# Quantum Oscillations in Magnetization and Resistivity 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 speculate about a new kind of quasiparticle in Kondo insulators 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

The quantum oscillations in magnetization were measured by cantilever-based torque magnetometry in the dil-fridge and He3 fridge in the 45 T Hybrid magnet. Soft thin gold wires were connected to the sample to track the *in situ* electrical resistance. The sample was rotated for more than 100 degrees to map the oscillation frequencies. We tracked the temperature dependence to oscillation amplitude.

## Results and Discussion

Quantum oscillations are observed in both magnetization and electrical resistivity, shown in Fig. 1 (a) and (b). The temperature dependences of the oscillation amplitudes are shown in Fig. 1(c) and (d).

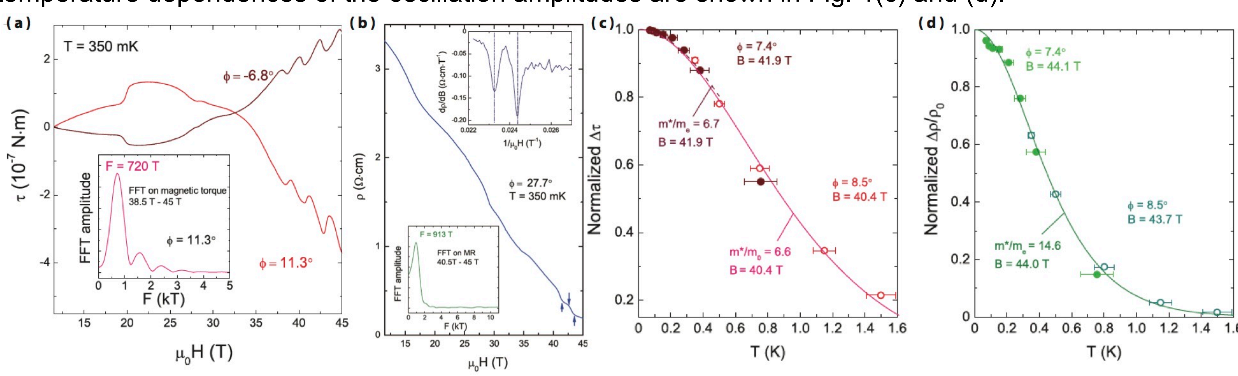


**Fig.1** Quantum oscillations in $YbB_{12}$ in the magnetic torque (Panel a) and electrical resistivity (Panel b). The temperature dependences of the oscillation amplitudes for magnetization (Panel c) and resistivity (Panel d)

## Conclusions

Quantum Oscillations of observed in both magnetization and electrical resistivity in $YbB_{12}$. The temperature dependence of the oscillation amplitudes follows exactly the prediction of the Fermi liquid theory --- the Lifshitz-Kosevich behavior. The resulting effective masses are in the order of 10 me, confirming the heavy fermion nature of the electrons in this Kondo insulator.

## Acknowledgements

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## References

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