Quantum Oscillations in Insulating and Metallic states of Kondo Insulators

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Introduction

The Kondo insulator samarium hexaboride (SmB_6) has been intensely studied in recent years as a potential candidate of a strongly correlated topological insulator. One of the most exciting phenomena observed in SmB_6 is the clear quantum oscillations appearing in magnetic torque at a low temperature despite the insulating behavior in resistance. These quantum oscillations show multiple frequencies and varied effective masses. The origin of quantum oscillation is, however, still under debate with evidence of both two-dimensional Fermi surfaces [1] and three-dimensional Fermi surfaces [2]. The biggest mystery is the missing of the quantum oscillations in the electrical resistivity in SmB_6, making the community speculating a new kind of quasiparticles in Kondo insulator that couple only to magnetic fields but not electrical fields. We solved the problem by testing a number of other Kondo insulators with smaller gap-closing magnetic fields. In the end, ytterbium dodecaboride (YbB_{12}) single crystals turn out to reveal quantum oscillations in both magnetization and electrical resistivity in magnetic fields above 35 T [3].

Experimental

Quantum oscillations were first measured in the magnetoresistance using a standard 4-proble setup using a straight probe in a 65 T short pulse magnet. The magnetic-field-driven insulator-to-metal transition is determined in the magnetoresistance measurements. The quantum oscillations in the higher field metallic state are detected in the proximity-diode-oscillator (PDO) measurement of the electric field penetration length of these samples.

Results and Discussion

Quantum oscillations are observed in the electrical resistivity (Fig. 1 (a)) and in the PDO resonance frequency (Fig. 1(b)). Fig. 1(c) compares the Fast Fourier Transformations (FFT) spectra of the oscillation patterns in the insulating state (upper pattern) and the metallic state (lower pattern).

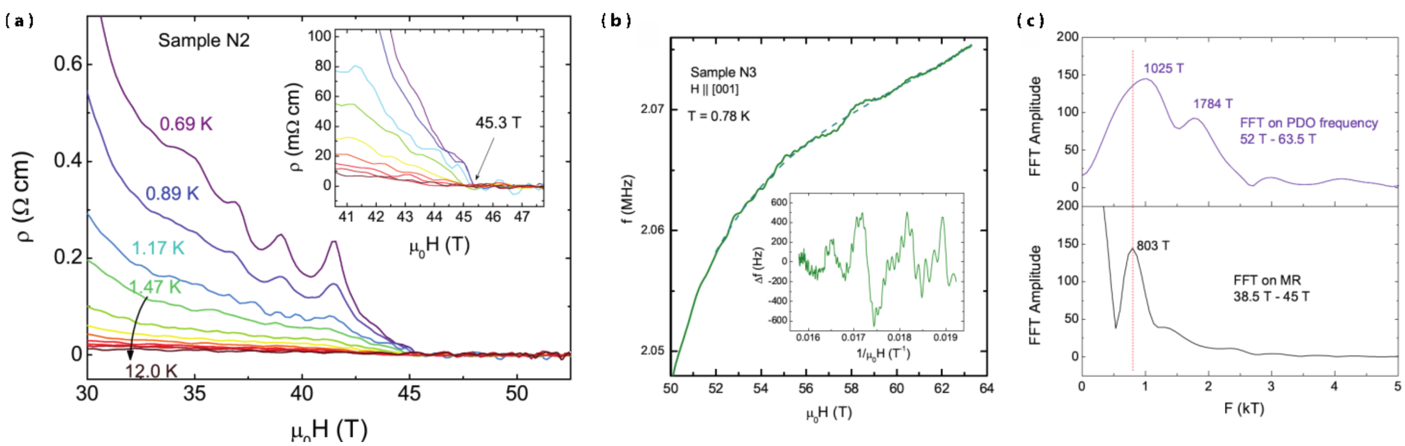

Fig. 1 (a) The magnetoresistance of single crystal YbB_{12}. Shows oscillations in the insulating field range (32 T < B < 45 T). The insert shows the same pulsed field data near the transition field ~ 45 T. (b). The PDO measurements also show oscillatory wiggles in the metallic state above the transition field. (c). The direct comparison of the oscillation FFT shows that the oscillation frequencies are much larger in the high field metallic state. Adapted from Ref. [3]

Conclusions

Quantum Oscillations of observed in the electrical resistivity in YbB_{12}. The oscillation frequencies in the insulating state are much smaller than those in the metallic state. The observation confirms that the oscillation pattern in the low field insulating state is not a residual of the metallic state.

Acknowledgements

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References

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