Physics 223
Experiment 8: Interference from Multiple Slits

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Double slit interference

In Young's double slit interference experiment, two infintely small slits are illuminated by a single plane wave (see Figure 1) of wavelength λ. The interference pattern which appears on a screen far away is a result of the different distance traveled by the light from the two slits. If the slit separation is d and the screen is at a distance $L \gg d$ from the two slits, the interference maxima and minima occur at angles θ such that

$$\begin{array}{lrcll} \text{maxima} & d\sin\theta & = & m\lambda & \\ \text{minima} & d\sin\theta & = & (m+\frac{1}{2})\lambda & \quad m = 0,1,2,3\ldots \end{array} \tag{1}$$

This leads to a simple intensity function:

$$I(\theta) = \cos^2\left(\frac{\pi d}{\lambda}\sin\theta\right). \tag{2}$$

However, when the slits have a finite aperture a, the resulting intensity pattern becomes a combination of the simple Young's experiment and the single slit diffraction derived above.

$$I(\theta) = \left[\frac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta/\lambda}\right]^2 \cos^2\left(\frac{\pi d}{\lambda}\sin\theta\right). \tag{3}$$

The second term is a simple two slit interference pattern with equally spaced minima and maxima while the first term, arising from single slit diffraction, is more slowly varying and modulates the intensity and introduces some additional minima.

Diffraction gratings

A diffraction grating is similar to an ideal double slit with the difference that instead of two sources interfering to give maxima, the diffraction grating contains many "slits". The angular position of the maxima is given by

$$n\lambda = d\sin\theta \tag{4}$$

where $\theta = \arctan(x/L)$, n is the order number (0,1,2...), x is the distance of the n^{th}

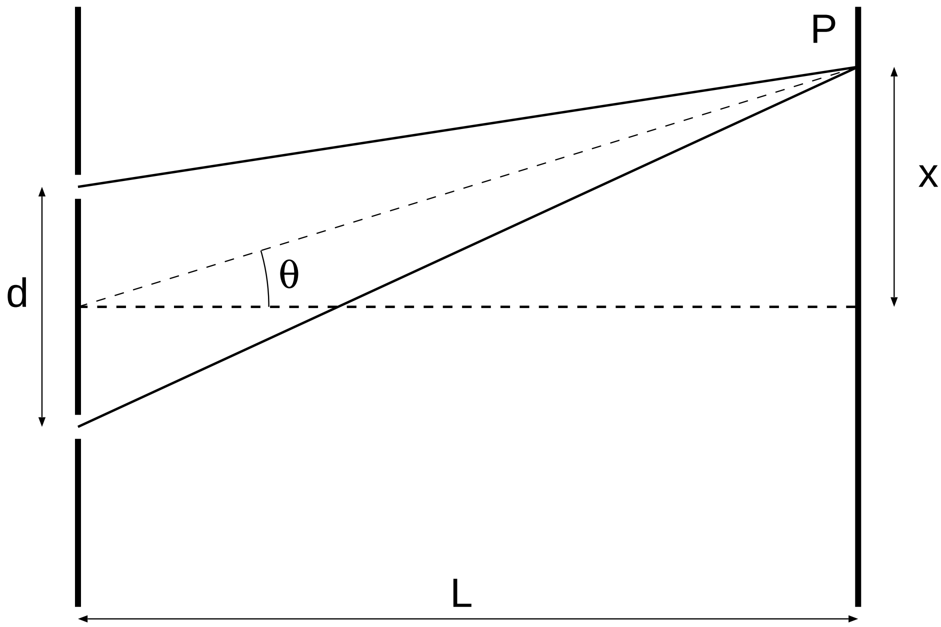

Figure 1: Double slit interference, maxima and minima