# NEWTON'S RINGS

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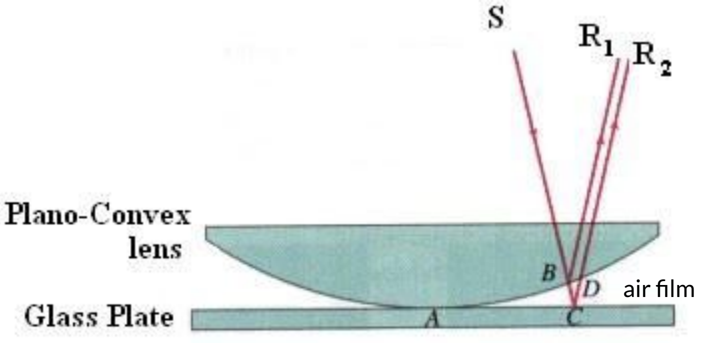
## Newton’s rings by Reflected light:

- When a plano-convex lens of the large focal length is placed with its convex surface in contact with a glass plate, a thin film of air is enclosed between them.
- The thickness of the air film gradually increases from the center to the ends.
- The locus of all points having the same thickness of an air film is a circle.
- Different thickness corresponds to different circles.



- Suppose monochromatic light is incident on it normally a part of it undergoes reflection at the curved surface of the lens (ray R1) and a part of it undergoes reflection from the top surface of the plane glass plate (ray R2).
- These two reflected rays are derived from the same incident ray and have travelled over different paths, they act as two coherent sources so they are in a condition to interfere.
- Alternate bright and dark circular rings are formed .
- These are known as Newton's rings.

If **t** is the thickness of the air film,

total path difference between the two reflected rays is $2\mu t\cos(r) + \lambda/2$

For air film $\mu = 1$ and for normal incidence $r = 0$

Then total Path difference is $2t + \lambda/2$ ------ (1)

- At the Point of Contact $t = 0$, and the path difference is $\lambda/2$ which is the condition for minimum intensity. Therefore central spot is dark
- If $2t + \lambda/2 = n\lambda$, the bright ring is formed where $n = 1,2,3 \ldots$
- If $2t + \lambda/2 = (2n+1)\lambda/2$ dark ring is formed where $n = 0,1,2,3 \ldots$

## Theory: Determination of Diameter of the Ring

Suppose the radius of curvature of the lens is **R** and thickness of air film is **t** at a distance **r** from the point of contact O,

from

properties of circle (QN)(NP) =( ON)(ND)

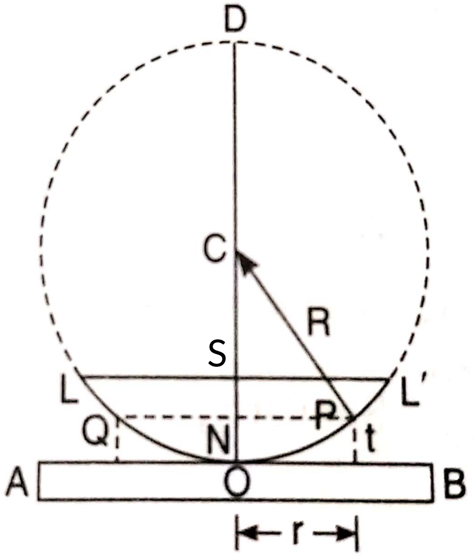
$\Rightarrow$ r.r = t(2R-t)

$\Rightarrow r^2 = 2Rt - t^2$

$\Rightarrow r^2 \cong 2Rt$ ( $\because$ t is very small $t^2$ can be neglected)

$\Rightarrow 2t = r^2/R$

For $n^{th}$ bright ring $2t + \lambda/2 = n\lambda \Rightarrow r_n^2/R + \lambda/2 = n\lambda$ ( $r_n$ is the radius of nth bright ring)



$\Rightarrow (r^2_n)/ R = n\lambda - \lambda/2 = (2n-1)\lambda/2$

$\Rightarrow r^2_n = (2n-1)R\lambda/2$

$\Rightarrow r_n = \sqrt{(2n-1)R\lambda/2}$

Thus the radius of the $n^{th}$ bright ring is proportional to $\sqrt{\lambda}$, $\sqrt{R}$ and $\sqrt{(2n-1)/2}$

Similarly for a dark ring $2t \pm \lambda/2 = (2n \pm 1)\lambda/2$ $\quad n = 0,1,2,3 \ldots.$

$$(r^2_n)/ R = n\lambda$$

$$\Rightarrow \quad r_n = \sqrt{Rn\lambda}$$

Thus the radius of the $n^{th}$ dark ring is proportional to i) square root of natural no's ii) square root of radius of curvature and iii) square root of wavelength of light.

