**Interference fringes:**

The Science of light is called optics. The study of optics acoustic impedances of the media. This property is used is divided into geometrical optics and physical optics, in ultrasonic testing. Geometrical optics deals with the applications of the rectilinear propagation of light to different optical light must travel in straight lines. Optical instruments like microscope, telescope and camera work on this principle. Reflection and Refraction can be explained by this principle.

Interference, Diffraction and polarisation can be explained only on the basis of wave theory of light. That is, these phenomena could be explained only it we assume that light is a form of wave motion. The physical optic deals with these phenomena exhibited by light on account of its wave aspect.

**Interference:**

Interference is the optical phenomenon in which brightness and darkness are produced by two exactly similar light Waves meeting. When two light waves, of same frequency and having constant phase difference, coincide in space and time, there is a modification in the intensity of light. The resultant intensity at any point depends upon the amplitudes and the phase relationships of the two waves." This modiciation in the intensity distribution resulting from the superposition of two waves of light is called' interference and the pattern of bright and dark fringes produced is called interference pattern.

**Principle of Superposition:**

When two or more waves arrive at a point in space simultaneously the net wave disturbance at that point and at any given time is the vector sum of all-the wave, disturbances at that point at that particular time. This is called principle of superposition. This principle is applied to the analytical treatment of interference of light.

**Conditions for interference:**

1. To produce interference, we require two light sources. That two light sources must be coherent i.e. two sources must send out waves having 1 constant phase difference or same phase,
2. The two sources must be perfectly monochromatic emitting light, of a single wavelength.
3. The two sources must be as near as possible and the screen must be as far as possible from them.
4. The frequency and amplitude of the waves from these two coherent sources must be the same.
5. The two sources must be narrow.
6. The two waves must be propagated along the same direction to get coincidence.
7. The interfering waves are polarised, then their state of polarisation must be same.

The two coherence sources can be obtained from the same single soured. Any change in phase at the time of emission will affect these two sources (which are derived from a single source) equally and the light starting from them will always be in phase.

**Production of the coherent sources in various methods:**

1. Lloyd’s single mirror
2. Fresnel’s double mirror

3. Fresnel's biprism
4. Billet's split lens
5. Michelson's interferometer, Newton's rings and thin films

**Formation of interference fringes:**

The intensity of a light wave at a point is proportional to the square of its amplitude. When two waves meet at a point the resultant amplitude is the vector sum of the two amplitudes. If it is maximum there will be brightness and it is zero, there will be darkness at that point. The point where a light wave has got maximum possible displacement, is termed crest.

The point where there is negative displacement is called trough. Wavelength is the distance b/w two successive crests or troughs. Prom Fresnel's biprism method,

Bandwwidth $'\beta' = \frac{D}{d}\lambda$

where 'd' is the distance b/w the 'two virtual images of a narrow monochromatic source S produced by the biprism.

D - distance of the screen XY from the source S

$\lambda$ - wavelength of light

This shows that the distance b/w two consecutive dark or bright fringes is equal and so the bandwidth or fringewidth is constant throughout the interference pattern.

- If d and D are constants, the bandwidth, $\propto \lambda$. Hence fringes produced by shorter wavelengths will be narrower than those produced by longer wavelengths.
- If D, d and p are known, the wavelength of light can be determined.

**Determination of wavelength of light from a monochromatic source using Biprisms:**

A narrow adjustable slit S, a biprism and a micrometer • eye-piece E are arranged in uprights on the bed of the optical bench in the same straight line and at the same height.

**Fringewidth $\beta$:**

$\beta_2 - \beta; = \frac{0.20}{d}\lambda$

where

d is the distance b/w the two virtual sources $S_1$ and $S_2$.

By this method we are able to eliminate D, the distance from the virtual source to the eyepiece which is difficult to measurer.

**Determination of d:**

To measure d, the distance b/w the two virtual sources by a direct method is difficult. Hence a convex lens is introduced b/w the biprism and the eyepiece and it is moved until the two images of the slit are obtained in the eyepiece.

$\beta_2 - \beta_1 = \frac{0.20}{\sqrt{d_1 d_2}}\lambda$

Since $\beta_2$, $\beta_1$, $d_1$ and $d_2$ are all known, the wavelength of light can be calculated.

