Investigation of Possible Field-Induced Superconductivity in β-(BDA-TTP)$_2$FeCl$_4$

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Introduction

Field-induced superconductivity (FISC) has been observed in several charge transfer salts containing the BETS donor molecule [1-3]. In this phenomenon the FeX_4 (where X = Cl or Br) anions create an internal field which compensates for the applied magnetic field, making SC in high fields possible.

Another candidate for FISC due to magnetic anions is β-(BDA-TTP)$_2$FeCl$_4$, which has a zero-field superconducting (SC) transition above pressures of 4.5 kbar [4]. In the λ- and κ-(BETS) materials discussed above, the presence of an internal exchange field from the magnetic anions was detected through spin splitting in the frequency of the Shubnikov de Haas (SdH) magnetoresistance oscillations. Calculated estimates of the exchange field for β-(BDA-TTP)$_2$FeCl$_4$ predict ~ 4 T [5].

Experimental

Two β-(BDA-TTP)$_2$FeCl$_4$ single crystals were mounted in a conventional double-clamped BeCu cell with a pressure of 5.2 kbar. Measurements were made along the most resistive axis (*b*-axis) of this quasi-two-dimensional compound. The single axis rotation probe of the SCM1 system allowed us to rotate the pressure cell in an attempt to align the crystallographic sample axes and applied magnetic field. Measurements were made to 20 mK in the dilution refrigerator of the mK facility.

Results and Discussion

Two magnetoresistance (MR) traces are shown in figure 1 with the magnetic field oriented perpendicular and parallel to the conducting planes of the samples. The frequency of the Shubnikov de Haas (SdH) oscillations (shown in the figure inset) observed with B // *b*-axis closely matches the results of Choi, *et al.*, for the β-orbit of the Fermi surface.

Conclusions

A spin-splitting of ~ 50 T was observed from the fast Fourier transform (FFT) of the MR oscillations. This corresponds to an estimated internal field of ~ 15 T using $\delta F = (1/4)g\,(m_{eff}/m_0)H_J$, where δF is the frequency difference, g is the g-factor, m_{eff} is the effective mass and H_J is the exchange field (i.e. internal field). Even with this evidence, no FISC state was observed with careful alignment of the magnetic field and conducting planes (see B//*ac*-plane in fig. 1). Sample alignment within a pressure cell can be uncertain, which may suggest repeating this experiment using a two-axis rotation system.

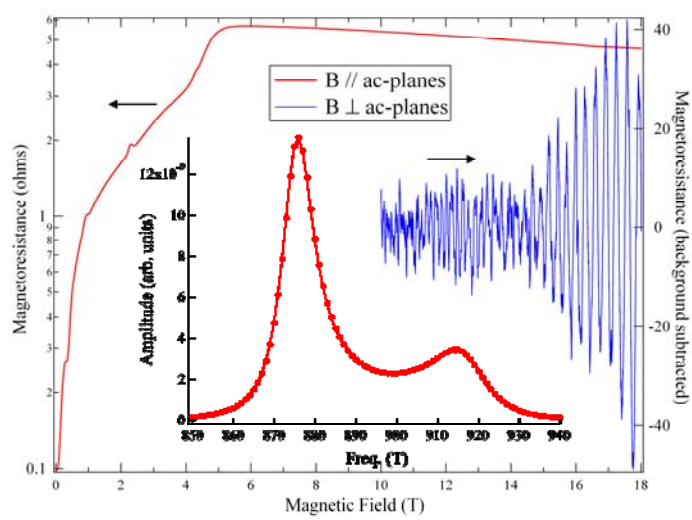

Figure 1. Magnetoresistance measurements of β-(BDA-TTP)$_2$FeCl$_4$ in orientations parallel and perpendicular to the conducting planes (pressure ~ 5.2 kbar). Inset: Fast Fourier transform (FFT) calculated by the maximum entropy method (MEM) of the SdH oscillations.

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