Zone-Folded Phonon Spectroscopy of Magnetic Periodicity in the Frustrated van der Waals Antiferromagnet CrOCl

Amit Pawbake,[1,*] Florian Petot,[2] Florian Le-Mardelé,[1] Tristan Riccardi,[1,3] Julien Lévêque,[2] Bing Wu,[4] Zdeněk Sofer,[4] Benjamin Piot,[1] Benoît Grémaud,[2] Andrés Saúl,[2] Johann Coraux,[3] Milan Orlita,[1] and Clément Faugeras[1,*]

[1]*LNCMI, UPR 3228, CNRS, EMFL, Universite Grenoble Alpes, 38000 Grenoble, France*
[2]*Aix Marseille Univ, CINAM, AMUtech, CNRS, 13288 Marseille, France*
[3]*Institut Neel, Universite Grenoble Alpes, 38000 Grenoble, France*
[4]*Chemistry Department, University of Chemistry and Technology Prague,16628 Prague, Czech Republic*

*corresponding author: amit.pawbake@lncmi.cnrs.fr ; clement.faugeras@lncmi.cnrs.fr

It was recently discovered that the family of van der Waals (vdW) bonded materials includes members with magnetic properties that persist down to the monolayer. This breakthrough opens up numerous opportunities both in fundamental physics and for practical applications based on these intriguing materials. They present different magnetic ground states that can be probed with optical techniques combined with magnetic fields. One such material is CrOCl, a stable frustrated vdW antiferromagnetic insulator, with a low-symmetry orthorhombic structure. The magnetic frustration in principle produces very rich magnetic phase diagrams comprising highly-degenerate disordered phases and complex spin orders. Varying the temperature, magnetic field or hydrostatic pressure, one can navigate through these exotic phase diagrams. Along with remarkable properties, including anisotropic thermal conductivity, spin interactions of different natures, magnetic phase transitions, and optical anisotropy. However, a comprehensive understanding of the magnetic phase dependent phonon modes in CrOCl is still lacking.

We report on the Raman scattering spectroscopy of bulk CrOCl and observed anomalies in the phonon modes at the magnetic transitions. We observe the appearance of a series of low intensity phonon modes below T_N ~ 13 K, characteristic of the size of the magnetic unit cell and the phonon band structure through the phonon zone folding effect. When applying an external magnetic field, we stabilize new magnetic ground states with different magnetic unit cells which can be identified by the series of folded phonon modes. The spectroscopy of such zone folded phonons (ZFP) provides a unique insight into the field induced magnetic phases of frustrated vdW magnets.

In this talk, based on our low temperature and high magnetic field experimental results I will establish ZFP spectroscopy is an efficient way to probe different magnetic periodicity.

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