Thermodynamic Measurements of One-dimensional Organic Conductor $(TMTSF)_2ClO_4$ in High Magnetic Fields up to 35 T

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Introduction

$(TMTSF)_2X$ series of the organic conductors, where $X=ClO_4$, PF_6, etc., is known as the first bulk quantum Hall(QH) system. The stacked-layer structure of the plate-like TMTSF molecules yield two pairs of open Fermi surface (FS) sheets. In $(TMTSF)_2ClO_4$, magnetic field along the c axis (perpendicular to the conducting ab plane) leads to cascade-like field-induced spin-density-wave (FISDW) transitions, which are associated with the QH effect. The overall features of the FISDW transitions are well understood by the so-called standard theory, which requires imperfect nesting of the open sheets of the FS. The final FISDW phase (SDW I) with the quantum number n=1 is stabilized in the wide field range between 8 T and 26 T [1]. At 26 T, the QH state is broken and a different SDW phase (SDW II) appears. Above 26 T, the Hall resistance periodically oscillates with inverse field, associated with the sign change [2]. The results suggest that the major carriers alternately change their character (electron or hole) with field. The change should also cause the density of state (DOS) oscillation.

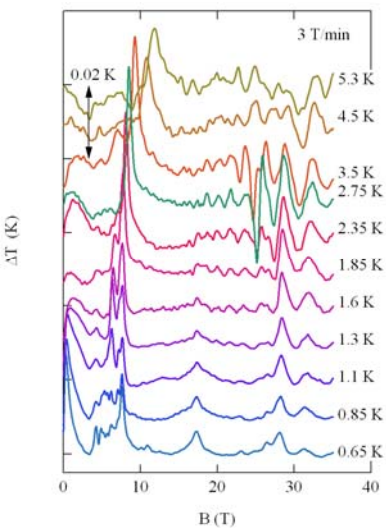

Fig. 1 Magneto-caloric effect of $(TMTSF)_2ClO_4$

Experimental

In order to investigate the DOS oscillation in the SDW phases, we have made a miniature vacuum cell, and performed the magneto-calorimetric and heat capacity measurements of single crystals of $(TMTSF)_2ClO_4$ in high magnetic field, using the resistive 35 T magnet. Magnetic torque and resistance measurements have also been carried out.

Results and Discussion

In the magneto-caloric effect (Fig. 1), we find a large anomaly at around 8 T, showing the presence of the first order phase transition associated with the latent heat release. The oscillatory behavior (so-called rapid oscillation) is seen in a wide field range. The rapid oscillation is periodic with inverse field and most enhanced at around 2.75 K. A sharp anomaly is seen at 18 T below 1.6 K. A striking feature is the large oscillation of the heat capacity in the SDW II phase above 26 T (Fig. 2). This is a clear evidence of the DOS oscillation. The peaks of the heat capacity appear at the dip positions of the resistance, suggesting that the DOS maxima give resistance minima. The magnetic torque also shows clear rapid oscillation, which is consistent with the thermodynamic Maxwell relation.

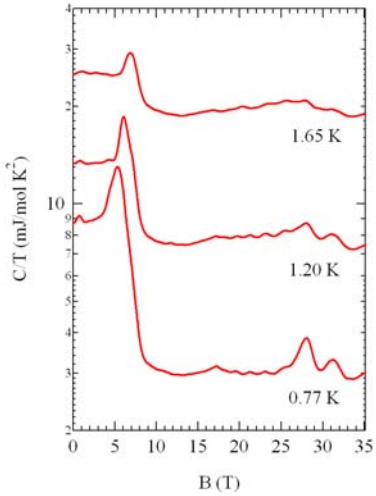

Fig. 2 Heat capacity of $(TMTSF)_2ClO_4$

Conclusions

The DOS oscillation is clearly observed in the SDW phases of $(TMTSF)_2ClO_4$.

References

[1] S. K. McKernan, *et.al.,* Phys. Rev. Lett. **75**, 1630 (1995)
[2] S. Uji, *et al.*, Phys. Rev. Lett. **94**, 077206 (2005)