Chapter 9 Diffraction

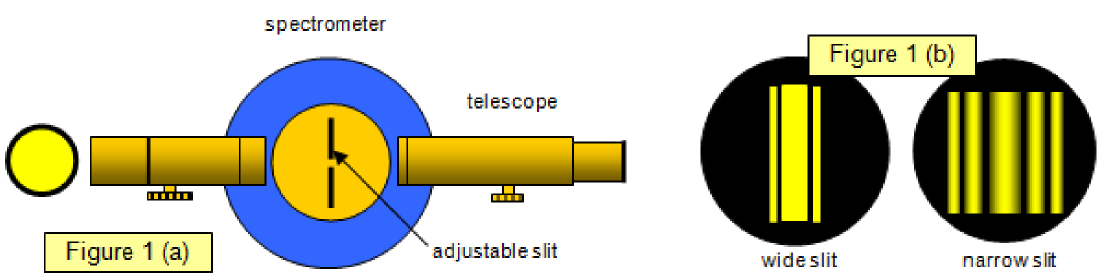
Diffraction is special case from interference, to explain the diffraction
Define of **Diffraction:**

When a beam of light passes through a narrow slit, it spreads out to a certain extent into the region of the geometrical shadow.

Fresnel and Fraunhofer diffraction
We can define two distinct types of diffraction:
(a) Fresnel diffraction is produced when light from a point source meets an obstacle, the waves are spherical and the pattern observed is a fringed image of the object.
(b) Fraunhofer diffraction occurs with plane wave-fronts with the object effectively at infinity. The pattern is in a particular direction and is a fringed image of the source.

Fresnel diffraction
Fresnel diffraction can be observed with the minimum of apparatus but the mathematics are complex. We will therefore only treat it experimentally here.

If a razor blade is placed between the observer and a point source of monochromatic light, dark and bright diffraction fringes can be seen in the edges of the shadow. The same effects can be produced with a pinhead, when a spot of light will be seen in the center of the shadow.



Fraunhofer diffraction - Single slit

the general condition for a minimum for a single slit is:

$$m\lambda = a \sin \theta$$
where m = 1, 2, 3, 4 and so on

For a circular aperture and a small angle the formula has to be modified to give:

Smallest resolvable angle (φ) = $1.2\lambda/a$

You can see that higher resolution is possible with large apertures or with short- wavelength radiation such as ultraviolet light, X-rays or even electrons.

This is why ultra violet light or electrons are used in microscopes where a very high magnification is needed.

The eye can resolve fine detail rather better if the lighting is not too strong, so that the pupil will have a large aperture.

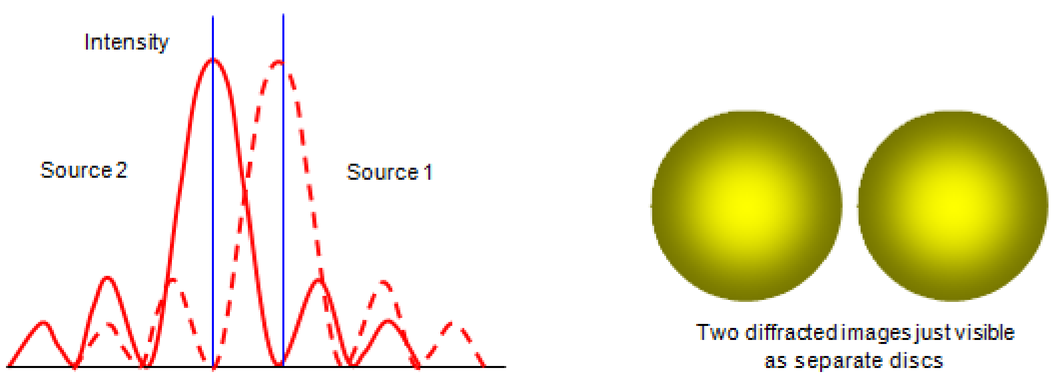


Figure 1

The problem with very large optical telescope mirrors has been overcome to some extent by the use of multiple mirror telescopes. These instruments use a number of smaller mirrors mounted to give the same light-gathering power and resolving power as a very large single mirror

Fraunhofer diffraction	Fresnel diffraction
1- both of light source and screen are an infinite distance from diffraction element	1- Either the source and the screen or both are finite distance from the diffraction element
2-We are dealing with plane wave	2-We are dealing with spherical wave
3-lenses are required	3- lenses are not required

