10.3.2.2 Dispersion of X-ray radiation

Wavelength dispersion refers to spatial separation of characteristic X-rays according to their wavelengths.

10.3.2.2.1 Crystal diffraction

Radiation emitted by a specimen is limited to an approximately parallel beam by passage through a collimator (see Figure 10.12). The beam is directed to the *analyzer crystal* which selectively diffracts different wavelengths at different angles according to *Bragg's equation*, $n\lambda = 2d \sin \theta$, where n is the order of diffraction, d is the interplanar spacing for the diffracting planes, and θ is the *Bragg angle* between the incident radiation and the diffracting planes. The angle between the diffracted radiation is equal to 2θ making the total angle between the incident and diffracted radiation equal to 2θ. A grating with very fine spacing may be used instead of crystal for wavelengths greater than 1 nm, but pseudo crystals of barium stearate layers, etc., are preferred up to 10 nm. By rotating the crystal, each wavelength is diffracted, in turn, up to the maximum wavelength, λ_{max}, where $\lambda_{max} = 2d$.

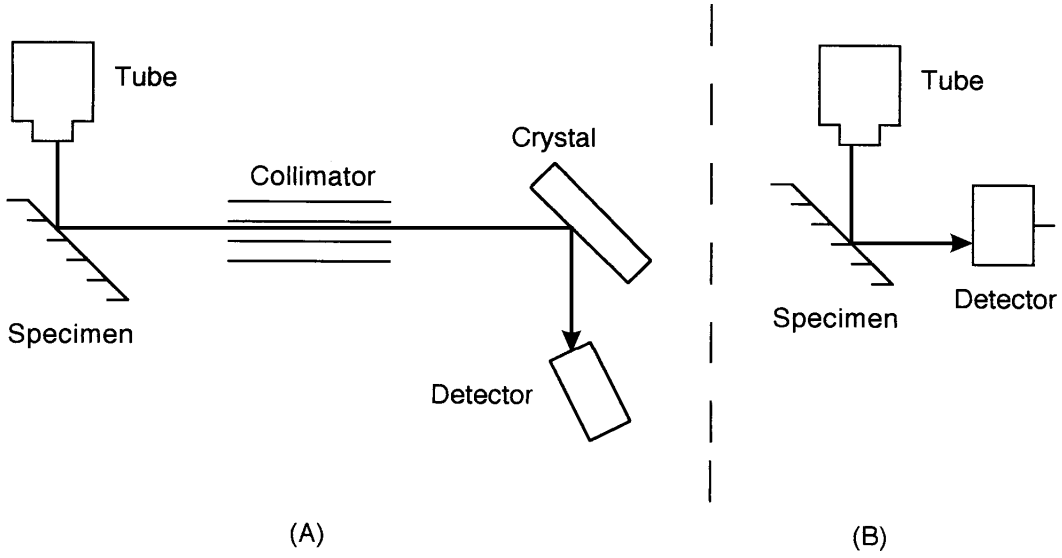

Fig. 10.12 Two Methods of X-ray Spectrometry (A): Wavelength dispersion, (B): Energy dispersion

10.3.2.2.2 Crystal characteristics

The selective reflection of monochromatic radiation occurs over a small angular range because of crystal imperfections. The shape of the diffraction peak for monochromatic radiation is described by the *rocking curve* when the crystal is rotated through the Bragg

angle. Three properties of the peak allow different crystals to be compared quantitatively: the full width at half maximum (FWHM) of the rocking curve, the maximum value *viz.* the *peak diffraction coefficient*, P, having values of 0.1 to 0.8 for common crystals, and the *integral reflection coefficient*, R, which is $\vee P(\theta)\mathrm{d}\theta$, in radians, and has values ranging from 10^{-5} to 10^{-3} rad.

10.3.2.2.3 Spectrometer resolution

Referring to Fig. 10.12, the collimator limits angular divergence of the radiation passing through it. The intensity decreases linearly with angle on each side of the direct beam, thus forming a triangular-shaped collimator intensity distribution at half-maximum intensity designated the *collimator resolution*, B_c. This is convoluted with the crystal rocking curve FWHM, W, to give the overall spectrometer resolution, B.

$$B = \sqrt{B_c{}^2 + W^2}$$

B has values ranging from 10^{-3} to 5×10^{-3} rad (4 to 20 min of arc) for common collimators. The crystal spectrometer diffracts several orders of radiation at the same θ angle, i.e., if $\lambda_2 = \lambda_1/2$ the second order diffraction of λ_2 will overlap the first order diffraction of λ_1 (*harmonic overlap*) and they cannot be distinguished except with the aid of pulse height selection.