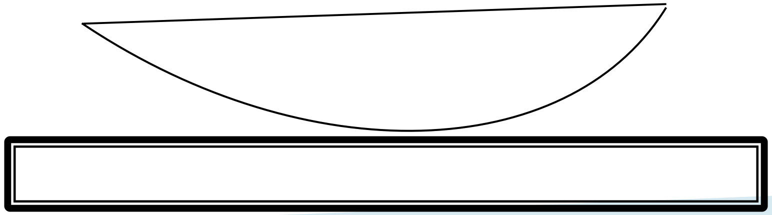
# Newton's Ring

**Formation of Newton's Rings:**

- When a plano convex lens of large radius of curvature is placed on a glass plate, an air film is formed between the lower surface of the lens and upper surface of the plate.
- The thickness of the film gradually increases from the point of contact to outwards.



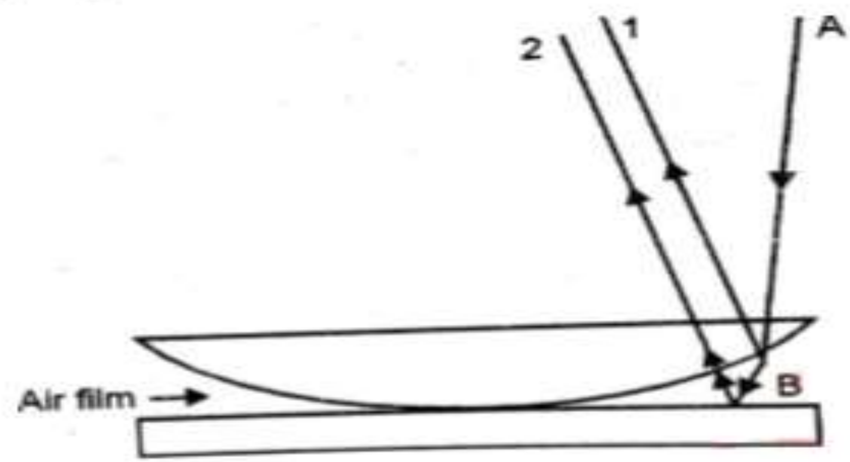
If monochromatic light is allowed to fall normally on this film, a system of alternate bright and dark concentric rings, with center dark is formed in the air film.

These rings were first studied by Newton and hence they are known as Newton's ring.

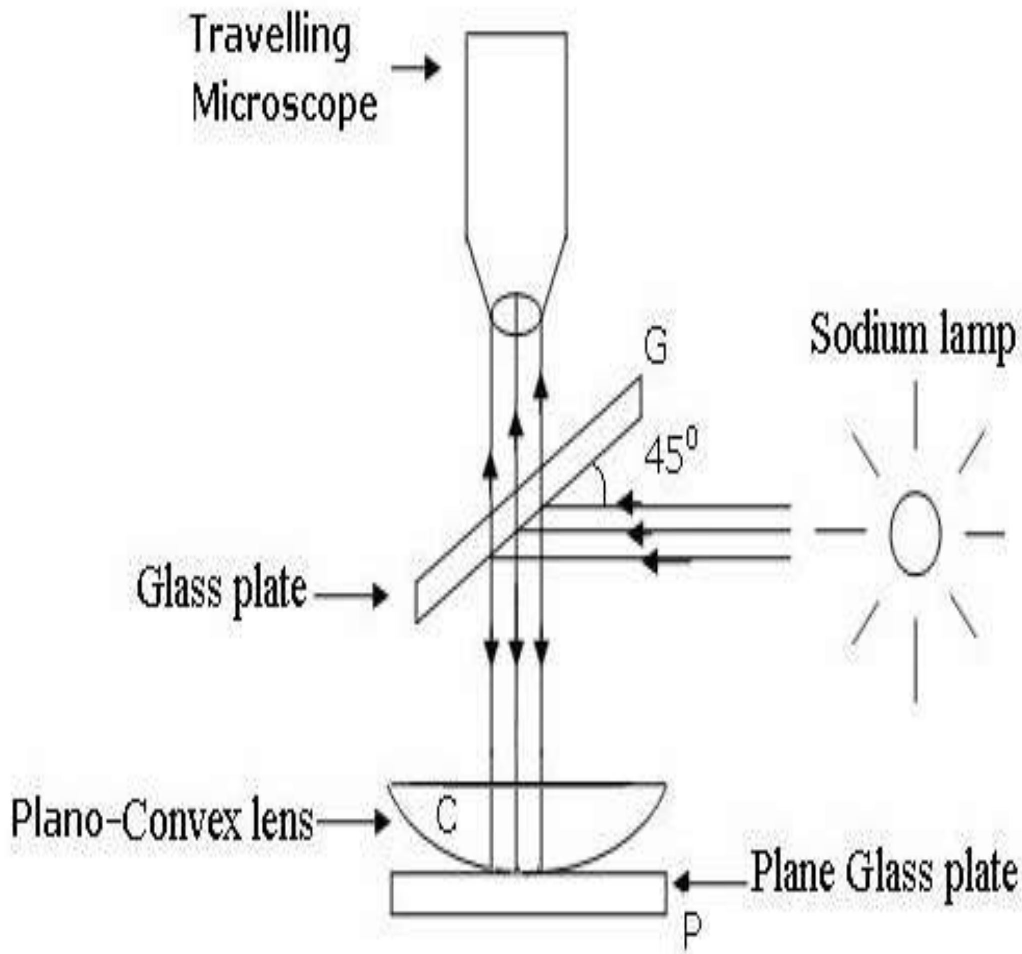
.

