Synthetic Metals 103 (1999) 2092

High-Field Electrodynamic Investigation of $(TMTSF)_2ClO_4$

S. Hill [a], J.S. Brooks [b], S. Takasaki [c], J. Yamada [c] and H. Anzai [c]

[a] *Department of Physics, Montana State University, Bozeman, MT59717, USA*
[b] *National High Magnetic Field Laboratory, 1800 E. Paul Dirac Dr., Tallahassee, FL32310*
[c] *Himeji Inst. of Technology, Akaho-gun, Hyogo 678-12, Japan*

Abstract

We have used a millimeter-wave technique to probe the complex AC conductivity of $(TMTSF)_2ClO_4$ in fields to 30 tesla. The field-induced-spin-density-wave (FISDW) transitions are clearly seen at low temperatures and low fields, as are the rapid oscillations at higher fields. In addition, we see evidence for a collective pinning mode of the FISDW at high fields.

Keywords: Conductivity, Organic conductors

We use a phase sensitive millimeter-wave cavity perturbation technique to study the phase diagram of $(TMTSF)_2ClO_4$ at low temperatures and high magnetic fields. Details of the experimental technique are described elsewhere [1]. The sample was oriented within a cylindrical cavity with its ***c**** axis parallel to the applied DC magnetic field, and currents were excited in the ***ab*** plane of the sample. Fig. 1 shows the dissipative and reactive response of the sample; the former corresponds to the change in amplitude of radiation transmitted through the cavity, while the latter corresponds to the shift in the resonance frequency (f_o) of the cavity.

The qualitative behavior of the dissipative response of the sample may be understood as follows. At low fields, the sample is metallic. The monotonic increase in the dissipation simply reflects the magnetoresistance of the sample. The weak inflection at low fields (1 - 3 T) is due to a novel form of quasi-one-dimensional cyclotron resonance; this is discussed in detail in ref. [2].

At the lowest temperatures, the field region from about 5 to 8 tesla corresponds to all but the last of the well known field-induced-spin-density-wave (FISDW) phases [3]. The sample is still conducting in this field region. The sharp increase in dissipation seen in the lowest temperature trace is due to the loss of carriers to the FISDW. Careful inspection of this data reveals more than one FISDW transition.

Once the final FISDW phase is entered, the sample becomes insulating [4], and the effect of the sample on the cavity resonance condition changes significantly. The cavity resonance frequency (f_o) shifts strongly downwards, indicating that the effective volume of the cavity increases. At the same time, dissipation within the cavity decreases to a level well below its zero field value. These facts suggest that the electromagnetic fields within the cavity penetrate the entire sample, and that there is little or no dissipation. This confirms that the radiation frequency (44.2 GHz) is well below the single particle gap and well above the collective mode response of the FISDW. In contrast, when the sample is conducting, the millimeter-wave radiation only penetrates into the sample skin depth, and dissipation is dominated by the surface resistance of the sample.

Even though the sample is supposedly insulating, we still observe a significant dissipative peak at high fields, together with quantum oscillations. We do not comment on the oscillations here. However, the present data suggest that a reorganization of the FISDW condensate occurs in the vicinity of the phase boundary at ~28 T [5]. Consequently, we see a significant contribution to the conductivity due to the FISDW, at these frequencies. Similar findings, at lower frequencies and fields, have been reported in a recent work by Fertey *et al.* [6].

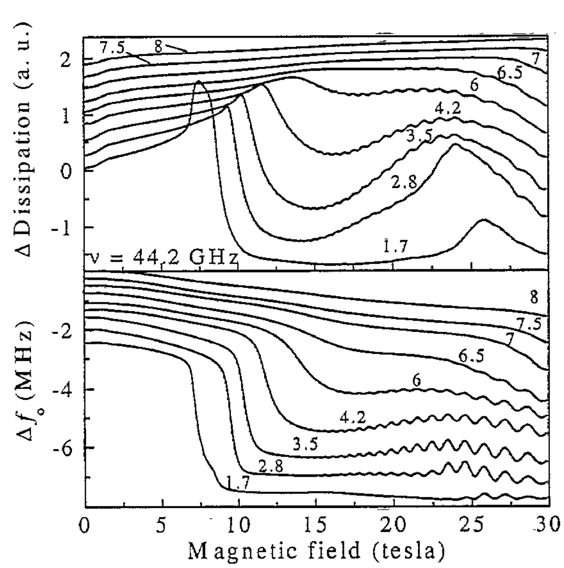

Fig. 1: The dissipative and reactive responses of the sample. The temperatures are indicated in the figure and the traces are offset.

We acknowledge NSF cooperative agreement No. 98-71922.

References

[1] S. Hill *et al.* to be published in Physica B (1998).
[2] S. Hill, these proceedings.
[3] For a review, see *e.g.*, T. Ishiguro and K. Yamaji, *Organic Superconductors* (Springer-Verlag, Berlin, 1990).
[4] S. Hill *et al.*, Phys. Rev. B, accepted (October 1998).
[5] S. K. McKernan *et al.*, Phys. Rev. Lett **75**, 1630 (1995).
[6] P. Fertey *et al.*, Phys. Rev. B **57**, 14357 (1998).

PII: S0379-6779(98)00450-0