X-ray optics for Synchrotron Radiation Beamlines

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The basic task for any X-ray optical system is to act upon the X-ray beam to obtain the best match to the experimental needs. The various optical elements in a typical beamline can be required to modify the beam shape and divergence, spectral distribution and intensity, and polarisation. All of the components used in visible light optics find their counterparts in X-ray optical schemes (e.g. slits, filters, mirrors, beam splitters, monochromators, phase plates and lenses) although the configurations and physical phenomena which are exploited occasionally vary due to the large difference in radiation wavelengths.

The two extreme cases of high heat-load optics and high spatial-resolution focusing optics illustrate well the range of demands placed upon X-ray optics in modern light sources;

X-ray emission from insertion devices of modern synchrotron radiation sources is generally characterised by highly collimated beams covering a wide spectral range. In many cases, in this 'white'-beam illumination, upstream optical components must withstand both high incident powers (>5 kW) and power densities (>50 W/mm^2). For such devices, it is a continual technical challenge to develop optical systems which are durable (~years) and can perform their primary optical function without significantly degrading the intrinsic quality of the downstream X-ray beam. Cooling strategies for this class of component are in constant evolution.

For downstream optical systems, positioned close to the experimental station, there is intense developmental activity for devices capable of producing highly focused beams. Even ten years ago, hard X-ray beams focused to sub-micron dimensions were only just becoming available. Currently, sub-10nm focusing of both hard X-rays (20keV) using reflective optics and soft X-rays (1.2keV) using diffractive lenses have been reported. In most cases the behaviour of these and other nanofocusing devices is well described on a theoretical level. however fabrication aspects remain challenging. Routine implementation of such small focusing resolutions is non-trivial however and will in turn impose extremely high demands upon the performance of the end-stations.

Apart from these cited cases; a wide-range of optics is typically employed along the optical path of beamlines which are often several tens of meters long between source and experimental station. In this presentation I will attempt to give a broad introduction to the requirements and operating principles of these X-ray optical systems and, through a range of examples, show the highly diverse classes of optical devices which are implemented at X-ray light sources in order to tailor the X-ray beam characteristics to the experimental requirements.