever was cooled using a He-3 cryostat so measurements at 1.9K and 0.5K were performed in exchange gas and liquid, respectively.

Results and Discussion

De Haas van Alphen oscillations were clear on a flat background at a temperature of 1.9K. At lower temperatures, second harmonic (2α ~ 1237 T) and magnetic breakdown orbits (β + α ~ 4598 T) were also observed, which agree well with the previous results of Ref. 3. Critical fields of 1.3 and 2.7 T (for 1.9 and 0.5K, respectively) created a strong response from the cantilever but are not show in the figure for clarity.

Conclusions

Further refinement of this method is underway using a lock-in amplifier designed by NHFML staff member, Al Miglori, which allows for a multiple of the reference signal to be digitized. The mass of the sample must be considered for measurements using the PRC120 cantilevers to avoid frequencies where quantum oscillations might be mixed with the resonant frequencies of the levers. This experiment provided a "proof of concept" measurement for this simple method that will be added to the arsenal of techniques available to users of the NHMFL-LANL.

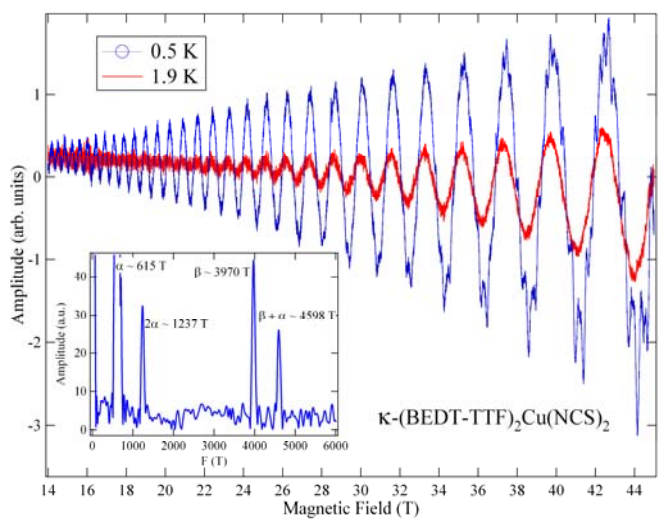

Fig. 1. Magnetization measurement of κ-(BEDT-TTF)$_2$Cu(NCS)$_2$ with the field perpendicular to the crystallographic bc-plane. Inset: Fast Fourier transform of the downsweep data taken from 20-45T.

Acknowledgements

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References

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