SEM-II
Hons (C IV: WAVES AND OPTICS)
L-3
Manoj Kumar Saha,
Assistant Professor, Department of Physics K C College Hetampur

Fraunhofer diffraction:Multi Slits ,Diffraction grating

In this case a large number of parallel slits of equal width and separated from one another by equal opaque spaces. The corresponding diffraction pattern obtained from it known as the grating spectrum. Grating may be two type

a. Transmission Grating

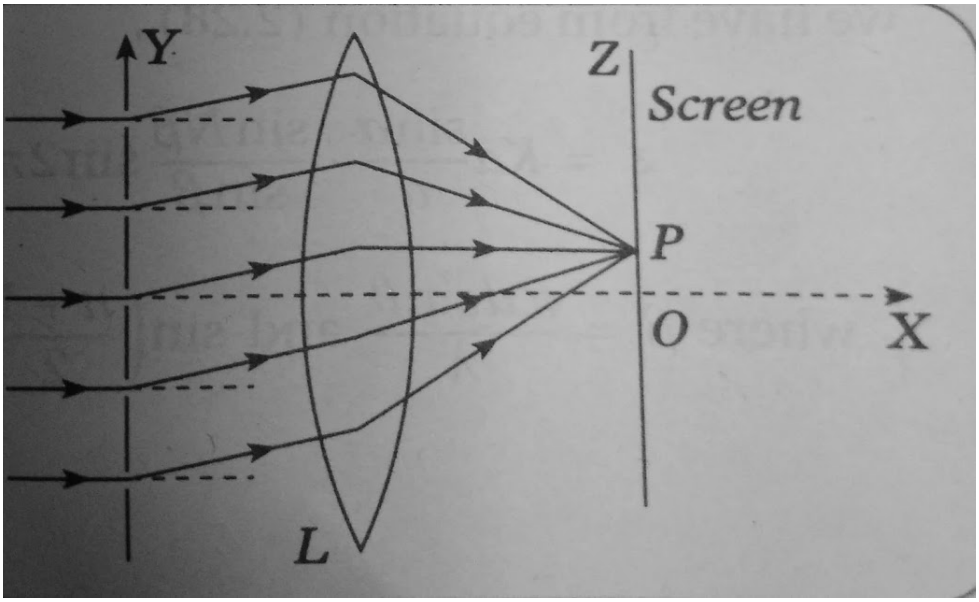
b. Reflection Grating

A plane transmission diffraction grating is an optically plane transparent glass plate on which equidistant, extremely close groves are made by rulling with diamond point. But, when the rulling are made on a polished metal surface , it is called reflection grating.
A plane transmission type replica grating is used for ordinary laboratory

Grating element: The distance covered by a slit and an opaque space between two slits of the grating is called grating element. If a and b are the width of the clear space and the opaque space respectively, the distance $(a + b)$ is called grating element.
The points in the two slits separated by grating element are called corresponding points.

Diffraction by a plane transmission grating (Diffraction at N - parallel slits.)

Suppose a parallel beam of monochromatic light of wavelength λ be incident normally on the plane transmission diffraction grating placed with its lines parallel to the incident rays. According to Huygen's principle, each of the points in between the slits sends secondary wavelets in all directions. So the rays will be diffracted by the grating. The diffracted light is focused by a Lens L on the screen Z placed on the focal plane of L. The secondary wavelets traveling in the same direction of the incident light will form central maximum at the point o on the screen. But the diffracted rays which will reach at the point P on the screen in different phases will form bright and dark bands on the both sides of central maximum. The bright bands are referred to as diffraction spectra .



The expression for the intensity distribution due to diffraction grating of N number of slits

$$I = I_0 \frac{Sin^2\alpha}{\alpha^2} \frac{Sin^2 N\beta}{Sin^2\beta} \tag{0.1}$$

Where $I_0 = K^2 a^2$ maximum intensity for $\alpha = 0$ and $\beta = 0$
Here the first factor $\frac{Sin^2\alpha^2}{\alpha^2}$ represents the diffraction pattern due to single slit and the second term $\frac{Sin^2 N\beta}{Sin^2\beta}$ represents the interference effects due to secondary waves from N slits.

For $N = 1$ and $N = 2$, the equation (0.1) reduces to the single slit and double slit diffraction pattern respectively.

Intensity of Principle maxima:

From equation (0.1) the Intensity would be maximum if

$$Sin\beta = 0 \ \ or \ \beta = \pm n\pi, \quad n = 0, 1, 2, 3, ... \tag{0.2}$$

But in that time , $\frac{SinN\beta}{Sin\beta} = \frac{0}{0}$ i.e. Indeterminate . Hence it is evaluated by L. Hospital's rule and the resultant intensity becomes

$$I = N^2 I_0 \frac{Sin^2\alpha}{\alpha^2} \quad for \ \ \beta = \pm n\pi \tag{0.3}$$

These maxima are called principle maxima. The intensity of these principal maxima increases with increase of the number of slits N.

The direction of nth order principal maxxima are

$$\beta = \pm n\pi, \quad n = 0, 1, 2, 3, ... \tag{0.4}$$

or

$$\pi d \frac{Sin\theta_n}{\lambda} = \pm n\pi \tag{0.5}$$

or

$$\underbrace{dSin\theta_n = \pm n\lambda} \tag{0.6}$$

This is known as grating equation. Here, θ_n is the angle of diffraction for nth principle maxima. When $n = 0$,$\theta_n = 0$ gives the zero order principle maxima at which all the waves arrive in the same phase. By putting $n = 1, 2, 3$ we obtain $1st$,$2nd$,$3rd$ order maximum.