Magnetic Field Induced Charge and Spin Gaps in the Organic Conductor $Per_2[Pt(mnt)_2]$

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Introduction

$Per_2[Pt(mnt)_2]$ is a quasi-one dimensional organic conductor with coupled-segregated spin and charge chains. Under ambient conditions the conducting perylene chains and insulating spin ½ $Pt(mnt)_2$ chains undergo a charge density wave (CDW) and spin-Peierls (SP) transition, respectively, around 8 K. Previous NMR[1] and electrical transport[2] studies show that these two states are coupled up to 20 T, so our motivation has been to determine if this coupling is still present.

Experimental

Magnetic susceptibility studies were performed using a resonant circuit with the sample inside of the inductor. In this setup, the change in susceptibility of the sample can be measured via shifts in the resonance frequency. Three single crystals of the organic conductor were placed inside of the inductor with an estimated filling factor of 60 -75% and a resonant frequency of ~365 MHz., such that the long b-axis was collinear to the coil and perpendicular the magnetic field. These studies were performed down to 500 mK in the 45 T hybrid magnet at the NHMFL DC facility.

Results / Discussion / Conclusions

Our susceptibility versus field for a wide range of temperatures provided verification of the continued coupling of the electrically conducting chains and the localized platinum spins well above 20 T (a)[3]. The increase in negative frequency, which corresponds to an increase in the susceptibility, allows for the determination of the phase boundaries for the two low temperature states: low-magnetic field state (SP_0+CDW_0) and a high-magnetic field state (SP_1+CDW_1). We were also able to calculate the magnetization by integrating the frequency versus field and observed plateaus at the lowest temperatures, as expected for the gapped regions (b). These results imply that the CDW is a necessary condition for the formation of the SP state, as well as provide motivation to extend the theoretical frame work of the quasi-one-dimensional interacting spin and charge systems beyond the existing models. Our future plans are to continue the experiment to 65 T using a pulsed field to check for additional gapped states at higher fields.

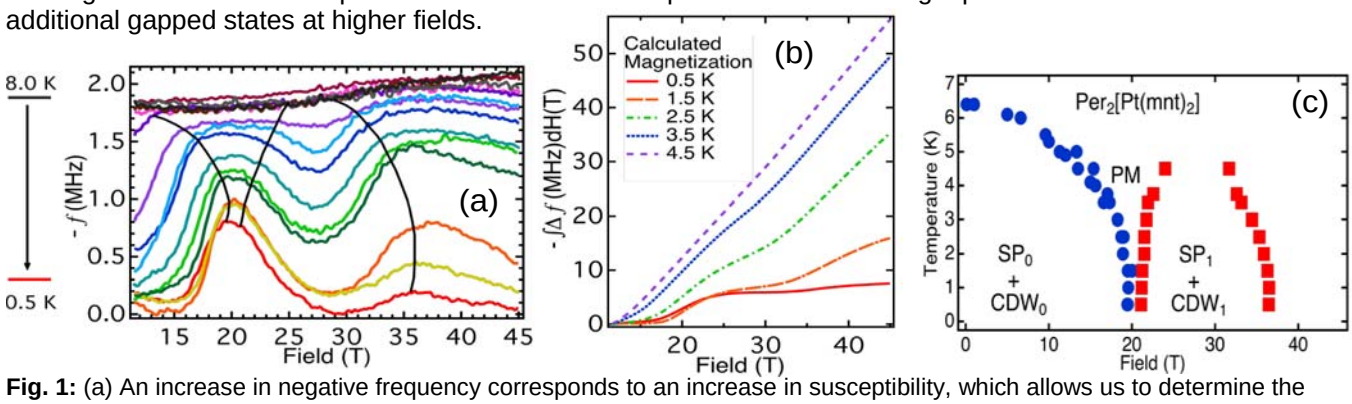

Fig. 1: (a) An increase in negative frequency corresponds to an increase in susceptibility, which allows us to determine the SP+CDW phase boundaries (solid black lines) as a function of field and temperature. (b) Integrating the frequency versus field yields magnetization, which exhibits plateaus in the gapped regions, as expected. (c) Temperature and magnetic-field dependent phase boundaries of $Per_2[Pt(mnt)_2]$. PM, SP_0+CDW_0, and SP_1+CDW_1 correspond to the paramagnetic normal, low-magnetic field suppressed, and high-magnetic field induced phases, respectively.

Acknowledgements

This work was supported by NSF-DMR 1005293, National Science Foundation Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy. PS is supported by the DOE grant DE-FG02-98ER45707.

References

[1] Green, E.L., *et al*., Phys. Rev. B **84**, 121101 (2011)
[2] Graf, D., *et al*., Phys. Rev. Lett. **93**, 076406 (2004).
[3] Winter, L., *et al.*, Europhys. Lett. **103**, 37008 (2013).