NATIONAL HIGH MAGNETIC FIELD LABORATORY
2018 ANNUAL RESEARCH REPORT

Cyclotron Resonance in ZrSiZe

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Introduction

ZrSiSe was predicted to be a topological nodal-line semimetal in absence of spin-orbital interaction (SOI) [1]. Several reports claim the existence of these nodal-lines in ZrSiSe [2]. However, the SOI lifts the degeneracy gapping the nodal-lines in ZrSiSe. According to our DFT calculations as well as Ref.[1], bulk ZrSiSe could be topologically trivial if the nodal-line closer to the Fermi level is gapped. In this sense, it is pertinent to ask how large the SOI is for ZrSiSe. The Landé *g*-factor is an indicator of the strength of SOI and can be precisely measured *via* the Zeeman-effect. Furthermore, an extreme *g*-factor was reported for its isostructural compound ZrSiS [3] which shares a similar electronic structure but contains a lighter element "S" instead of "Se". Thus, we proposed the EMR experiment, i.e. to measure cyclotron resonance, to resolve the contradiction between Ref. [2] and Ref. [3] and to better understand ZrSiSe.

Experimental

The resonance absorption in ZrSiSe was measured in the X-band spectrometer Bruker Elexsys 680 at the EMR Facility. ZrSiSe was firstly ground into powder in order to increase the microwave absorption area but, for stabilizing the powder under a field, the sample tube was simultaneously loaded with ethanol and the powder and later inserted to a resonator in a cryostat. During the measurement, 9 GHz microwave excitation was continuously injected into the resonator and monitored while an applied field was ramped from 5 mT to 1.5 T. Absorption as a function of the field is shown in **Fig.1(a)**. Another tube with the same amount of ethanol was measured subsequently with the same setup to evaluate background signal. Sample absorption was obtained by subtracting the raw spectra from the background.

Results and Discussion

The results are summarized in **Fig.1**. A clear resonance signal was observed at $\mu_0 H$ ~1.2T which represents a *g*-factor ~ 2 in **Fig.1(a) and 1(b)**. Due to the fact that ZrSiSe contains large Fermi surfaces and high residual conductivity, most of the microwave energy was reflected by ZrSiSe even in powder form. This resulted in a significant reduction in the Q factor of the resonator when the powder was loaded. Consequently, the pure ethanol absorption was an order of magnitude larger than the sample absorption, and thus the background spectrum must be rescaled with respect to the resonance at $\mu_0 H$ ~1.2T. The spectra after background subtraction are displayed in **Fig.1(c)**. Despite of the effort of removing the contribution from the ethanol, sizable residues are still clearly detected. Otherwise, no other resonance is observed. A dip emerges at low temperatures around $\mu_0 H$ ~0.3 T and disappear above 21 K. But the shape of this dip makes us believe that it is not attributable to any electron spin resonance. The broad background absorption can be removed by subtracting the 21 K trace from the 5 and 8 K ones; results are shown in **Fig.1(d)**.

Conclusions

Because of the nature of ZrSiSe, electrons screen out microwave too effectively so it leads to our inconclusive results.

Acknowledgements

DOE-BES (Award No. DE-SC0002613). NSF/DMR-1644779.

References

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[2] Jin Hu, J., *et al*., Phys. Rev. Lett., **117**, 016602 (2016).
[3] Jin Hu, J., *et al*., Phys. Rev. B, **96**, 045127 (2017).

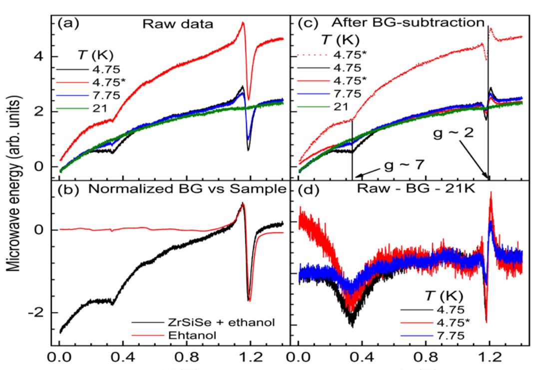

Fig.1 Cyclotron resonance spectra from ZrSiSe powder. (a) Raw-data at various temperature. (b) Normalized background (tube + ethanol) and the raw data at 4.75 K. The background is plotted in red and multiplied by a constant to scale to the same absorption with respect to the raw signal. (c) Spectra at different temperatures after background subtraction. (d) Low temperature spectra (4.75 and 7.75 K) after subtraction of the high temperature data (21 K).