Interference of Light

Formation of Newton's Rings

(Theory and Experiment)

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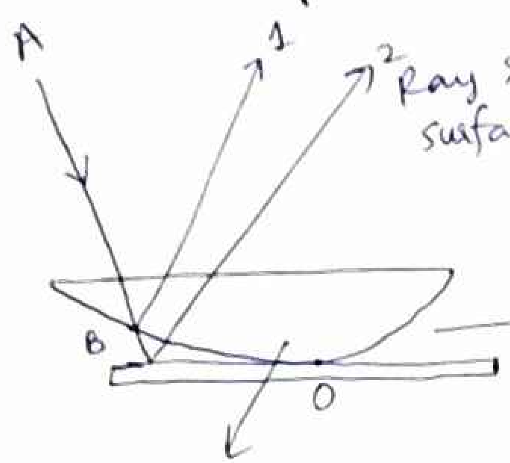
Newton's Ring



Ray ② undergoes a phase change of π
$\equiv$ path diff of $\frac{\lambda}{2}$ (because it is reflected from a denser medium)

$\therefore$ effective path diff between ray ① and ②

$p = 2\mu t\cos r + \frac{\lambda}{2}$

For air film, $\mu = 1$, and if light falls normally then $\cos r = 1$

$\therefore p = 2t + \frac{\lambda}{2}$ (t is the thickness of the air film at point B)

At the point of contact of lens and plate (i.e. point O), $t = 0$

$\therefore p = \frac{\lambda}{2}$ $\Rightarrow$ Interference will be destructive

$\Rightarrow$ central spot will be dark

Newton's Ring

At B, there will be a bright fringe only if

$$p = n\lambda \quad \text{or} \quad 2t + \frac{\lambda}{2} = n\lambda$$

$$\text{or} \quad \boxed{2t = (2n-1)\frac{\lambda}{2}} \quad —(1)$$

and the condition that there will be a dark fringe at point B is

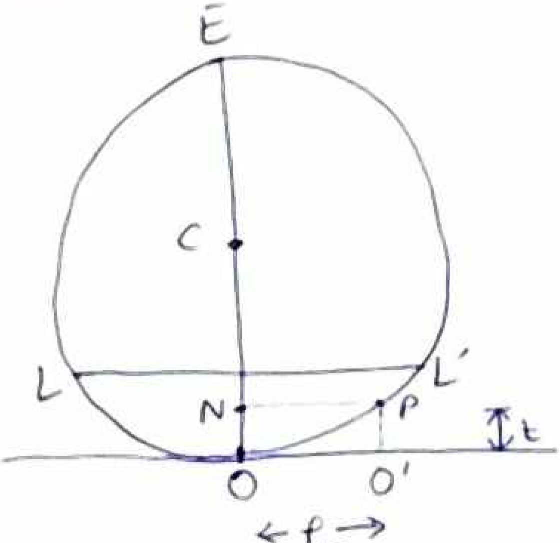
$$p = (2n+1)\frac{\lambda}{2}$$

$$\text{or} \quad 2t + \frac{\lambda}{2} = (2n+1)\frac{\lambda}{2}$$

$$\text{or} \quad \boxed{2t = n\lambda} \quad —(2)$$

$\Rightarrow$ For a particular value of t, there will either be a bright fringe or a dark fringe; and since t remains const. along the circles centred at O, fringes will be concentric circles centred at O.

Diameter of Bright Rings-



$$PN^2 = ON \times NE$$

$$\text{or} \quad r_n^2 = t \times (2R - t)$$

$$= 2Rt - t^2$$

~~Since~~ Since t is small, t^2 can be neglected

$$\therefore r_n^2 = 2Rt$$

$$\text{or} \quad 2t = \frac{r_n^2}{R} \quad —(3)$$

Newton's Ring

Condition for bright ring is

$$2t = (2n-1)\frac{\lambda}{2} \quad (\text{eq.} ①)$$

or $$\frac{r_n^2}{R} = (2n-1)\frac{\lambda}{2}$$

or $$r_n^2 = (2n-1)\frac{\lambda R}{2}$$

If D_n is the diameter of n^{th} bright ring then $D_n = 2r_n$

$$\therefore \left(\frac{D_n}{2}\right)^2 = (2n-1)\frac{\lambda R}{2}$$

or $$D_n^2 = 2(2n-1)\lambda R$$

or $$D_n = \sqrt{2\lambda R}\sqrt{(2n-1)}$$

or $$\boxed{D_n \propto \sqrt{(2n-1)}}$$

Since n is an integer, $(2n-1)$ will be an odd number.

$\Rightarrow$ diameter of bright rings $\propto$ square root of odd natural numbers

$\therefore$ Diameter of first few Bright rings are given by

$$1 : \sqrt{3} : \sqrt{5} : \sqrt{7} : ---$$

or $$1 : 1.732 : 2.236 : 2.646 : ---$$

$\Rightarrow$ Seperation between the rings are in the ratio

$0.732, 0.504, 0.410, ---$

Newton's Ring

$\Rightarrow$ Separation decreases as order increases.