Diameter of $n^{th}$ Dark Ring $(D_n) = 2r_n = 2\sqrt{Rn\lambda}$

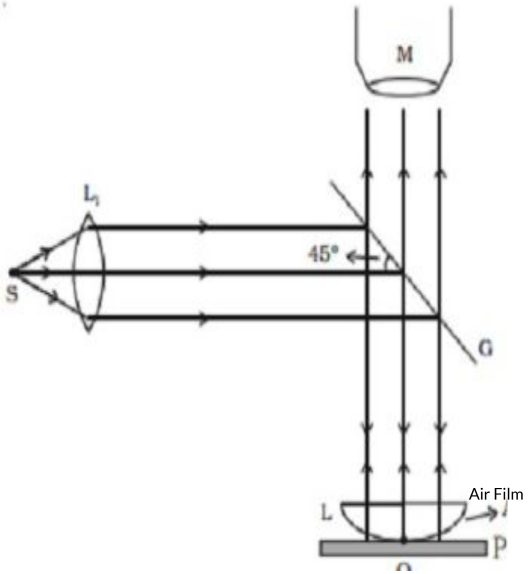
# Determination of Wavelength(λ) of Sodium Light

The experimental arrangement of the Newton's rings is as shown in the figure.

L is plano-convex lens of large radius of curvature R. It is placed on the plane glass plate with the curved surface in contact with the glass plate.

The light from monochromatic source S is made parallel by means of convex lens $L_1$. These parallel rays are allowed to incident on plane glass plate G inclined at an angle of $45^o$ to the incident rays. The rays reflected by G incident normally on the Combination of the plano-convex lens and glass plate.

A part of the ray is reflected by the curved surface of the lens and part if it is transmitted. This transmitted light is reflected back from the top of the plane glass plate. These two reflected rays interfere with each other, alternate bright and dark rings are observed through the microscope M.



## Theory

We know that,

Radius of the $n^{th}$ dark ring $r_n = \sqrt{Rn\lambda}$ where R=radius of curvature,

Diameter of the $n^{th}$ dark ring $D_n = 2\sqrt{Rn\lambda}$ $\lambda$ is wavelength of light used

$$\therefore\ D^2_n = 4nR\lambda \text{ ----------- } (1)$$

If Dm is the diameter of the $m^{th}$ dark ring then

$$D^2_m = 4mR\lambda \text{ ----------- } (2)$$

$$(1) - (2) \Rightarrow D^2_n - D^2_m = 4R\lambda(n-m)$$

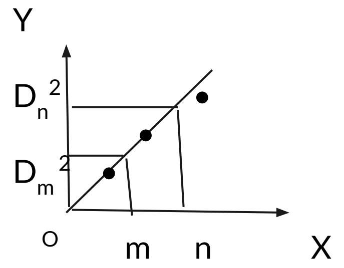
$$\boxed{\lambda = (D^2_n - D^2_m)/4R(n-m)}$$

# Procedure :

To measure the diameters of the rings , travelling microscope is moved from centre to the left side. The centre of cross wires is adjusted tangentially in the middle of the 20th bright ring, the reading is noted . The microscope is moved back (right side) such that the cross section of the cross wires is at 19,18,......5,4.. bright rings till we are very near to the centre spot and the readings are noted. Again crossing the central dark spot in the same direction , the readings corresponding to 4,5,.....20th rings are noted on the right side.The readings are tabulated.

| S.No. | No of the ring | Microscope readings | | Diameter D=(a~b) | $D^2$ |
|---|---|---|---|---|---|
| | | Left(a) | right(b) | | |
| | | | | | |

A graph is drawn between the order of the rings and the square of the diameter of the corresponding rings. The graph is a straight line passing through the origin as shown in the fig.




The Values of $D^2_m$, $D^2_n$ of $m^{th}$ and $n^{th}$ rings are noted from the graph. The radius of curvature R of the lens is obtained using a spherometer.

$R = l^2/6h + h/2$ where l is the distance between any two legs of the spherometer, h is the height of the spherical surface of the lens

The wavelength of the monochromatic source of light is calculated using the formula

$$\lambda = (D^2_n - D^2_m)/4R(n-m)$$