Illuminating the Role of Brightness in X-ray Diffraction

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Single crystal diffraction experiments require intense X-ray beams. In a given geometry the photon flux is determined by the beam properties and the crystal properties. Ideally the beam diameter should only be a little bigger than the sample. The maximum divergence is reached when reflections, due to large mosaicity and large lattice constants, start to overlap.

The Brightness (B) of an X-ray source is linked to the divergence (Ω), beam size (A) and flux (Φ) by: $B = \Phi/A\Omega$. This brightness is a constant and can't be changed according to Liouville's theorem. No optic will be able to increase the brightness of the source; it can only lower the brightness by having an efficiency lower than 100%. Today's best quality multilayer optics have an efficiency of about 70%. Thus, given the sample properties and the efficiency of the optic, the only way to increase the flux on the crystal is by increasing the brightness of the source.

Rotating anode generators are the logical X-ray source choice for Structural Biology home laboratories. These generators offer a much higher brightness than sealed tube X-ray sources due to the larger power density applied on the anode. In this paper we show the results of brightness measurements on rotating anode sources with various focal sizes and optics with different efficiency. We give examples of how the electron spot on the anode influences the number of photons on a sample and how this affects the quality of the diffraction experiment.

Keywords: intensity measurement, brightness, x-ray optics