Polarization analysis

X-ray polarization is nothing but a correction factor for crystal structure analysis. In some cases, however, polarization of the scattered X-ray includes significant information about electronic degree of freedom, that is, charge, spin, and orbital [1, 2]. To perform linear polarization analysis, a crystal polarizer is widely used in X-ray diffraction experiments [3].

Crystal polarizer

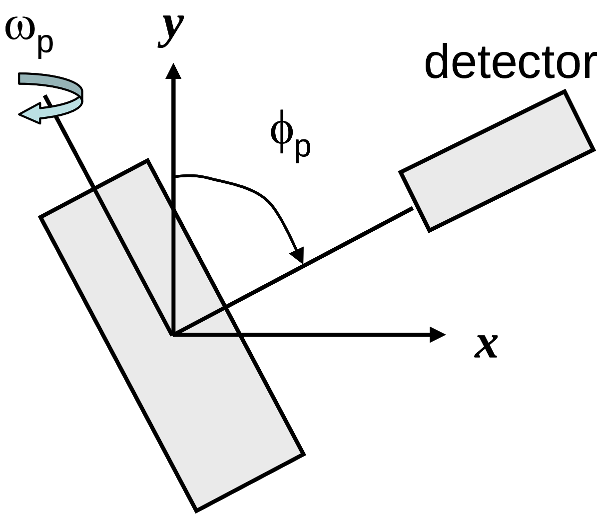
Monochromatic light is 100 % polarized upon reflection at Brewster's angle. In case of X-rays, reflection occurs at certain angles of incidence; this is known as Bragg's law. Therefore, the crystal polarizer must meet the conditions of Brewster's law and Bragg's law, simultaneously. In this practice, Cu 333 reflection is utilized for a crystal polarizer, which restricts the wavelength to 0.984 Å. Since the scattering amplitude parallel to the scattering plane of the crystal polarizer is suppressed, the scatter x-rays are 100 % linearly polarized perpendicular to the scattering plane.

Polarization analysis

To measure the polarization state of the scattered beam, a crystal polarizer is installed in front of a detector. By rotating a crystal polarizer about the scattered beam, arbitrary linear combinations of the ***x*** and ***y*** components (see Fig. 1) can be selected by varying the rotating angle ϕ_p. The intensity may now be written as

$$\begin{aligned} I(\phi_p) &\propto \left| E_x \cos\phi_p + E_y \sin\phi_p \right|^2 \\ &= I_0 \left[\frac{E_x^2 + E_y^2}{E_x^2 + E_y^2} + \frac{E_x^2 - E_y^2}{E_x^2 + E_y^2} \cos 2\phi_p + \frac{\mathrm{Re}[E_x E_y]}{E_x^2 + E_y^2} \sin 2\phi_p \right] \\ &= I_0 \left[1 + P_\zeta \cos 2\phi_p + P_\xi \sin 2\phi_p \right] \end{aligned}$$

Where I0 is the total intensity, and $P_i (i = \xi, \zeta)$ are the normalized Stokes parameters [4]. Consequently, one can determine the polarization state of the scattered beam by measuring the dependence of intensity on the rotation angle ϕ_p. Rocking a crystal polarizer is also necessary for obtaining correct integrated intensities, because the divergence of the scattered beam is not isotropic.



Practical work

Let’s determine the polarization state of the direct beam from the monochromator.

References

[1] F. de Bergevin and M. Brunel, Acta. Cryst. A**37**, 314 (1981).
[2] Y. Murakami *et al*., Phys. Rev. Lett. **80**, 1932 (1998).
[3] D. Gibbs *et al*., Rev. Sci. Instrum. **60**, 1655 (1989).
[4] M. Blume and D. Gibbs, Phys. Rev. B **37**, 1779 (1988).