Beam Expansion Analysis

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1 General Discussion of Beam Spreading for a Rectangular Aperture

The diffraction angle $\Delta\theta$ of a laser beam of wavelength λ going through an aperture of width D is given by $\dfrac{\lambda}{D}$. The central maximum of the beam in the far-field is independent of distance between aperture and screen. The spreading of the central maximum with length is given by

$$L\Delta\theta = \frac{2L\lambda}{D}$$

We can remove the slit width and just assume a beam of width D and it will behave identically. After collimation, a "parallel" beam of light spreads just as if it emerged from a single opening.

1.1 Practice Problems

1. Imagine a parallel beam of 546-nm light of width D = 0.5 mm propagating across the laboratory, a distance of 10 m. Determine the final width of the beam due to diffraction spreading.

   Solution Using the equation $\dfrac{2L\lambda}{D}$ we get

   $$W = \frac{2L\lambda}{D} = \frac{2(10)(546x10^{-9})}{0.5x10^{-3}} = 21.8mm$$

2. Assume:

   - $I_o = 100\ W/cm^2$
   - A Square Aperture
   - Aperture Width = 10 cm
   - $\lambda = 1$ x 10^{-6} m

- Range = 1 km

Find the irradiance of the far-field beam 0.5 cm from the peak.
Using Matlab plot the shape of the beam from the peak to the zero crossing.

Solution Using the equation $\frac{2L\lambda}{D}$ we get

$$W = \frac{2L\lambda}{D} = \frac{2(1x10^3)(1x10^{-6})}{1x10^{-1}} =$$

2 General Discussion of Beam Spreading for a Circular Aperture

2.1 Practice Problems