Structural Phase Transitions in Bilayer Iridates

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Introduction

Transition metal oxides (TMO) are a class of materials exhibiting a broad range of physical phenomena, including superconductivity, Mott gaps, frustration, and novel magnetism. Having inspired research for over 70 years, TMOs continue to reveal unexpected new physics. A particularly interest example of TMOs is the Iridium based Ruddlesden-Popper series $Sr_{n+1}Ir_nO_{3n+1}$ (n = 1, 2,..,∞). In these iridates strong spin-orbit coupling splits the 5d t_{2g} band of Ir^{4+} into a $J_{eff=3/2}$ and $J_{eff=1/2}$ band [1,2]. Furthermore, due to strong coulomb repulsion, the $J_{eff=1/2}$ band is split into an upper Hubbard band and a lower Hubbard band. With 5 available Ir^{4+} electrons to fill up all 5d states, this results in a Mott insulator with temperature dependent magnetic and structural ordering. Previous DC-magnetization data has revealed three critical temperatures in $Sr_3Ir_2O_7$ (Sr-327): T* ≈ 70 K, below which the magnetic susceptibility drops steeply at low magnetic fields (but rises for **B** > 0.5 T); T_o ≈ 220 K, below which the susceptibility rises sharply; and the Neel temperature, T_N ≈ 285 K, below which the susceptibility rises weakly [1,3,4]. Interestingly, there has been no explanation for the steep rise in susceptibility below T_o, although the possibility of a structural phase transition has not been excluded. A temperature and magnetic field dependent Raman spectroscopy study of Sr-327, showing the phonon spectrum over the full range of critical temperatures and magnetic fields, could thus shed light on possible structural transitions.

Experimental

We measured the magneto-Raman spectra of two different Sr-327 samples, grown by S.D. Wilson at and near critical temperatures 4 K, 70 K, 220 K, 270 K, and 292 K. All measurements where performed in magnetic fields up to 14.5 T using the SC magnet at the EMR Facility, and over a frequency range 100-1500 cm^{-1}.

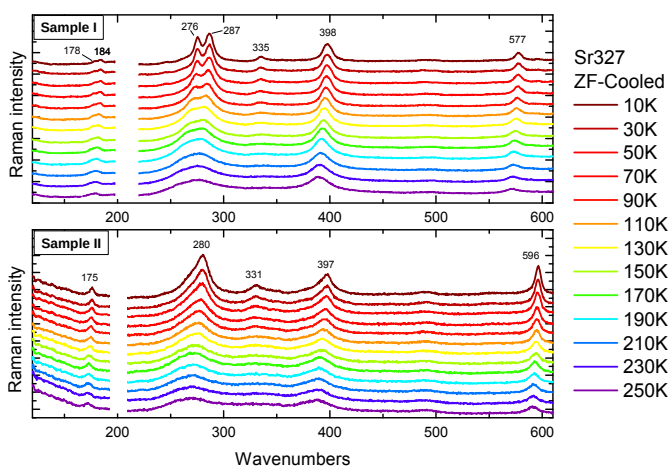

Figure 1. Temperature dependent Raman spectra of two different Sr-327 samples, revealing the splitting of a phonon mode in sample 1, and considerable sample to sample variation.

Results and Discussion

Fig.1 shows the temperature dependent Raman spectra of two different Sr-327 samples at 0T. Surprisingly, no magnetic field dependence was observed in the spectra of either of the two samples. The high quality data do, however, reveal the splitting of a phonon in sample 1, and a comparison of the two Raman spectra shows considerable sample-to sample variation. A careful characterization of the phonon modes (including the apparent emergence of a new mode around 335 cm^{-1}) could reveal signatures of structural phase transitions that are tied to previously observed magnetic phase transitions.

Conclusions

While no magnetic field dependence was observed in the Raman spectra of Sr-327, high quality temperature dependent data can nevertheless provide valuable insights into possible structural phase transitions in Sr-327. Analysis and additional optical experiments are still ongoing.

Acknowledgements

This research was partially funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Prins Bernhard Cultuurfonds (the Netherlands). We also acknowledge D. Smirnov, J-M. Poumirol, and J. Ludwig for their support at the NHMFL.

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