Beamline practice at BL12XU (Cheiron school 2013)

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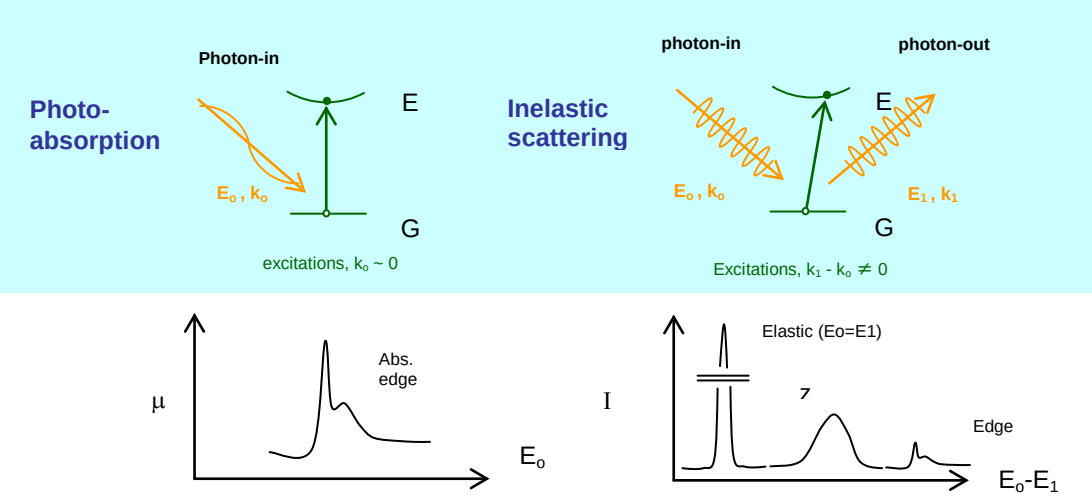
1. Introduction – Inelastic X-ray Scattering -

Brilliant and energy-tunable third-generation synchrotron radiation sources allow us to carry out various types of spectroscopic experiments in the hard x-ray region. The undulator beamline BL12XU is primarily designed for resonant and non-resonant inelastic X-ray scattering (RIXS and NIXS) experiments. Participants at our course will learn basic ideas of inelastic x-ray scattering. In practice, we will perform a NIXS experiment: We will measure carbon K-edge (around 284 eV) in diamond, graphite, and C60 fullerene, using 10-keV x-rays.

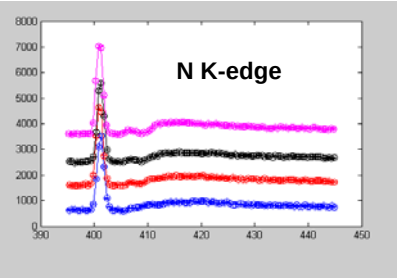
Figure 1 indicates a difference between (normal) photo-absorption and inelastic scattering. In photo-absorption, an incident photon is totally absorbed and all the energy is transferred to an electron to be excited. The absorbance is recorded as a function of the photon energy in a spectrum. In the inelastic scattering, the energy is partially transferred. The electron is excited while another photon is emitted with the rest of the energy (scattered photon). The scattering intensity is recorded as a function as the transferred energy (E_0-E_1).



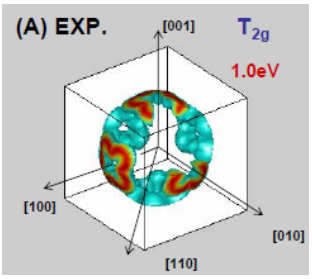
Advantages of the inelastic scattering are mainly,

(i). Absorption edge residing in the soft x-ray region (10 eV < E < 1 keV) can be measured under an extreme condition such as high pressure (Soft x-ray experiments are incompatible with high-pressure experiments)

(ii). Significant momentum (q) is transferred and its magnitude is fully tunable with a scattering angle, therefore it has a richer information (Inelastic scattering spectrum becomes equivalent to photo-absorption at a small q).