**Effect of width of the slit on interference bands:**

When the width of the slit is increased continuously in Fresnel's biprism experiment, a broad source of light is obtained. A broad source of light is equivalent to a large number of sources lying side by side. Each set of two sources will give rise to its own pattern of fringes. The overlapping of a number of such patterns will result in general illumination and hence the fringes will vanish.

**Displacement of fringes due to the introduction of mica sheet:**

With a thin mica sheet of refractive index '$\mu$' is placed in the path of light from one of the two sources, the central bright fringe is shifted to some other points due to the change in the path difference. If the shift can be measured, then the wavelength of light used or thickness of the sheet or the refractive index of the material of the sheet can be found out if two out of three quantities are known.

Displacement of any maximum or central bright fringe by introducing mica sheet of thickness T is given by

$$S = \frac{D}{d}(\mu - 1)t$$

or $t = \frac{Sd}{D(\mu - 1)}$

knowing the value of refractive index 6f the mica the thickness of mica sheet can be determined.

**Interference due to thin films:**

When white light is reflected by thin films like soap bubbles, oil layers on water and oxide layers on metal surfaces a variety of colours could be seen. This is due to interference b/w light waves reflected by the front and back surfaces of these films.

**Important points:**

1. When a light wave travels, in denser media other, than air or. vacuum the path of the light rays in that media is called optical path. The optical distance in a medium is the product of the refractive index of the medium and the distance travelled by light in it.

2. A phase change of n or a path difference of $\lambda/2$ is introduced when light travels from rarer to denser, medium and sets reflected at the surface of denser medium (rarer-denser boundary). But no such phase change occurs when the light travels from denser to rarer and the rejection of light takes places at the surface of the rarer medium (denser-rarer boundary).

**Interference at a wedge - shaped film:**

Fringewidth $\beta = \frac{\lambda}{2\mu\theta}$

$\mu$ - refractive index of a wedge shaped film having a very small angle 0 at a point A.

A wedge shaped air film can be obtained by inserting a thin piece of paper or Gain or their wire between two plane parallel glass plates.

For air film $\mu = 1$ and $\theta = \frac{t}{X}$

where t is the thickness of paper and X is the distance from the edge where the two plates touch each other to the paper.

$\therefore t = \frac{\lambda X}{2\beta}$

Using this relation we can measure the thickness of paper or hair or thin wire very accurately.

**Anti-reflection and reflection coatings:**

In the case of transparent materials, a certain fraction of the incident light is always reflected back by the interface, whenever a beam of light passes through the boundary of two media. Now in photographic objectives and other optical instruments, like range finders and periscopes, there is a large number of glass - air interfaces, which must give use to a notable loss as a result of reflection and the transmitted light should suffer in intensity. This reflected light undergoes refraction from other surfaces in the system, gets into the image and spoil its detail and contrast. It further gives rise to ghost images specially when the illumination is intense as a result of flare which is due to multiple reflections from lens surfaces and is an undesirable phenomenon. One of the important applications of thin film interference is used to reduce this unwated reflection from the lens surfaces. When a light beam travels in a medium of refractive index $n_1$, and is incident on a dielectric medium of refractive index $n_2$, then the amplitudes of the reflected and transmitted beams are related to that of the incident beam by the following relation

$$a_r = \frac{n_1 - n_2}{n_1 + n_2} a_i$$

$$a_r = \frac{2n_1}{n_1 + n_2} a_i$$

So when $n_2 > n_1$, $a_r$ = -ve which shows that when a reflection occurs at a denser medium, a phase change n occurs.

The reflection coefficient at the denser medium

$$= r = \frac{n_1 - n_2}{n_1 + n_2}$$

The transmission coefficient at the denser medium 't'

$$= \frac{2n_1}{n_1 + n_2}$$

**Newton's rings:**

Circular interference fringes can be produced by enclosing a very thin film of air or any other transparent medium of varying thickness between a plane glass plate and convex lens of a large radius of curvature. Such fringes were first obtained by Newton and are known as Newton's rings.

The radius of curvature $R = \frac{d_n^2 - d_m^2}{4\lambda(n-m)}$

where $d_n$ and $d_m$ are the diameters of any two bright rings.

**Holography:**

Holography is the process of image construction by recording and reconstruction of hologram by means of interference techniques without the aid of lenses. Thus it is a way of recording and then reconstructing waves, invented by Dennis Gabor in 1948. The waves may be of light or sound.