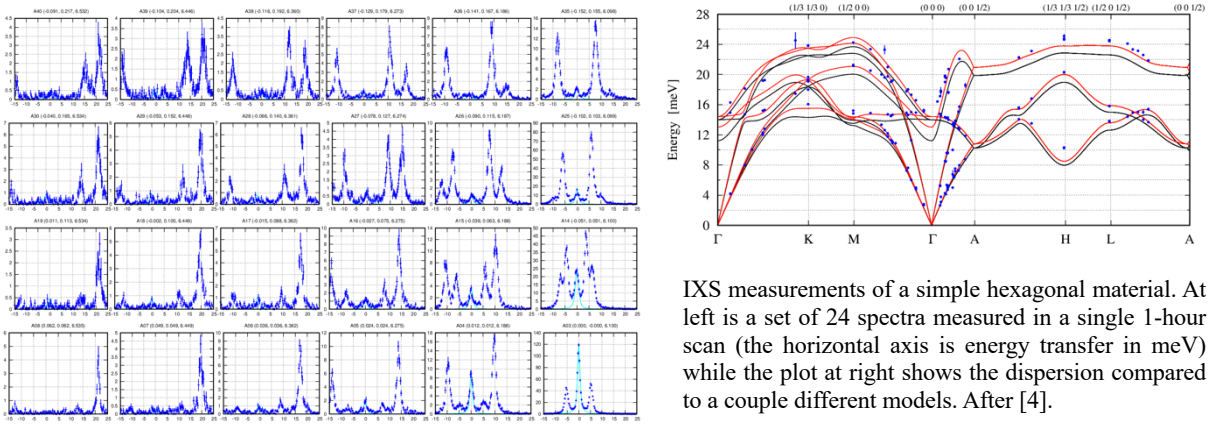
Easy Measurement of Phonon Dispersion at SPring-8

Materials Dynamics Laboratory, RIKEN SPring-8 Center, 1-1-1 Kouto, Sayo, Hyogo 679-5148 JAPAN
Precision Spectroscopy Division, CSRR, SPring-8/ JASRI, 1-1-1 Kouto, Sayo, Hyogo 679-5198 JAPAN

Alfred Q.R. BARON, Daisuke ISHIKAWA, Hiroshi FUKUI, Taishun MANJO

SPring-8, in Hyogo prefecture, has the world's most advanced facilities for measuring phonons using x-rays. The spectrometers at the SPring-8 beamlines, BL35XU [1] and BL43LXU [2], provide world-leading flux in small beam sizes (from 0.005 to 0.1 mm) that can be used to investigate atomic dynamics on meV energy scales over ~nm to Å correlation lengths via inelastic x-ray scattering (IXS) (see [3] for a general introduction). These measurements are used to investigate many classes of materials, focusing on issues relevant to thermal transport, ferroelectricity, superconductivity, formation of charge density waves, phase transformations, localized phonon modes, interactions of phonons with magnons, *etc.* The instruments are also effective for investigating liquids, phonons in thin films, and elastic properties of materials in extreme (high-pressure and high temperature) conditions, even those approaching those of the Earth's inner core – measurements that can be difficult or impossible by other methods.

Perhaps most notably the samples for IXS can be small: a comfortable size sample is ~ 0.5 mm scale, but the method also has been used on ~ 0.005 mm samples, or even 0.0001 mm films. This makes it easy to investigate samples that are not available in the large (cubic-centimeter scale) needed by inelastic neutron scattering, the main competing technique. The figure below gives an example of measured dispersion from a relatively simple hexagonal sample [4]. The plot at left shows a set of 24 spectra that were measured in a single 1-hour scan, while that at right show the dispersion measured in about half a day of data collection.



IXS measurements of a simple hexagonal material. At left is a set of 24 spectra measured in a single 1-hour scan (the horizontal axis is energy transfer in meV) while the plot at right shows the dispersion compared to a couple different models. After [4].

The present talk will describe the main principle of operation of the meV-IXS spectrometers at SPring-8, discuss the variety of samples that may be investigated, and the range of available sample environments.

SPring-8 is a user facility. We are happy to consider collaboration with new groups, and/or on new materials, or in new setups or geometries. Please do contact us if you may be interested. We can be reached most easily by e-mail at baron@spring8.or.jp, disikawa@spring8.or.jp, fukuih@spring8.or.jp, manjo.taishun@spring8.or.jp.
Additional information can also be found on the web pages:
https://beamline.harima.riken.jp/bl_info/bl43lxu_info.html
https://beamline.harima.riken.jp/bl43lxu/
http://www.spring8.or.jp/wkg/BL35XU/instrument/lang-en/INS-0000001397/instrument_summary_view

References
[1] Baron, *et. al*., (2001) *J. Phys. Chem. Solids*. **61**, 461–465. DOI: 10.1016/S0022-3697(99)00337-6.
[2] Baron (2010). *SPring-8 Inf. Newsl.* **15**, 14–19. http://user.spring8.or.jp/sp8info/?p=3138.
[3] *ArXiv: Cond-Mat*. 1504.01098. DOI: 10.1007/978-3-319-14394-1_52.
[4] Baron, Heid & Ishikawa, work in progress.