*International Tables for Crystallography* (2018). Vol. H, Figure 2.1.18, p. 42.

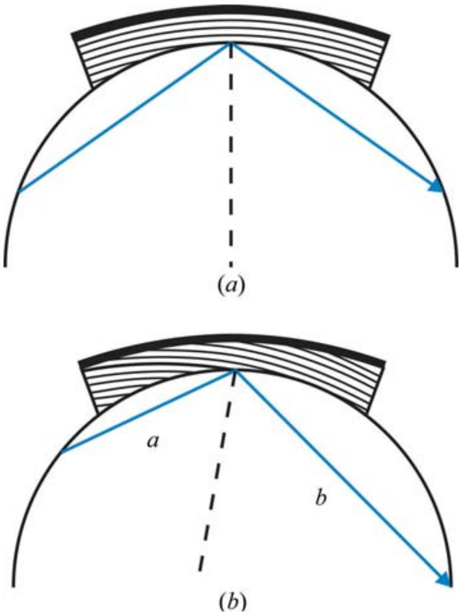

**Figure 2.1.17**
Illustration of curved and ground single-reflection monochromators. Only the central beam is shown for clarity. (*a*) Symmetrically cut crystal, (*b*) asymmetrically cut crystal with two different focal lengths *a* and *b*.

sufficiently large, then the instrument geometry can be converted between the Bragg–Brentano and the focusing Debye–Scherrer geometries by shifting the monochromator crystal and the X-ray source along the incident-beam X-ray optical bench (see Section 2.1.4.1 and Fig. 2.1.3).

The most commonly used monochromator crystal materials are germanium and quartz, which have very small mosaic spreads and are able to separate the $K\alpha_1/K\alpha_2$ doublet. In contrast to germanium and quartz crystals, graphite and lithium fluoride have large mosaic spreads and thus high reflectivity, but cannot suppress $K\alpha_2$. In principle, any of these monochromators can be mounted in the incident as well as the diffracted beam; the choice mostly depends on the purpose of the monochromator. Germanium and quartz monochromators are typically used as incident-beam monochromators to produce pure $K\alpha_1$ radiation. Graphite (focusing geometries) and lithium fluoride (parallel-beam geometry) are often used as diffracted-beam monochromators to suppress fluorescence radiation. Germanium and quartz can also be used as diffracted-beam monochromators, but are usually not because of their lower reflectivity. Where mounting of diffracted-beam monochromators is difficult or impossible, which is specifically true for one- and two-dimensional detector applications, curved graphite monochromators are frequently used as incident-beam monochromators.

The use of diffracted-beam monochromators – at least in powder X-ray diffraction – is declining steeply because of the geometric incompatibility issues with one- and two-dimensional detector systems (which, since 2010, have been sold with more than 90% of all diffractometers; see Section 2.1.3.2). With the recent improvements of energy-discrimination capabilities for silicon micro-strip detectors, the need for diffracted-beam monochromators will further diminish (see Section 2.1.7.2.3).

### 2.1.6.3.2.2. *Multiple-reflection monochromators*

Multiple-reflection monochromators can reduce the wavelength dispersion $\Delta\lambda\,/\lambda$ significantly more than single-reflection monochromators. Multiple-reflection monochromators are often made of monolithically grooved single crystals and are also known as channel-cut monochromators (Bonse & Hart, 1965). In Fig. 2.1.18 an overview is given of the most common channel-cut monochromator types; for a detailed discussion see *e.g.* Hart (1971) and Bowen & Tanner (1998). Successive reflection of the X-ray beam at the channel walls by the same lattice planes causes a strong reduction of the X-ray intensity contained in the tails of the beam. Depending on the number of reflections, multiple-reflection monochromators are denoted as two-bounce, three-bounce *etc.* channel-cut monochromators. The Bartels monochromator (Bartels, 1983) comprises two two-bounce channel-cut crystals. For Cu radiation, such a monochromator results in a wavelength spread which is less than the natural line width of the Cu $K\alpha_1$ line. The most commonly used crystal material is germanium, which delivers higher intensity than silicon, using the 400, 220, or 440 reflections. Crystals may be cut symmetrically or asymmetrically. In Table 2.1.5 several types of

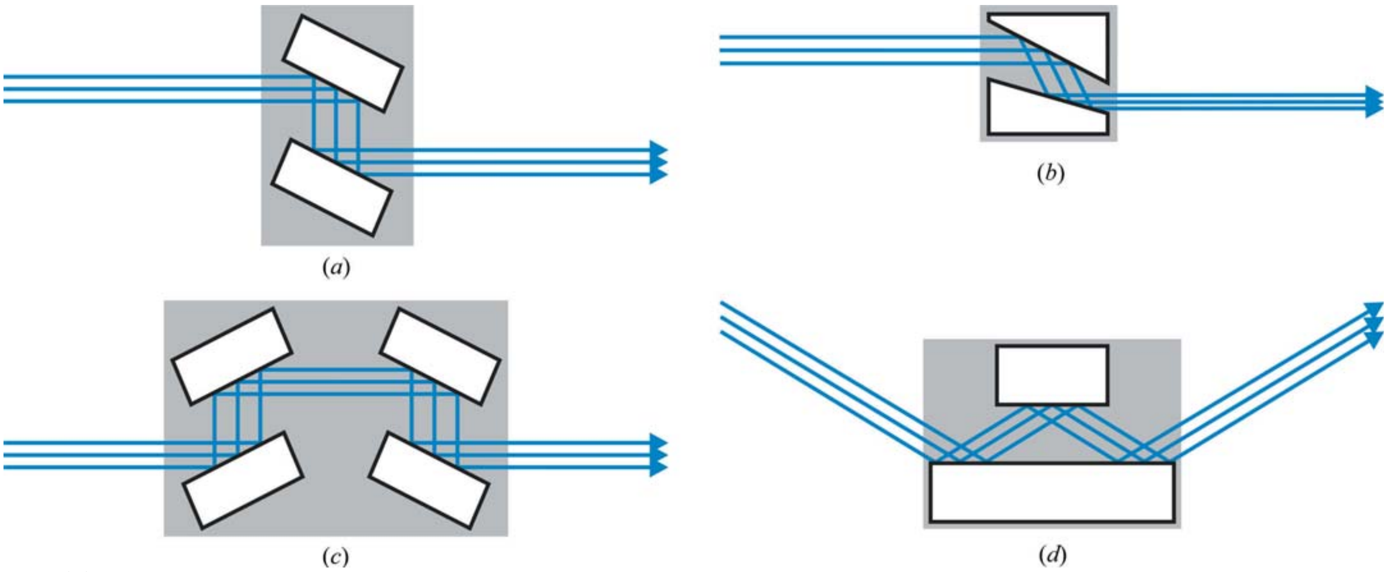

**Figure 2.1.18**
Illustration of multiple-reflection monochromators. (*a*) Symmetrically cut two-bounce channel-cut monochromator, (*b*) asymmetrically cut two-bounce channel-cut monochromator for beam compression, or, if reversed, for beam expansion, (*c*) symmetrically or asymmetrically cut four-bounce channel-cut monochromator, (*d*) symmetrically cut three-bounce channel-cut monochromator.

references