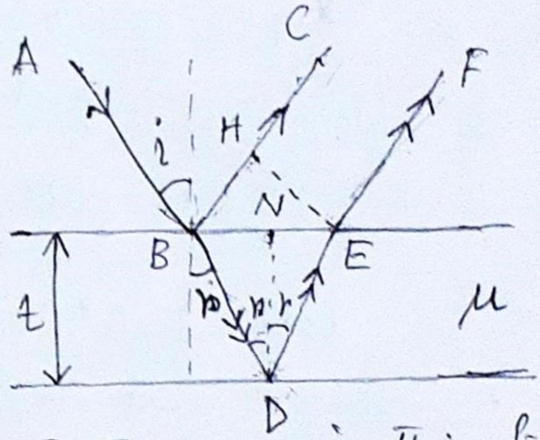
Interference in thin films

When a thin film of transparent material like oil drop spread over the surface of water is exposed to an extended source light, it appears coloured. This phenomena can be explained on the basis of interference of light

Interference in reflected light in thin film of uniform thickness

Let us consider a thin film of refractive index 'μ' and thickness 't' as shown in the fig. Further, let a ray AB of monochromatic light of wavelength λ is incident on the film at an angle i. This ray is partly reflected along BC and partly refracted along BD at an angle r.



Interference in thin film

The ray BD is again partly reflected from the lower surface of the film along DE an then transmitted along EF in the rarer medium air. As the rays BC and EF are derived from the same source; therefore, they are coherent. As the film is thin and of uniform thickness, the rays BC and EF will be parallel.

As the path beyond EH is the same, therefore, the path difference between two rays

$= (BD+DE)$ in film $-$ BH in air.

$= \mu(BD+DE) - BH = 2BD\mu - BH$

Now from right angled ΔBDN

$$\frac{DN}{BD} = \cos r, \quad BD = \frac{DN}{\cos r} = \frac{t}{\cos r}$$

Also, from right angled ΔBHE

$$\frac{BH}{BE} = \sin r, \quad BH = BE \sin i = (BN+NE)\sin i$$

or, $BH = 2BN\sin i$.

Again from right angled ΔBDN, $\frac{BN}{DN} = \tan r$

$\therefore BN = DN \tan r = t \tan r$

$\therefore BH = 2t \tan r \sin i$

Therefore, the path ~~of~~ difference $= \frac{2\mu t}{\cos r} - 2t\tan r \sin i$

$$= \frac{2\mu t}{\cos r} - \frac{2t\sin r}{\cos r} \times \sin i \times \frac{\sin r}{\sin r} = \frac{2\mu t}{\cos r} - \frac{2\mu t \sin^2 r}{\cos r}$$

[because $\mu = \frac{\sin i}{\sin r}$] $\quad = \frac{2\mu t}{\cos r}(1-\sin^2 r) = 2\mu t\cos r$

From the ~~st~~ Stoke's law of reflection, we know that the reflection from the surface of the denser medium involves a phase change of π or a path difference of $\lambda/2$. Here, the wave train EF has travelled in denser medium and is reflected and refracted inside the film, there will be no phase change, where as wave train along BC reflected from denser medium hence, occur a path change $\lambda/2$

The overall path difference $= \left(2\mu t\cos r + \frac{\lambda}{2}\right)$