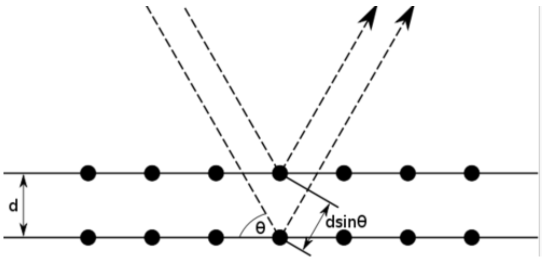
Answer on Question#61821 – Physics – Solid State Physics

At what angle will a diffracted beam emerge from the (111) planes of a face centered cubic crystal of unit cell length 0.5 nm? Assume diffraction occurs in the first order and that the x-ray wavelength is 0.3 nm?

Solution. Bragg diffraction. Two beams with identical wavelength and phase approach a crystalline solid and are scattered off two different atoms within it. The lower beam traverses an extra length of 2dsinθ. Constructive interference occurs when this length is equal to an integer multiple of the wavelength of the radiation.



The effect of the constructive or destructive interference intensifies because of the cumulative effect of reflection in successive crystallographic planes of the crystalline lattice (as described by Miller notation). This leads to Bragg's law, which describes the condition on θ for the constructive interference to be strongest:

$$2dsin\theta = n\lambda,$$

where n is a positive integer (order) and λ is the wavelength of incident wave.

For a crystalline solid, the waves are scattered from lattice planes separated by the interplanar distance d. For (111) planes of a face centered cubic crystal of unit cell length 0.5 nm

$$d = \frac{a_0}{\sqrt{3}}.$$

$a_0 = 5 \cdot 10^{-10} m$ – unit cell length.

According to the condition of the problem

$n = 1$ and $\lambda = 3 \cdot 10^{-10} m.$

Get $2dsin\theta = n\lambda \rightarrow 2\frac{a_0}{\sqrt{3}}.sin\theta = n\lambda \rightarrow sin\theta = \frac{\sqrt{3}n\lambda}{2a_0} \rightarrow \rightarrow \theta = \sin^{-1}\left(\frac{\sqrt{3}n\lambda}{2a_0}\right)$

$\theta = \sin^{-1}\left(\frac{\sqrt{3}\cdot 1\cdot 3\cdot 10^{-10}}{2\cdot 5\cdot 10^{-10}}\right) = \sin^{-1}\frac{3\sqrt{3}}{10} \approx 31.3^0.$

Answer. $\theta = \sin^{-1}\frac{3\sqrt{3}}{10} \approx 31.3^0.$

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