Simultaneous TDO and Resistivity Measurements on λ-$(BETS)_2XCl_4$ where X= Ga , Fe

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Introduction

Organic materials reveal many different phenomena depending on the temperature, the applied magnetic field and its direction with the sample crystallographic axes. For example, λ-$(BETS)_2GaCl_4$ and λ-$(BETS)_2FeCl_4$ have totally different behavior at the same conditions. In λ-$(BETS)_2GaCl_4$, the superconductivity state is destroyed by applying a magnetic field. In λ-$(BETS)_2FeCl_4$, the antiferromagnetic state is destroyed and a superconducting state is induced (after paramagnetic metal state) by applying the magnetic field parallel to c-axis [1, 2]. To understand these different behaviors, these samples have been studied by a simultaneous TDO technique and resistivity measurements on the same sample. The TDO (rf) method involves an ac tunnel diode oscillator (TDO) circuit that can measure penetration depths and skin depths on very tiny single crystals with great sensitivity [3]. The motivation for simultaneous rf and electrical transport methods is to correlate the behavior at the onsets of superconducting and magnetic transitions as manifested in the different measurements.

Experimental

Single crystals of λ-$(BETS)_2GaCl_4$ and λ-$(BETS)_2FeCl_4$ were inserted in a testing coil (radius = 0.24 mm) with a very stable resonance frequency (150MHz). After each sample was inserted in the measurement coil four contacts were attached to the sample along the c-axes. The circuit was fixed on a single axis rotating probe and it was rotated in magnetic field up to 33 tesla and low temperature as low as 0.5 K.

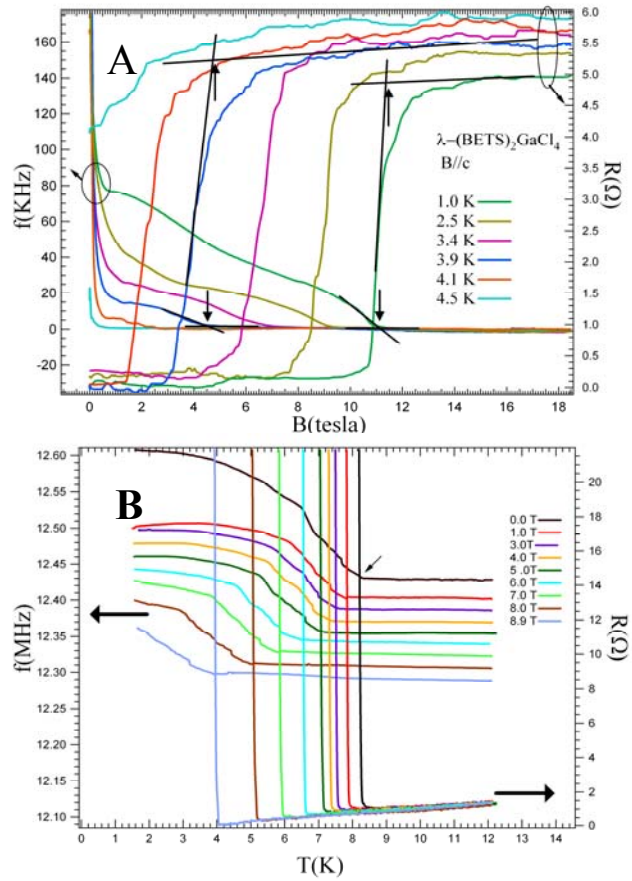

Fig.1: A) The λ-$(BETS)_2GaCl_4$ superconducting transition with resistivity and TDO measurements when sweeping field at fixed temperature - arrows indicate the transitions in both measurements for T= 1,3.9 K. B) shows the transition between the paramagnetic metal and the antiferromagnetic insulator in λ-$(BETS)_2FeCl_4$ state at different fixed fields.

Results and Discussion

When measuring the λ-$(BETS)_2GaCl_4$ sample, both techniques give the same transition points with very small error (see the slopes intercepts points in both methods in Fig1.A). In the λ-$(BETS)_2FeCl_4$, the transition between the antiferromagnetic and paramagnetic metal states in the TDO curves occur at the same point when the sample resistance increased (see Fig.1.B)

Conclusions

The TDO probe is a very useful technique to study superconducting and magnetic transitions in organic materials such as λ-$(BETS)_2GaCl_4$ and λ-$(BETS)_2FeCl_4$ respectively. Work is presently underway to make detailed correlations between the onset characteristics of rf and transport signals, and their coincidence or difference for given temperatures in the transition regions for both superconducting and antiferromagnetic transitions.

Acknowledgements

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References

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