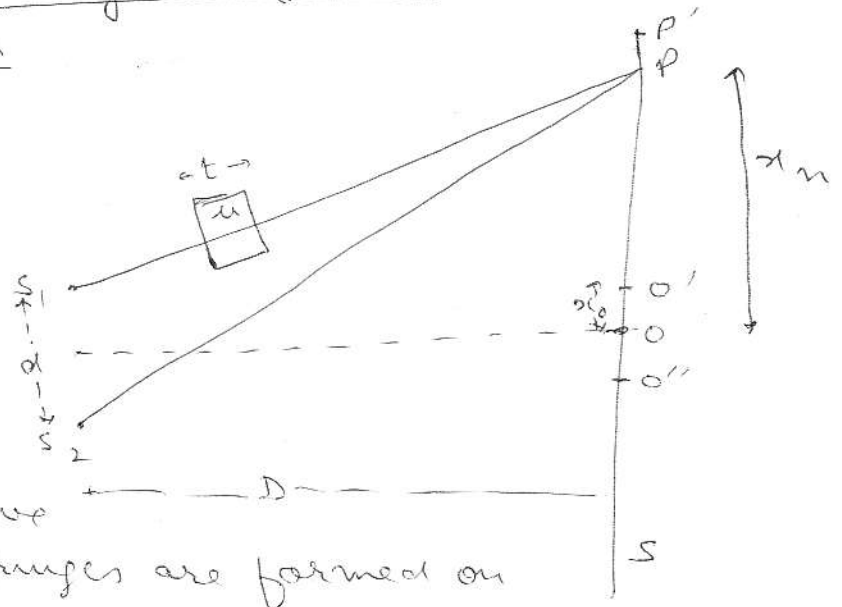
Displacement of fringes by thin films and measurement of μ & t of film



Let S_1 and S_2 be coherent sources of light of wavelength λ and seperated by distance d.

on absence of thin film of thickness t and refractive index μ, interference fringes are formed on screen S at distance D from sources

Point O, symmetric w.r.t S_1S_2 is bright (in absence of film) & P is pt on screen at distance x_n from O. Then

$$S_2P - S_1P = \frac{x_n d}{D} \quad \text{---------- (1)} \quad \& \quad \beta = \frac{\lambda D}{d} \quad \text{---- (2)}$$

On inserting film in path S_1P, the fringes will be found to be shifted along OP. But if film is inserted in path S_2P, the fringes will be shifted towards PO. central fringe will be shifted towards O' and O'' respectively as explained below

With film

Path along S_1P $= (S_1P - t) + \mu t$

& Path along S_2P $= S_2P$

$\therefore$ Path difference $= S_2P - [S_1P - t + \mu t]$

$= S_2P - S_1P - [\mu - 1]t$

Path diff $= \frac{x_n d}{D} - (\mu - 1)t$

But for Brightness

Path diff $= 2n\lambda/2 = n\lambda$

$$\Rightarrow \frac{x_n d}{D} - (\mu - 1)t = n\lambda$$

$$\therefore x_n = \frac{D}{d}[n\lambda + (\mu - 1)t] \quad \text{---------- (3)}$$

For $n = 0$ (central fringe)

$$x_0 = \frac{D}{d}(\mu - 1)t \neq 0$$

Since $\mu > 1$ $\therefore x_0 > 0$ $\therefore$ fringes are shifted and fringe shift of central fringe $x_0 = \frac{D}{d}(\mu - 1)t$ ---------- (4)

(3) ⇒ Position of $(n-1)$th bright fringe is given by

$$x_{n-1} = \frac{D}{d}\left[(n-1)\lambda + (\mu-1)t\right]$$

$$\therefore \beta = x_n - x_{n-1} = \frac{D}{d}\lambda \quad \text{——— (5)}$$

This shows that fringe width does not change with the insertion of film.

This means that all fringes are shifted equally

Determination of λ

d is measured by microscope. D is measured by meter rod.

If x is distance for n fringes using microscope then $\beta = x/n$

$\therefore \lambda$ can be measured using eq (5)

Determination of μ or t

using equation (4), if μ is known t can be measured and if t is ~~measured~~ known then μ can be measured. provided x_0 can be measured.

Measurement of x_0

Since all fringes have same β and all fringes shift as soon as film is introduced, therefore, x_0 can not be measured using monochromatic light.

Equation (4) also shows that x_0 is independent of λ.

If we use white light, then central fringe will be white and all other fringes will be coloured.

On introducing film, the central fringe still remains white

Thus by measuring position of central white fringe before and after introducing thin film, x_0 can not be measured.

$\therefore$ t or μ can be measured as required