Inductive Magnetic Susceptibility Measurements on Nanoparticle $(TMTSF)_2ClO_4$

L.E. Winter, E. Steven, J.S. Brooks; (Florida State University/NHMFL) J.H. Park (NHMFL); D. de Caro, L. Valade, C. Faulmann (Univ. de Toulouse/CNRS); J. Fraxedas (ICN2/CSIC Spain)

Introduction

The organic conductor $(TMTSF)_2ClO_4$ is known to undergo a superconducting (SC) phase transition below T_C = 1.2 K if the sample is cooled sufficiently slow, less than 0.1 K/min, through the T_{AO} ~ 24 K anion ordering temperature[1]. With the recent findings reported by de Caro *et al*.[2] on isolating nanoparticles (NPs) of molecule-based conductors including $(TMTSF)_2ClO_4$, studies are underway to determine the conductivity of these materials as well as determine if their properties are different from the bulk material.

Experimental

Inductive magnetic susceptibility measurements using a resonant circuit were used to study the superconducting state of 7.385 mg of nanoparticle $(TMTSF)_2ClO_4$. The NPs were placed inside of a plastic capsule which was then placed inside of the inductor coil such that the filling factor between the two was about 84% and the resonant frequency was 15 MHz. The initial cooling rate was 0.05 K/min to insure the anion ordered state was obtained. Finally, field sweeps between -2 and +2 Tesla were performed between 35 mK and 1.2 K in a dilution refrigerator using a 16 T superconducting magnet.

Results, Discussion, and Conclusions

Negative frequency (-f) results, which correspond to magnetic susceptibility, show that susceptibility decreases as the sample is cooled through T_c, corresponding to the superconducting transition (Fig. 1(a) insert). As the (positive or negative) field is increased the susceptibility increases as in seen in Fig. 1(a). This corresponds to the destruction of the SC state. As the temperature is increased towards T_c, the field necessary to destroy the superconductivity (H_{C2}) decreases. We note the field at which the frequency increase levels off to estimate H_{c2} for the NPs, which we find is in reasonable agreement with the averaged data by previous groups on the bulk material[3], as seen in Fig. 1(b). Based on these preliminary findings it is reasonable to suggest that the NPs have the same characteristic critical field and SC transition temperature as the bulk material. Future work should be done to determine whether some differences do exist between the bulk material and the NPs, such as the effects of the cooling rate.

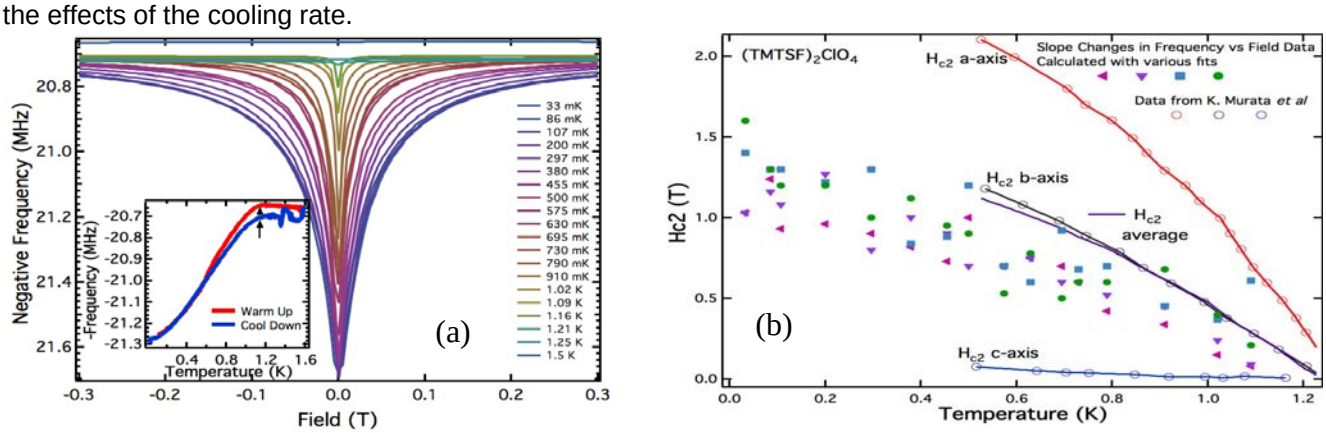

Fig. 1: (a) The increase in susceptibility (-f) as the positive (or negative) field is increased corresponds to the destruction of the superconducting state. As the temperature increases towards T_c, H_{c2} decreases. (Insert) Susceptibility decreases as a function of temperature when the sample becomes superconducting at T_C = 1.2 K. (b) Determining where the frequency increase levels off in (a), we can determine an estimate on H_{C2} (colored shapes), which appears to be in reasonable agreement with averaged data from Murata *et al*[3].

Acknowledgements

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References

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