Answer on Question #75230, Physics / Optics

Sodium light is incident normally on a grating of width 4×10^{-3}m. The total number of lines on the grating is 2000. Determine the angular separation between the sodium D-lines in the first order spectrum.

Solution:

This light contains two closely spaced lines (the well-known sodium doublet) of wavelengths 589 nm and 589.59 nm.

The grating spacing d is given by

$$d = \frac{l}{N} = \frac{4 \times 10^{-3}\, m}{2000} = 2 \times 10^{-6}\, m$$

For first line

$$d \sin\theta_1 = m\lambda_1$$

So,

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda_1}{d}\right) = \sin^{-1}\left(\frac{1 \times 589 \times 10^{-9}}{2 \times 10^{-6}}\right) = 0.298932\, rad = 17.13° = 17°\, 7'39''$$

For second line

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda_2}{d}\right) = \sin^{-1}\left(\frac{1 \times 589.59 \times 10^{-9}}{2 \times 10^{-6}}\right) = 0.299241\, rad = 17.15° = 17°\, 8'43''$$

The angular separation is

$$\Delta\theta = \theta_2 - \theta_1 = (0.299241 - 0.298932)\, rad = 0.000309\, rad = 1'4\,''$$

Answer: $0.000309\, rad = 1'4\,''$