A **diffraction grating** consists of a large number of equally spaced, identical slits. The condition for intensity maxima in the interference pattern of a diffraction grating for normal incidence i s

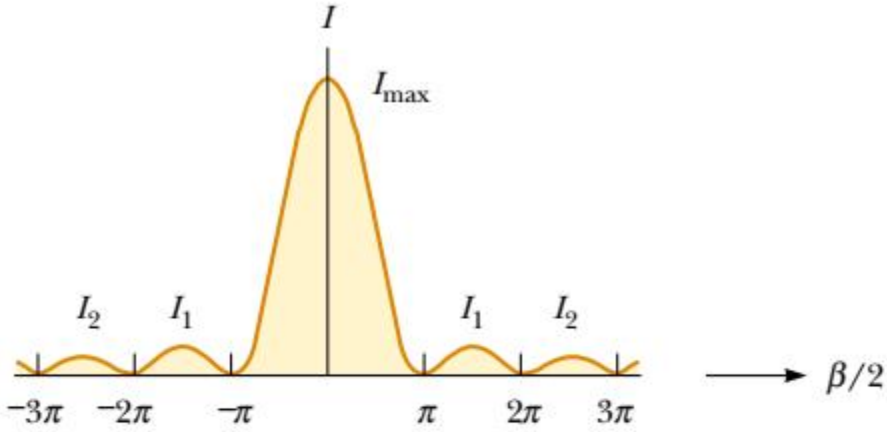
$$d \sin \theta = m\lambda \qquad m = 0, 1, 2, 3, \ . \ . \ .$$

Where d is the spacing between adjacent slits and m is the order number of the diffraction pattern. The mth order of, the diffraction pattern is

$$R = Nm$$

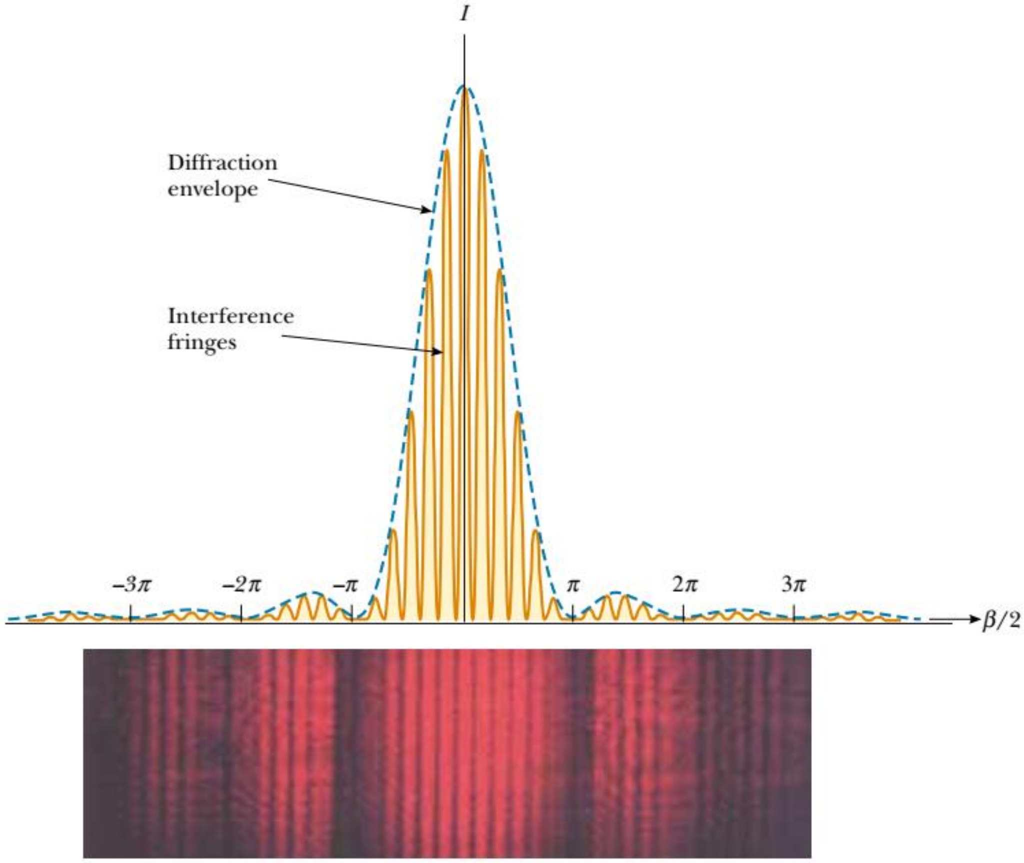
Where N is the number of lines in the grating that are illuminated.

