Raman Spectroscopy of Low Dimensional Spin Systems: $SrCu_2(BO_3)_2$

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Introduction

Raman scattering technique, an important tool in probing the collective excitations involving spin, charge, orbit, and lattice was used to understand the spin-lattice coupling in $SrCu_2(BO_3)_2$ (SCBO). In SCBO, a low dimensional spin system, the Cu ions form a 2D network of orthogonal dimers. An important feature of SCBO is its proximity to a quantum critical point (QCP) by virtue of its ratio of exchange interactions between the dimers. This QCP separates an ordered anti-ferromagnetic state from a disordered isolated network of 2D dimers (Shastry-Sutherland Model) [1]. Presence of a gap in the spin excitation at low temperature and the existence of magnetization plateaus have made SCBO very interesting. It has been observed that the density of triplet excitations in SCBO can be tuned using an external magnetic field. In a recent X-ray diffraction measurement, a decrease in lattice constant, α, above a magnetic field of 20 T was observed [2]. Change in spin excitations at high field causes the shrinkage of the dimer bond length, which in turn reduces the Cu-O-Cu bond angle [2]. Any variation in the bond angle can affect the dimer interaction, and thus the proximity of SCBO to the QCP can be influenced. Raman scattering can be used to probe this change in bond angle; hence, we can gain more insight in to the nature of spin excitation at high magnetic fields.

Experimental

Raman scattering measurements were performed using a fiber-based Raman set-up available with the Optics group at NHMFL. The cell 15 Hybrid Magnet equipped with the Janis cryostat was used to access magnetic fields up to 45 T and temperatures up to 4 K.

Results and Discussion

Figure 1 shows the Raman spectra of $SrCu_2(BO_3)_2$ measured at 5 K. We observed a shift in one of Raman peak in the 150-900 cm^{-1} range at high magnetic fields above 10 T. The peak shifts by about 1.6 cm^{-1} at 45 T.

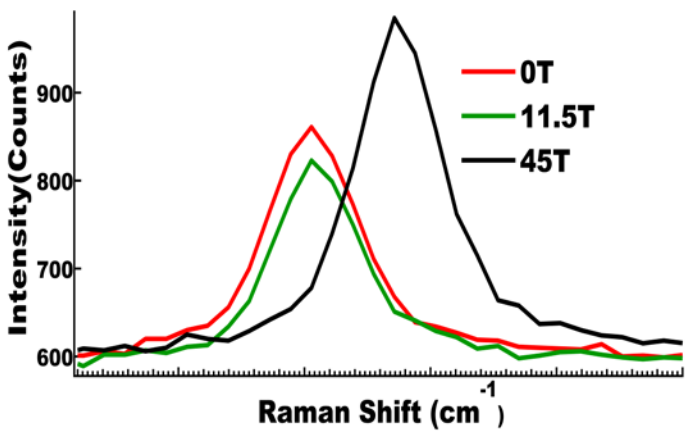

Figure 1: Raman Spectra of SCBO at 5K. Inset shows the shift under magnetic field in one of the Raman peak we observed. The optical excitation and magnetic field are along the c-axis of the sample

Conclusions

The change in bond angle at high magnetic fields can be observed as a shift in Rama spectra. Thus, using a Raman scattering measurement, we are able to observe how exchange interactions are altered by a magnetic field and thus learn further details about the collective magnetic and lattice excitations in $SrCu_2(BO_3)_2$.

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References

1. A.V. Narlikar, (Ed.) *Frontiers in Magnetic Materials*, Springer, (2005) 612 pp.
2. Y. Narumi *et al*., *J. Phys. Soc.Jpn.* **78**, 043702 (2009).