LECTURE 1/26-03-2020SEM II, Physics(H)PAPER: CC4 Dipanwita Das

MICHELSON INTERFEROMETER

This interferometer is designed based on the principle of interference of light. The design is basically the arrangement of the glass plates and the source of light.

Michelson designed the interferometer to

(i)to determine the wavelength of light

(ii) to determine the thickness of a thin film

(iii) to find the wavelength separation between two closely spaced spectral line

(iv) to find the refractive index of a film

(v) for standardisation of meter

Principle:

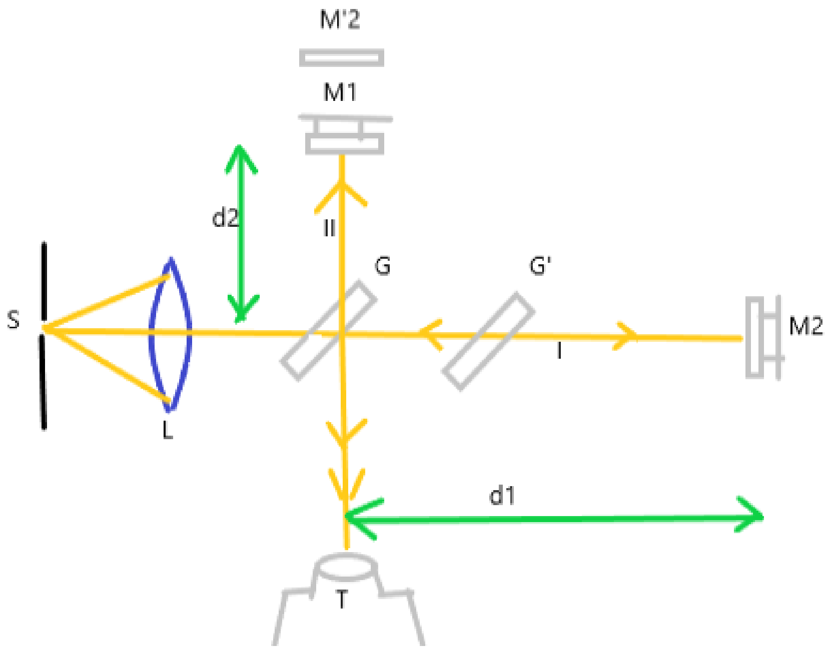
Two coherent sources which are basically divided in terms of amplitude. The amplitude of light beam coming from a source is divided into two parts one is due to partial reflection and the second one is due to transmission, and both are of same intensity.

After dividing the amplitude of light by partial reflection the beam is sent in two directions and after reflection from the mirrors placed at right angles are brought together to produce interference fringes. We are dividing them on the basis of partial reflection and transmission.

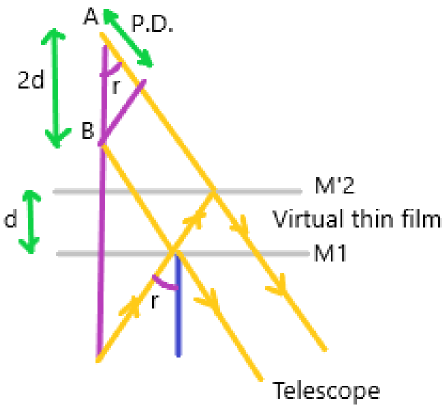
Construction: S is a source, L is collimating or convex lens, G, G' are two glass plates, M_1, M_2 are mirrors, T is a telescope.

- The glass plate G is partially polished (half silvered) to undergo the reflection and transmission process to produce two beams of same intensity
- The glass plates are of same thickness and placed at 45^0 with respect to the mirror.
- The plain mirrors are highly polished and aremutually perpendicular
- The mirrors are provided with screws on the back side of these mirrors so that they can be adjusted to be exactly perpendicular.
- This screwis fitted with a drum which can be read a displacement of 5-10 cm
- The interference bands can be observed with the help of a telescope placedat the bottom of the mirror.

The image of the mirror M_2 after reflection, makes an image M_2'. Looking from the telescope we saw a virtual thin film enclosed between mirror M_1 and the virtual image of M_2 i.e. M_2'.



The light incident on M_1 gets reflected, also travel to the second mirror M'_2 and reflected back.If we extrapolate the beams , they appears to come from A and B. These are parallel beams and thus we require a telescope to view the images.



The geometrical path difference (P.D.) = 2d cos r

Beam I is coming from the air glass interface and beam II is reflected from the glass air interface. So, we introduce an extra path difference of $\lambda\backslash 2$. Thus, the total path difference between the two beam is given by

$$\Delta = 2\ d \cos r + \frac{\lambda}{2}$$

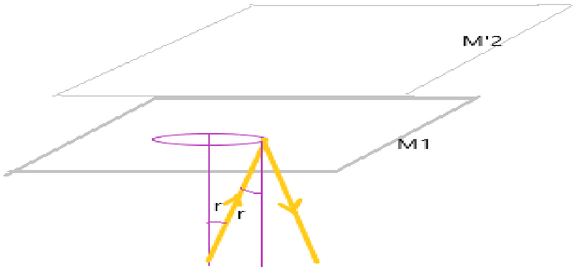
For interference maxima the path difference

$\Delta = 2\,d \cos r + \frac{\lambda}{2} = n\,\lambda$

$2\,d \cos r = (n - \frac{1}{2})\,\lambda$

For minima, $2d \cos r = n\,\lambda$, n = 1,2,3,…

The value of cos r remains constant if we take a constant thickness of the thin film, the locus of the fringes lie on a circle and cos r remains constant on the circumference of a circle. And concentric circular fringes are observed. These fringes originating from the constant inclination of the beam. These fringes were observed by Haidinger and known as Haidinger fringes.



Origin of circular fringes:

For normal incidence,i.e. r = 0

Condition 1: $d = 0 \Rightarrow d_1 = d_2$

$\Delta = 2\,d \cos r + \frac{\lambda}{2} = \frac{\lambda}{2}$, This gives the condition for destructive interference and the entire field will be black.

Condition 2: $d_1 - d_2 = \frac{\lambda}{4} \Rightarrow \Delta = \lambda$, This gives the condition for constructive interference. So, the centre remains bright and rest is dark.

Condition 3: $d_1 - d_2 = \frac{\lambda}{2} \Rightarrow \Delta = 3\frac{\lambda}{4}$, Thus the centre become dark again and the bright image thrown away.

Condition 4: $d_1 - d_2 = 3\frac{\lambda}{4} \Rightarrow \Delta = 2\,\lambda$, again bright fringe will appear at the centre

Thus as we move the mirror , the centre becomes alternately bright and dark.