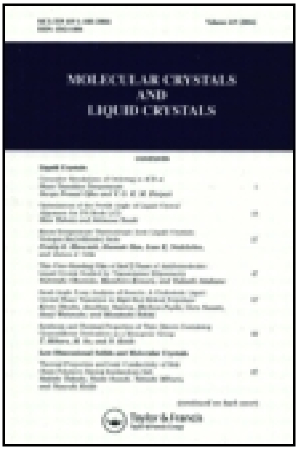

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Magnetic Order in Organic Superconductors

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MAGNETIC ORDER IN ORGANIC SUPERCONDUCTORS

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Abstract We have undertaken an electron spin resonance study at both low and high magnetic field on the superconducting phase of the ambient pressure superconductor $(BEDT-TTF)_2I_3$, $(ET)_2I_3$, over the temperature range 1-300 K and hydrostatic pressure range from 0 to 2 kbar. At ambient pressure the ESR results are consistent with the picture of $(ET)_2I_3$ as a metal. Superconductivity is observed at 1.6 K via low field ESR. Application of modest pressures strongly suppresses the superconducting transition temperature. At pressures above about 0.3 kbar the superconductivity is suppressed in favor of an as-yet-unidentified magnetic state whose onset is at 7K. Through an analysis of the microwave ESR lineshape we find that the microwave conductivity over the temperature range 5-50 K is in agreement with dc measurements.

INTRODUCTION

The recent discovery,[1] and confirmation,[2] of superconductivity (SC) at ambient pressure in $(ET)_2I_3$ has motivated the present study of the magnetic properties of this material. The observation that T_c is highly dependent upon pressure suggests that this material may be on the borderline between magnetic and superconducting ground states. It is for this reason that $(ET)_2I_3$ is fascinating and might afford a unique opportunity to study the competition between superconductivity and magnetism in organic conductors.

EXPERIMENTAL DETAILS

Synthesis[2] and structure[2,3] of the samples is presented elsewhere. The pressure studies were performed in a Be-Cu pressure cell using helium as the pressure transmitting medium.[4] Magnetic resonance coils of typical diameter 300 microns were wound around the single crystal samples. Both low field ESR(resonant field

10-25 Oe) and microwave ESR(resonant field 3.5 kOe) were performed. ESR measurements were also performed at ambient pressure in a microwave cavity over the temperature range 1.9-300 K.

RESULTS

We first present the ambient pressure, microwave ESR results. In Fig. 1 we show the ESR linewidth from 2-300 K. Note that the linewidth monotonically decreases from about 20 Oe at 300 K to a narrow line(2.3 Oe) in the low temperature regime. This observation is consistent with the interpretation that the ESR line is Korringa broadened with a low temperature residual linewidth due to dipolar interactions and/or impurities.

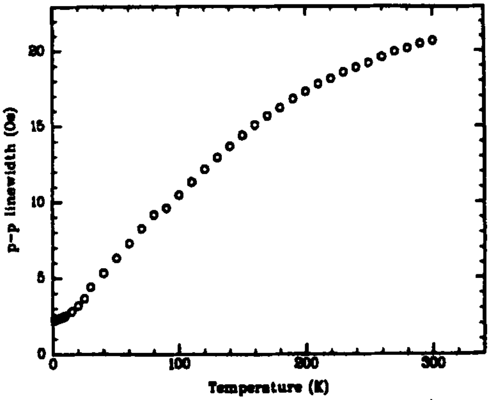

Fig. 1. The peak-peak derivative linewidth of $(ET)_2I_3$ vs. temperature at 9.8 GHz with field normal to slab.

The microwave conductivity, as deduced from the dysonian ESR lineshape, is shown in Fig.2 for the inplane direction. For comparison the conductivity measurements of ref. 1 are shown as a dashed line in Fig. 1. Our absolute measurement of the conductivity can be in error by as much as 50% due to uncertainties in the sample dimensions and a non-ideal sample shape(we assumed a slab geometry), but the microwave conductivity agrees with the dc measurements within experimental uncertainities. This observation is in accord with the picture of $(ET)_2I_3$ as a two dimensional metal. Also shown in Fig. 2 is the ESR susceptibility vs. temperature. Note that to within experimental error, the susceptibility is

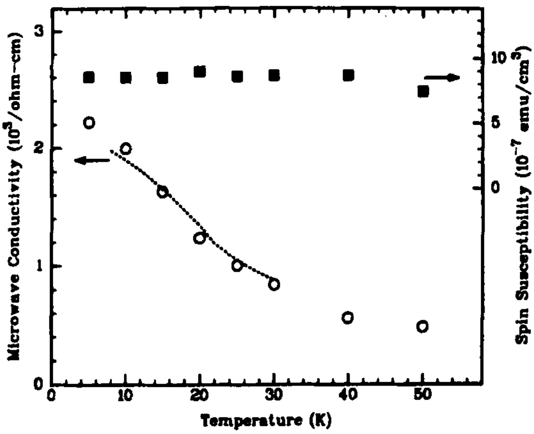

Fig. 2. The microwave conductivity(circles) and spin susceptibility (squares) vs. temperature. The dashed line shows the dc conductivity from Ref.1.

independent of temperature, consistent with that expected of the Pauli spin susceptibility of a metal. The measured g-value is 2.0083 with the field normal to the slab.

We now turn to the low field ESR results under hydrostatic pressure. First note that the onset of SC is observed at a temperature of 1.6 K at ambient pressure via rf penetration depth measurements. The low field ESR linewidth in the normal phase is the same as observed in the microwave experiments, consistent with that expected for a metal where the conduction electron spin resonance linewidth is frequency independent. In Fig. 3 we show the pressure dependence of T_c. Note that modest pressures strongly suppress T_c. In fact, at a pressure of about 0.5 kbar Tc is suppressed to below 1.1 K and a new feature is observed in the low field absorbtion spectrum. At a temperature of 7K a broad absorbtion is observed which is centered around zero magnetic field. The characterization of this state is in progress.

CONCLUSIONS

We have shown that at ambient pressure $(ET)_2I_3$ behaves as a two dimensional metal from dc to a least 10 GHz. The spin susceptibility is independent of temperature and the linewidth is Korringa broadened, consistent with that expected for a metal. The superconducting transition temperature is strongly suppressed by modest pressures with the favoring of a new ground state which possibly has magnetic order.

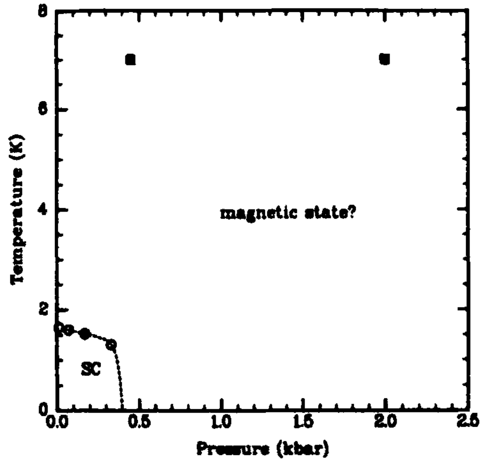

Fig. 3. Superconducting transition temperature(circles) and onset temperature of magnetic state(squares) vs. pressure.

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