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Difference between interference and diffraction.

Interference	Diffraction
→ This phenomena is result of interaction taking place between two seperate wavefronts originating from two coherant sources.	→ This phenomena is the result of interaction of light between secondary wavelength originating from the different point of same wavefront.
→ The region of minimum intensity is usually almost perfectly dark.	→ The region of minimum intensity are not perfectly dark.
→ Interference fringe may or may not be of the same width.	→ Diffraction fringe are not of the same width.
→ All maxima are of same intensity.	→ Maxima are of varying intensity.

Diffraction

The phenomena of bending of light round the corner of an optical aperture and their spreading into the geometrical shadow of an object is called diffraction.

The distribution of light intensity resulting in dark and bright fringes i.e with alternate maxima and minima is called diffraction pattern, this phenomena was first discovered in 1665 by . Italian scientist Grimaldi and was studied by Newton.

Diffraction phenomena is divided into two categories :

1. Fresnel's Diffraction
2. Fraunhoffer Diffraction

→ Fresnel's Diffraction

In this diffraction either the source or the screen or both are at finite distance from the aperture.

In this diffraction wave front is spherical or cylindrical due to this phase of secondary wavelets is not the same at all points in the plane of apperture, causing diffraction.

→ Fraunhoffer Diffraction

In this diffraction source of light and the screen on which the pattern is observed are effectively at infinite distances from the apperture causing the diffraction for into the Fraunhoffer diffraction.

In this diffraction wavefront incident on the optical apperture is plane and when it fall normally the secondary wavelets originating from the unblocked portion of the wavefront at the moment it just touches the apperture have the same phase at every point of the apperture.

→ Diffraction Grating

It is an optical element that disperses (divided) light composed of lots of different wavelength into light component by wavelength.

Simplest type of grating is one with the large number of evenly spaced parallel slits. There are two different types of diffraction grating.

1. Ruled Grating
2. Holographic Grating

A ruled diffraction grating is produced by a ruling engine that cuts grooves into the coating on the grating substrate.

Holographic diffraction grating is produced using interference lithography which results in a smooth groove surface and eliminates the periodic error found in ruled grating.

3. Reflection Grating

4. Transmission Grating

Diffraction grating can have a sinusoidal or blazed profile, a sinusoidal grating generally lower efficiency compared to blazed grating. But, it gives broader spectral coverage.

A blazed grating has saw-tooth profile and normally offer the higher efficiency.

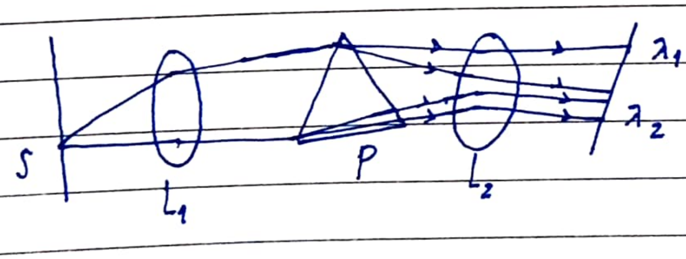
Dispersive Power

Dispersive power is power in a transparent medium in which the seperation of light occurs due to refraction. Angular seperation is defined as the rate of change of angle of deviation w.r.t it's wavelength.

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$

Resolving Power of an optical instrument

The resolving power of an optical instrument represent's it's ability to produce distinctly seperate spectral lines of light having two or more closed wavelengths.



Let us consider a simple prism spectroscope. In this, a slit S is illuminated by a source which emits two close by a source which emits two close wavelengths λ_1 and λ_2. A spectrum consisting of two lines correspond to λ_1 and λ_2 is obtained in the focal plane of L_2.

The faces of prism act as diffracting of aperture. Therefore the two lines in the spectrum are actually two Fraunhoffer patterns closed together having an intensity distribution. The two patterns overlap each other if overlapping is only to a little extent. If the principal maxima of the two pattern distinguishable, then said to be resolved. The resolving power of the grating;

$$R = Nn = \frac{N(e+d)\sin\theta_n}{\lambda}$$

$\lambda \rightarrow$ resolved wavelength

$\theta_n \rightarrow n^{th}$ principal maxima of λ

$e+d \rightarrow$ grating element

$n \rightarrow$ number of principal maxima / Order of diffraction

$N \rightarrow$ Total number of ruling on grating.

Q. A plane transmission grating has 40,000 lines in all with grating element 12.5×10^{-5} cm. Calculate the maximum resolving power for which it can be used in the range of wavelength 5000Å.

$\because$ To calculate maximum resalving power;

We must obtain maximum order of diffraction;

$$n = \frac{(e+d)\sin\theta_n}{\lambda}$$

As $n \rightarrow$ maximum

$\Rightarrow \sin\theta_n \rightarrow$ maximum

i.e $\sin\theta_n = 1$

$\Rightarrow \theta_n = 90°$

$\therefore n_{max} = \dfrac{12.5 \times 10^{-5} \times 1}{5000 \times 10^{-8}} = 2.5 \rightarrow$ order of diffraction must be a natural no $\Rightarrow$ 2.5 should be considered as 2.

$\therefore R_{max} = Nn = 40000 \times 2 = 80000$ Ans.

Q. A plane transmission grating has 16000 lines to inch over a length of 5 inches. Find the wavelength region of 6000A in the second order the resolving power of grating and the smallest wavelength difference that can be resolved.