Diameter of Dark rings–

condition for dark ring is

$$2t = n\lambda \qquad (\text{eq } 2)$$

But from eq. 3, $\frac{\rho_n^2}{R} = 2t$

$$\therefore \frac{\rho_n^2}{R} = n\lambda$$

If D_n is the diameter of n^{th} dark ring

then $\rho_n = \frac{D_n}{2}$

$$\therefore \frac{\left(\frac{D_n}{2}\right)^2}{R} = n\lambda \text{ or } \frac{D_n^2}{4R} = n\lambda$$

$$\text{or } \quad D_n = \sqrt{4n\lambda R}$$

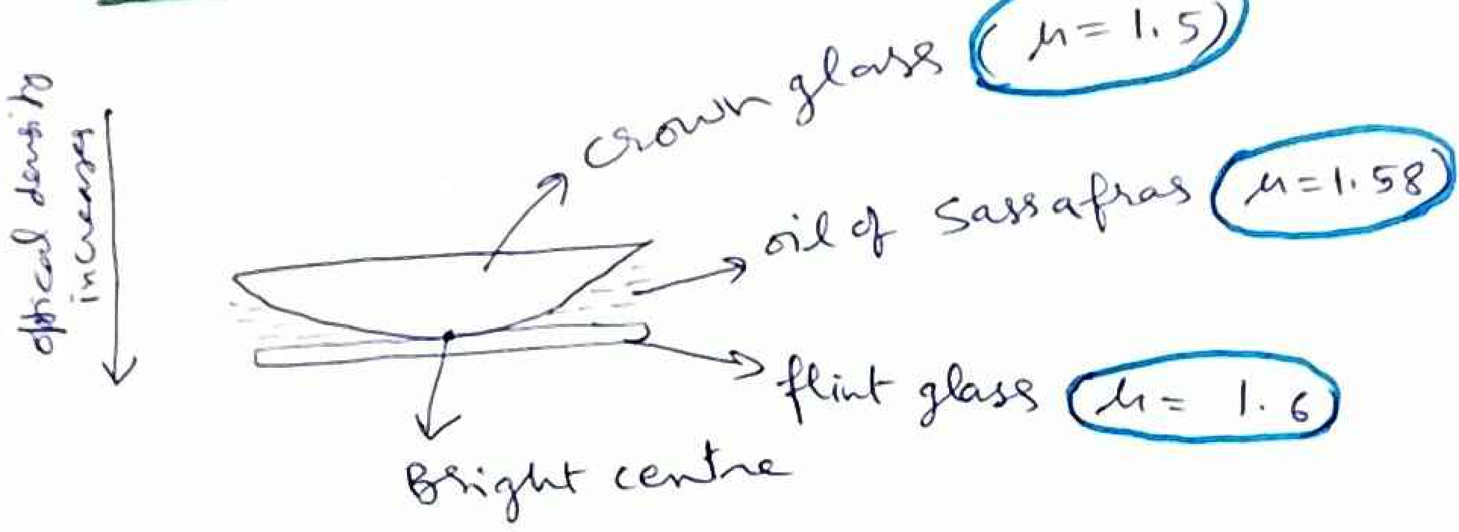
$$\Rightarrow \boxed{D_n \propto \sqrt{n}}$$

$\Rightarrow$ Diameter of Dark rings $\propto$ square root of Natural numbers.

p.T.O.

Newton's Ring

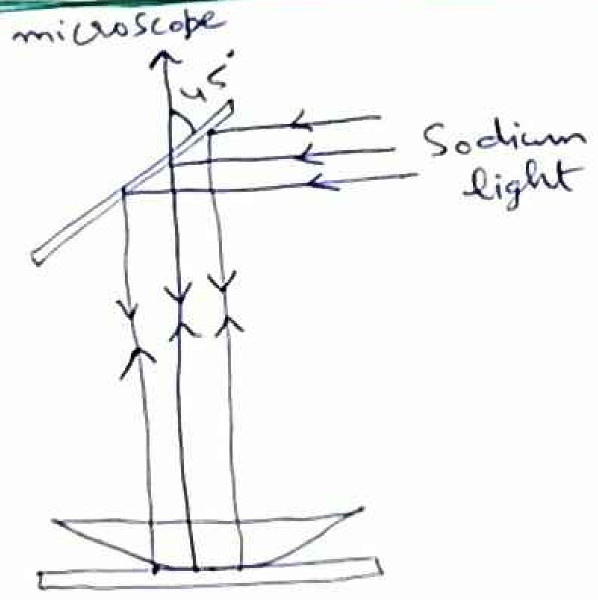
Bright centre –



Since both the rays undergo a phase change of π therefore effective ~~path~~ path diff. is zero at the centre.

$\Rightarrow$ central spot will be bright.

Experimental arrangement –



diameter of n^{th} bright ring is given by

$$D_n^2 = 2(2n-1)\lambda R$$

diameter of $(n+p)^{th}$ Bright ring

$$D_{n+p}^2 = 2[(2n+2p)-1]\lambda R$$

$$\therefore D_{n+p}^2 - D_n^2 = 4p\lambda R$$

$$\therefore \lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}$$

Newton's Ring

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