ENHANCED DETECTION OF THE QUANTUM OSCILLATION OF RESISTANCE USING THE FIELD MODULATION TECHNIQUE

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Introduction

The Shubnikov-de Haas (SdH) effect, where electrical resistance shows quantum oscillations periodic to inverse magnetic field, has been a useful tool for Fermiology studies. The extremal area of the Fermi surface can be estimated from the period of the oscillation. The effective cyclotron mass and relaxation time can be also obtained from the temperature and field dependence of the oscillation amplitudes. By introducing the field modulation technique (FMT) and the phase sensitive detection, we demonstrated that the sensitivity of the SdH oscillation can be enhanced significantly.

Experimental

We measured the SdH oscillation of an organic superconductor β-(BDA-TTP)$_2$SbF$_6$ which has a cylindrical Fermi surface [1]. The Cell 5 magnet with a modulation coil was used to perform this experiment. A conventional four probe technique with a constant dc current source was adapted to measure the resistance. Besides a nanovoltmeter to measure the dc resistance, a lock-in amplifier is used to measure the phase sensitive signal to the modulating ac field. A schematic diagram of the measure setup is shown Fig. 1. The sample was immersed in liquid ^{3}He bath to reduce the effect of Eddy current heating.

Results and Discussion

Fig. 2 shows the oscillatory part of the signal and the corresponding FFT spectrum. The field modulation peak field was 74 Oe with frequency of 17 Hz. It is clear that the SdH oscillation was significantly enhanced by using the field modulation technique. The FFT spectrum amplitude is larger by 30 times compared to the conventional dc method.

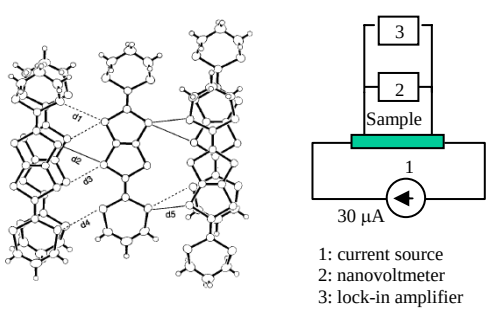

Fig. 1. (Left) Crystal structure of β-(BDA-TTP)$_2$SbF$_6$. (Right) Schematic diagram of the measurement setup.

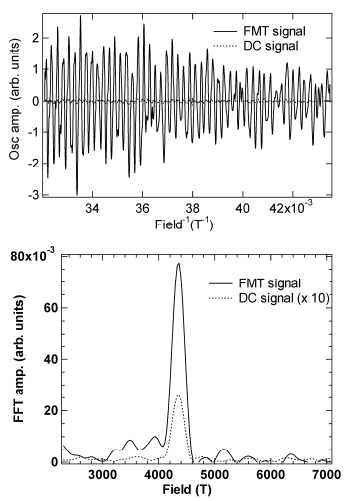

Fig. 2 The field dependence of SdH oscillation and the FFT spectrum.

Acknowledgements

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References

[1] Yamada, J. *et al.*, J. Am. Chem. Soc. **123**, 4174 (2001).

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