NATIONAL HIGH MAGNETIC FIELD LABORATORY
2018 ANNUAL RESEARCH REPORT

Magnetothermal Conductivity of Breathing Pyrochlore $Ba_3Yb_2Zn_5O_{11}$

Choi, E.S., Baek, H. (NHMFL); Lu, H., Steinhardt, W., Haravifard, S. (Duke U., Mech. Eng. Mat. Sci.)

Introduction

A breathing pyrochlore is a derivative of a pyrochlore based geometrically frustrated magnets, where a degree of freedom in the bond length is added to the tetrahedra that forms the pyrochlore lattice. $Ba_3Yb_2Zn_5O_{11}$ (BYZO) is dubbed as quantum breathing pyrochlore because of its quantum spin (S_{eff} = 1/2) and the lack of a long-range ordering down to 20 mK [1]. We measured magnetothermal conductivity of BYZO to investigate its field-induced phases at low temperatures and to study any itinerant low energy excitations under magnetic fields.

Experimental

Magnetothermal conductivity was measured with a typical one-heater- two-thermometer method with the sample in a vacuum cell. The vacuum cell is mounted on a rotator probe in the SCM2 magnet at the DC facility.

Results and Discussion

Fig. 1 shows the temperature and field dependence of thermal conductivity BYZO. The heat current is applied parallel with [111] direction with magnetic field perpendicular to the heat current. Below 1.4 K, the thermal conductivity is in the ballistic regime as shown in the inset of Fig. 1 (a). The effect of the magnetic field is more clearly seen from the magnetothermal conductivity (MTC, k(B)/k(0)) plot as shown in Fig. 1(b). Overall, the MTC decreases with field until a certain field (noted B* for T=2.0 K data) is reached. Upon further increasing the field, the MTC starts to increase, which are presented as a clear dip at low temperatures and as slope changes at high temperatures. B* tends to increase with temperature. Since there is no ordering in BYZO, the initial decrease of the MTC can be attributed to a scattering of phonons by the paramagnetic spins. The scattering peaks when the Zeeman splitting is comparable to the phonon energy, hence a MTC dip can appear at a certain field.

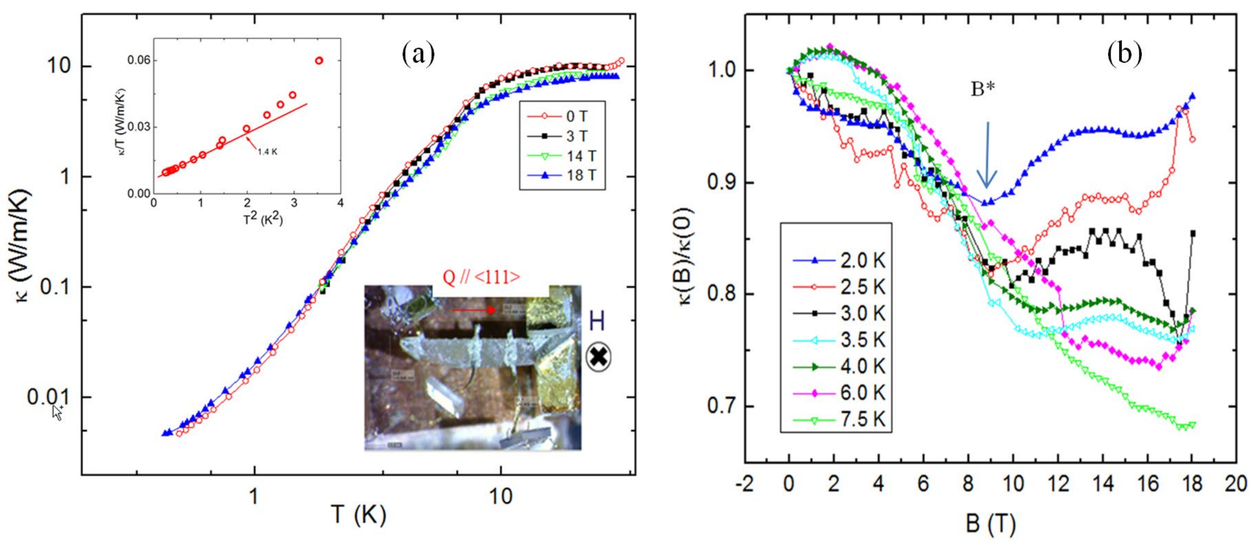

Fig. 1. (a) Temperature dependence of thermal conductivity of BYZO at different fields. The upper inset shows the κ/T vs. T^2 plot and the lower inset shows the BYZO single crystal sample on the sample holder and the directions of the heat and the external field. (b) Magnetothermal conductivity (k(B)/k(0)) at different temperatures.

Conclusions

The MTC of BYZO suggests a dominant mechanism is due to a phonon scattering by paramagnetic spins, whose energy level is governed by the Zeeman Effect. A further study on the anisotropy (or lack of it) at different field directions is under progress.

Acknowledgements

The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida.

References

[1] Haku, T. *et al*., Phys. Rev. B **93** 220407(R) (2016).