COMPARISON OF THE SINGLE-SLIT AND DOUBLE-SLIT PATTERNS



(a)

(b)



I
Diffraction
envelope
Interference
fringes
−3π
−2π
−π
π
2π
3π
β/2

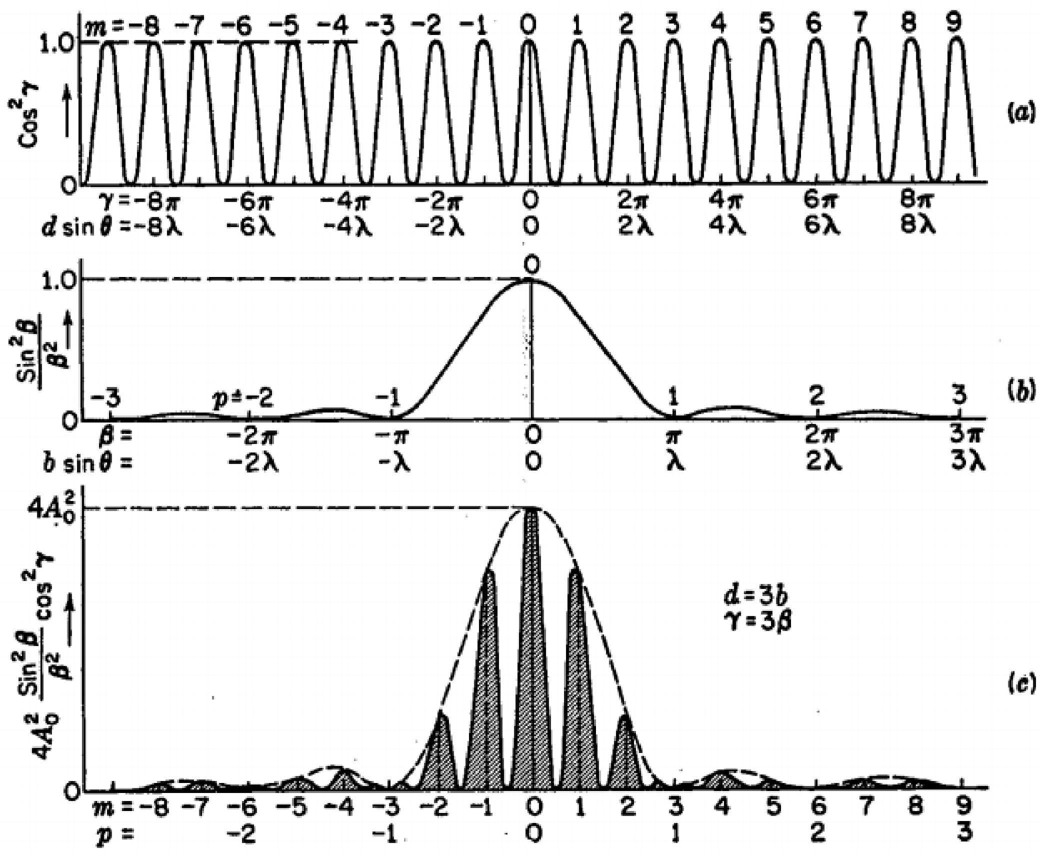


FIGURE 16D

Single slit diff. pattern	Double slit diff. Pattern
$I=A_o^2$ $$I = I_{\max}\left[\frac{\sin(\beta/2)}{\beta/2}\right]^2$$	$I=A^2$ $=4A_o^2\,\frac{sin_\beta^2}{\beta^2}\,cos_\beta^2$
$I_{max}=A_o^2$ $I_{min}=0$	$I_{o\ max}=4\ A_o^2$ $I_{o\ min}=0$
β=1/2 k b sin Θ	$\beta = \frac{1}{2} k\ b \sin \Theta$
	$\gamma = \frac{\pi l \sin \Omega}{\lambda}$

And **difference between interference and diffraction**

Interference	**Diffraction**
1.is results of interaction of light coming from different wave front originating from the source	**1.** is results of interaction of light coming from different parts of the same wave front .
2.interference fringes are the same width or may not be the same width	**2.** diffraction fringes are not the same width
3. All bright bands are of same intensity	**3.** the difference max. of varying intensities with max. intensity for central maximum.