Solid N2 under HP

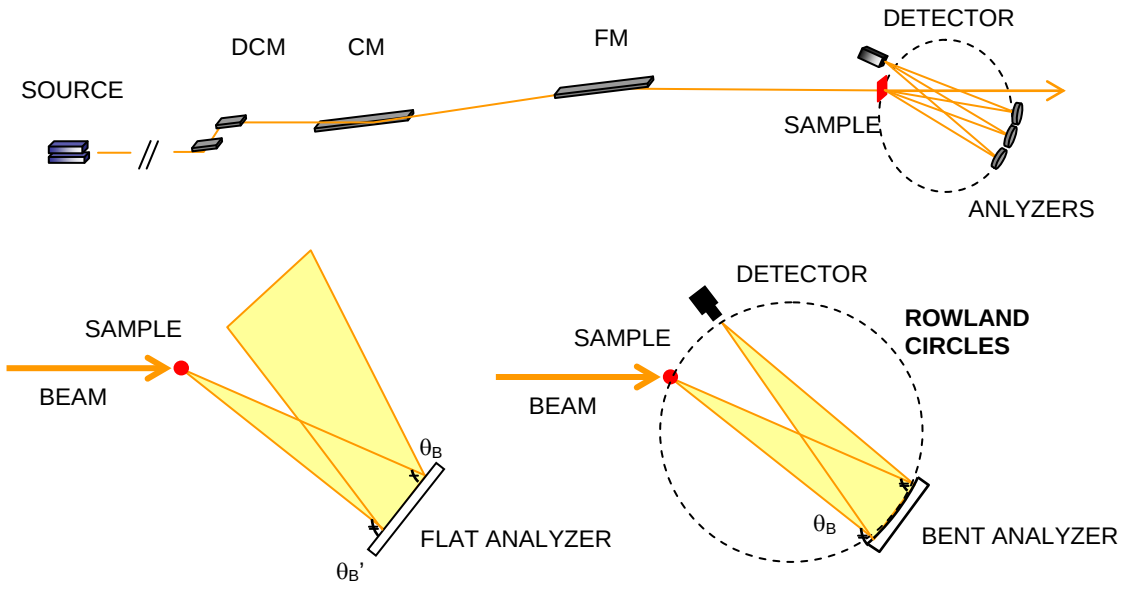


Intensity map of dd excitons in NiO in 3D q-space

A disadvantage is a weak intensity: An intense beam is essential

2. Rowland-circle type spectrometer

For inelastic experiments, a spectrometer is essential to measure the energy distribution of scattered photons. The most popular type of the spectrometers is Rowland-circle type, in which the photons are monochromated and focused into a small spot on a detector. A sample, an analyzer, and a detector are placed on the Rowland circle defined by the bending radius of the analyzer. To increase the count-rate, multiple analyzers are often used.

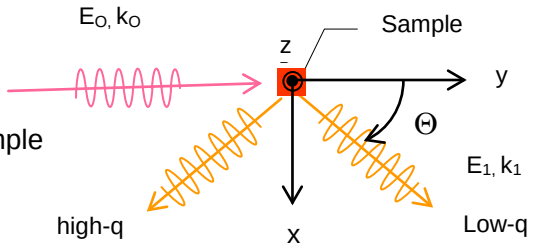


- **Monochromatic**
- **Focused photons**

3. BL Practice

We will try to measure the carbon K-edge in diamond, graphite, and C60-fullerene.

1. Sample alignment



- positioning along the beam-axis (y-axis) by a scope
- positioning along the x-z-plane by a PIN diode after the sample
- find an orientation of the sample axis by x-ray diffraction

2. Measurements

- evacuate a sample chamber and set back the detector
- measure the elastic line (E_0=E_1) : **N.B.** Incident photon energy is scanned in NIXS (unlike RIXS)
- measure the C-edge (E_0 = E_1+284)

If we have a time, we will try high-q (large momentum transfer) to see whether or not the spectra are different.