Detecting Quantum Oscillations in the Heavy-fermion Systems YbR_2Zn$_{20}$ (R = Co, Rh, Ir)

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Introduction

Thermoelectric devices allow direct conversion between heat and electricity, providing important alternatives for green energy technologies. Yet the efficiency during such energy conversion is limited by the competition between high electrical conductance and low thermal conductance of thermoelectric materials. Recently, we reported enhanced thermoelectric performance of heavy-fermion compounds YbR_2Zn$_{20}$ (R = Co, Rh, Ir), in which we observed the second highest thermoelectric figure of merit thus far at 35 K. [1] Through structural, electrical, and thermal properties analysis, our results show that strongly hybridized f-electron intermetallic compounds coupled with “rattling” features in the cage-like structures offer a unique approach to high power factors while maintaining small thermal conductivity values -- ideal systems for thermoelectric applications. It is therefore of great interest to map the 3-D Fermi surface of these materials through quantum oscillation in order to further our understanding of the charge transport in these materials.

Experimental

Tunnel diode oscillation (TDO) measurements were performed as a function of magnetic field (0 T to 60 T) at varied temperatures (0.5 K to 35 K). These measurements were performed at the NHMFL Pulsed Field Facility.

Results and Discussion

TDO measurements were performed, but we encountered difficulties in obtaining strong signals as well as lowering the background noise in YbR_2Zn$_{20}$ (R = Co, Rh, Ir) compounds (Fig. 1a). To be specific, the TDO signals were too small yet the torque magnetometry was not an option due to the strong magnetic moment in these materials. However, in order to take full advantage of this magnet time, we quickly switched to another 1-2-20 family of compound, $YbPd_2Cd_{20}$, and have obtained clear quantum oscillation signals through TDO measurements (Fig. 1b). We were able to trace the frequency changing with regards to different rotation angles at the base temperature.

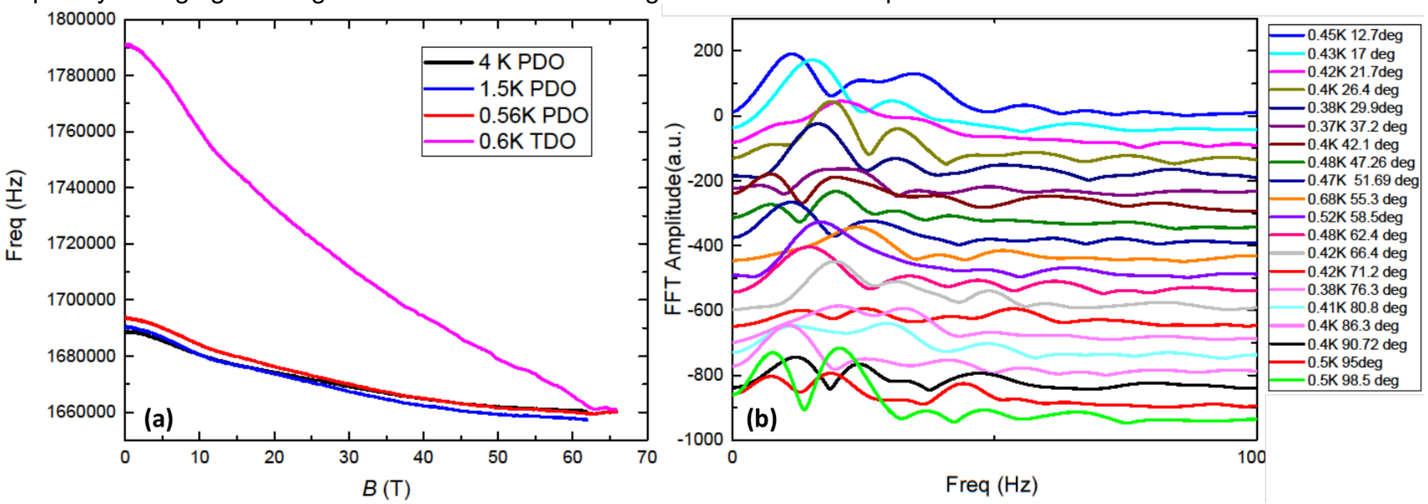

Fig.1 Quantum oscillations in (a) $YbIr_2Zn_{20}$ and (b) $YbPd_2Cd_{20}$.

Conclusions

We were able to obtain decent quantum oscillation signals for $YbPd_2Cd_{20}$, a new compound which has not been previously synthesized nor studied. The data we obtained during this magnet time will help us to construct the Fermi surface of this new compound and promote access to further explore the great potential of the 1-2-20 family of compounds. [2]

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References

[1] Wei, K., *et al*., Sci. Adv., under review (2019).
[2] Wei, K., *et al*., manuscript under preparation.