Magneto-Raman Spectroscopy on Lacunar Spinel GaV_4S_8

Knight, G., Richardson, R. (FAMU, Physics); Lu, Z. (FSU, Physics); Smirnov, D. (NHMFL); Pokharel, G., Mandrus, D. (U. Tennessee Knoxville) and Thirunavukkuarasu, K. (FAMU, Physics)

Introduction

The ternary chalcogenide GaV_4S_8 has recently attracted considerable attention due to its multiferroic properties with T_{FM} ~ 5 K. Its magnetization corresponds to S = 1/2 per formula unit and its electric polarization is also appreciable (~ 1 μCcm^{-2}). Furthermore, the experiments found evidence for a sizable magnetoelectric coupling [1]. GaV_4S_8 also exhibits magnetic cycloidal order between T_{FM} and T_N = 13 K, which can be transformed by moderate magnetic field (of about 40 mT) into a Neel-type skyrmion lattice (SkL) phase [2]. As predicted in the seminal work of Bogdanov *et al*., [3] the polar macroscopic symmetry of the underlying crystal lattice appears to be the important criteria for the appearance of this very unusual spin texture (Neel-type SkL). In GaV_4S_8, the suitable C_{3v} symmetry emerges together with the ferroelectric polarization below the Jahn-Teller phase transition T_{JT} = 42 K [4,5]. This unusual phase transition was shown to be driven by a strong electron-phonon coupling between the unpaired electron in the highest-energy, orbitally degenerate electronic state of the V_4 cluster and two corresponding Jahn-Teller-active zone-center modes of the non-centrosymmetric paraelectric structure of GaV_4S_8. Recent spectroscopic measurements performed by Hlinka *et al.*, identify the infrared and Raman active phonon modes including the F_2 Jahn-Teller active modes at 200 cm^{-1} and 130 cm^{-1} [6]. We plan to perform Magneto-optical experiments on this family of compounds starting with GaV_4S_8 as function of temperature and magnetic fields to obtain better insight in to the energy scale of the interactions and field-induced effects

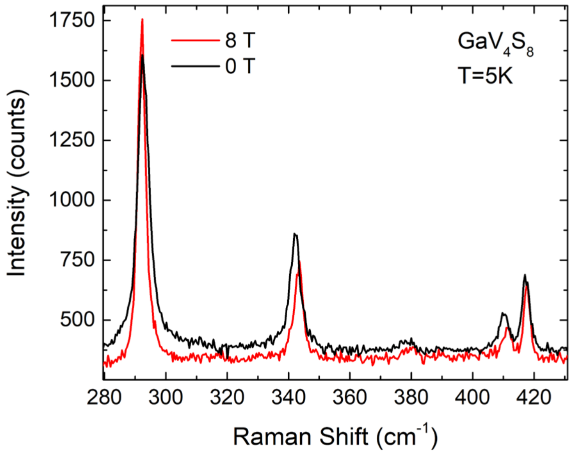

Fig.1 Raman spectra showing the phonons of GaV_4S_8 at 0 T and 8 T.

Experimental

Our initial magneto-Raman spectroscopy on GaV_4S_8 was performed at 5 K using Trivista Raman spectrometer with 532 nm laser excitation using the superconducting magnets. The sample will be placed on X-Y-Z actuator to obtain the best alignment as well as for position selectivity.

Results and Discussion

We attempted magneto-Raman spectra of GaV_4S_8 at 5 K for fields up to 14 T. Raman spectra of select frequency range measured at 0 T and 8 T are shown in **Fig.1**. Many of the Raman active phonons were observed clearly. There are signs of phonon mode shifting with magnetic field at 345 cm^{-1} and 415 cm^{-1}. A subsequent experiment up to 14 T did not indicate significant field-induced shifts in the phonon frequencies. Since the preliminary results are ambiguous, further investigations are currently underway exploring the possibility of sample quality being behind the various responses.

Conclusions

Our preliminary magneto-Raman experiments on GaV_4S_8 indicate possible shift in the phonon energies with increasing magnetic field. Further experiments are required to verify as well as quantify these field-induced effects.

Acknowledgements

NHMFL is supported by the NSF through NSF/DMR-1157490/1644779 and the State of Florida. This project is also supported by the Department of Defence HBCU/MI program.

References

[1] Ruff, E., *et al*., Sci. Adv. **1**, e1500916 (2015).
[2] Kezsmarki, I., *et al*., Nat. Mater. **14**, 1116 (2015).
[3] Bogdanov, A., *et al.*, Magn. Magn. Mater. **138**, 255 (1994).
[4] Pocha, R., *et al*., Chem. Mater. **12**, 2882 (2000).
[5] Wang, Z., *et al*., Phys. Rev. Lett. **115**, 207601 (2015).
[6] Hlinka, J., *et al*., Phys. Rev. B, **94**, 060104(R) (2016).