$\therefore$ $N = 16000$ per inch over 5 inch

$\Rightarrow$ grating element: 16000×5

$\lambda = 6000\,\mathring{A}$

$n = 2$

$\therefore$ $R = Nn = 16000 \times 5 \times 2 = 160000$

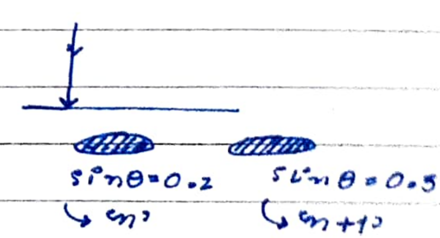
Smallest wavelength difference that can be resolved $\Delta\lambda$

$$R = \frac{\lambda}{\Delta\lambda} \Rightarrow \Delta\lambda = \frac{\lambda}{R}$$

$$\therefore \Delta\lambda = \frac{6000\,\mathring{A}}{160000} = 0.0375\,\mathring{A}$$ Ans.

Q. Light of $\lambda = 5000\,\mathring{A}$ falls on a grating normally to adjacent principal maxima occurs at $\sin\theta = 0.2$ and $\sin\theta = 0.3$ respectively. Calculate the grating element if the width of the grating surface is 2.5cm. Calculate the resolving power in second order.

$$\therefore \quad n = \frac{(e+d)\sin\theta_n}{\lambda}$$



$$\Rightarrow \quad e+d = \frac{n\lambda}{\sin\theta_n}$$

$\therefore$ $n \times \lambda = (e+d)(0.2)$ —— (1)

$(n+1) \times \lambda = (e+d)(0.3)$ —— (2)

Solving ① and ②

① − ②

$\therefore \quad (n+1)\lambda - n\lambda = (e+d)(0.3-0.2)$

$$e+d = \frac{5000\mathring{A}}{0.1} = \frac{5000\times10^{-10}}{0.1} = 5\times10^{-6} = 5\mu m$$

$$\therefore \quad N = \frac{\text{total width}}{e+d} = \frac{2.5\times10^{-3}}{5\times10^{-6}} = 5000 \text{ lines.}$$

$$\therefore \quad R = nN = 2\times5000 = 10{,}000 \quad \text{Ans.}$$

Dispersion of Light

Dispersion of light is splitting of white light into it's constituent colors due to ~~the~~ refractive index of ~~the~~ surface and ~~the~~ wavelength of the light.

→ Angle of dispersion;

$$\Delta = (n_v - n_r)A$$

$\Delta \rightarrow$ angle of dispersion
$n_v \rightarrow$ refractive index of violet
$n_r \rightarrow$ refractive index of red
$A \rightarrow$ Angle of prism.

→ Factor affecting dispersive power;
(i) Material of the prism.
(ii) Wavelength.

→ Chromatic dispersion; The phenomena where different wavelengths of light travel at different speeds ~~through~~ a medium, causing the light to spreadout or broaden as it travels.

→ **Polarization**

The phenomena of light that shown that light wave are transverse wave.
On passing the light through Tourmaline crystal the light waves are confined to a particular direction in a plane $\perp^r$ to the direction of propogation of light which aquire the property of one sideness is called polarised light and this phenomena is called 'polarisation of light'.

→ **Plane-polarized light**

In an unpolarized light an electric vector takes on all possible direction of variation in a plane $\perp^r$ to the direction of propogation if light vector vibrates only along a straight line in the plane $\perp^r$ to direction of propogation of light is said to be plane-polarised or linearly plane polarised light.

→ **Brewster's Law**

In a 1811, Brewster found that ordinary light is completely polarized in the plane of incidence when it is reflected from a transparent substance at a particular angle of incident called polarised angle. He discovered that there is a relation between the polarising angle p and refractive index μ of the transparent substance with respect to surrounding medium. This is known as Brewster's law and is given as:

$$\mu = \tan$$

$\mu \rightarrow$ refractive index

$p \rightarrow$ polarising angle

Q. A ray of light is incident on the surface of glass plate of $\mu = 1.5$ at the polarizing angle. What is the angle of

$$\mu = \tan p$$
$$1.5 = \tan p$$
$$p = \tan^{-1}(1.5) = 56.3°$$

$\because \; r + p = 90°$

$r = 90° - 56.3$

$r = 33.7°$ Ans.

→ Specific Rotation (S) :

Specific Rotation (s) of a substance at a given temperature and for a given wavelength of light λ is defined as the rotation (in degree) produced by 1 decimeter long column of the solution containing 1 gm of the active substance in one cc. liquid of active substance.

$$S = \frac{\theta}{L \times C}$$

θ → angle of rotation

L → Length of polaritube

C → concentration of given solution.

Unit : $\frac{\text{degree mL}}{(\text{gm dm})}$

→ The product of the specific rotation and molecular weight of active substance is called molecular rotation.

Q. A 20 cm long glass tube containing sugar solution rotate the plane of polarization by 11° if the specific rotation of sugar is 66°. Calculate the concentration of sugar solution.

$$S = \frac{\theta}{L \times C}$$

$$C = \frac{\theta}{L \times S} = \frac{11}{2 \times 66} = 0.833 \text{ gm/cm}^3$$ Ans.

These handwritten notes are of PHY-S102 taught to us by Prof. Prabal Pratap Singh, compiled and organized chapter-wise to help our juniors. We hope they make your prep a bit easier.

— **Saksham Nigam** and **Misbahul Hasan** (B.Tech. CSE(2024-28)