Phonons by High Resolution Inelastic X-Ray Scattering:

Magneto-Elastic Coupling in an Antiferromagnet

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This course will investigate coupling between magnetism and lattice vibrations. The inter-relation of different degrees of freedom (electronic, magnetic, lattice, orbital) is the cutting edge of materials science. Many of the most interesting and technologically useful properties of materials arise from the interplay between these systems – examples include magneto-resistance, ferroelectricity, multiferroicity, and superconductivity. Thus, there is an increasing drive to understand how these systems can affect each other. Here we will investigate a relatively simple system, focusing on the coupling between the magnetic and lattice degrees of freedom.

X-rays are now emerging as a uniquely powerful probe of atomic dynamics in materials. The small, ~meV, energy scale of most atomic motion, means that building a sufficiently high-resolution x-ray spectrometer is a huge task. However, when completed, the advantages of the x-ray source and the method, make such a spectrometer an invaluable and highly sought-after tool. This course provides an introduction to this tool, as it may be used to investigate phonons in crystalline materials.

We will investigate phonons in the antiferromagnet MnO. This material has a cubic NaCl-type structure at room temperature, but on cooling below the Neel point at about 120C, the Mn planes become antiferromagnetically ordered and the crystal becomes slightly distorted. It has been reported (PRB, 68 (2003) 140406) that the magnetic ordering is accompanied by a surprisingly large splitting of the optical phonon mode frequencies. The main goal of this experiment is to investigate this splitting. We expect that the improved resolution of our x-ray scattering technique (as opposed to the neutron scattering used previously) may allow added insight into the magneto-elastic coupling.

The class (Tuesday, 10 November, only) will begin with a brief introduction to the instrument and to phonons. We will align and measure the sample at room temperature. The sample will then be cooled below the Neel point during lunch, and, after lunch, we will measure again to see if splitting is observed. Additional measurements may be made, depending on the results. Computer simulations of the phonons, using a shell model, will be used to visualize the atomic motions corresponding to the observe spectra.

Course Name: **High Resolution IXS: Phonons in an Antiferromagnet**
Place: **BL35XU Control Station (about 100m from the D1 door)**
Date and Time: **10 November from 09:30 to ~16:00**
Maximum Number of Students**: 6**