They can be seen through a low power microscope focused on the film. Newton's rings are formed as a result of interference between the waves reflected from the top and bottom surface of the air film formed between the lens and the plate.

Newton's ring experiment:



# Newton's Ring experiment in Laboratory



# Expression for path difference :

- We know that in the case of wedge shaped thin film interference, the path difference-

$$=2\mu t \cos(r+\theta) + \lambda/2$$

$\Delta$

For normal incidence of light $r = 0$

For large radius of curvature of convex lens $\theta = 0$

for air film $\mu = 1$

$$=2t + \lambda/2 \qquad \text{-------1}$$

$\Delta$

Case 1: For bright ring:

$$\Delta = m \lambda$$

Therefore, $2t + \lambda/2 = m \lambda$

$$2t = (2m-1) \lambda/2$$

Case 2: For dark ring:

$$\Delta = (2m+1) \lambda/2$$

Therefore, $2t + \lambda/2 = (2m+1) \lambda/2$

$$2t = 2m \lambda/2$$

$$2t = m \lambda$$

# Calculation of Diameters of Bright and dark rings:

- Let O be the center of curvature of lens, R be the radius of lens and r be radius of a Newton's ring corresponding to the constant film thickness t.
- By Geometry: $R^2 = r^2 + (R - t)^2$

$$R^2 = r^2 + R^2 + t^2 - 2Rt$$

$$2Rt = r^2 + t^2$$

Neglecting term $t^2$ ,

$$2Rt = r^2$$

$$2t = r^2 / R \quad \text{------------} 1$$

# For Bright Ring:

$r^2 / R = (2m-1)\lambda/2$

$D^2 / 4R = (2m-1)\lambda/2$

$D^2 = 2(2m-1)R\lambda$

$D = \sqrt{2(2m-1)R\lambda}$

Or

$D_m = \sqrt{2(2m-1)R\lambda}$

$D_m \infty \sqrt{(2m-1)}$

# For Dark Ring:

$r^2 / R = m\lambda$

$D^2 / 4R = m\lambda$

$D^2 = 4\, m\, R\, \lambda$

$D = \sqrt{4\, m\, R\, \lambda}$

Or

$D_m = \sqrt{4\, m\, R\, \lambda}$

$D_m \infty \sqrt{m}$

# Applications of Newton's Ring Experiment:

(1) To determine the wavelength of monochromatic light

(2) To determine the Refractive Index of a given Liquid

# (1) To determine the wavelength of monochromatic light

We Know for $m^{th}$ bright ring:

$$D_m^2 = 2(2m-1)R\lambda \quad \text{-------}1$$

for $(m+p)^{th}$ bright ring:

$$D_{m+p}^2 = 2\{2(m+p)-1\}R\lambda \quad \text{--------}2$$

Now eq.(2)- eq.(1)

$$D_{m+p}^2 - D_m^2 = 2\{2(m+p)-1\}R\lambda - 2(2m-1)R\lambda$$

$$= 4pR\lambda$$

Or $\lambda = [D_{m+p}^2 - D_m^2]/4pR \quad \text{------}3$

This expression is used to determine the wavelength of monochromatic light.

# (2) To determine the Refractive Index of a given Liquid

We know, In case of Newton's Ring Experiment in a medium of refractive index $\mu$, path difference

$\Delta = 2\mu t + \lambda/2$ --------1

From geometry of setup

$2t = r^2 / R$ -----------------2

Therefore, diameter of $m^{th}$ bright ring formed through a medium wedge film

$D_m^2 = 2(2m-1) R\lambda / \mu$ -------3

for $(m+p)^{th}$ bright ring:

$D_{m+p}^2 = 2\{2(m+p)-1\} R\lambda / \mu$ --------4

Now eq.(4)- eq.(3)

$D_{m+p}^2 - D_m^2 = [2\{2(m+p)-1\} R\lambda - 2(2m-1) R\lambda] / \mu$

$[D_{m+p}^2 - D_m^2]_{liquid} = 4p R \lambda / \mu$ -------5

For air wedge film,eq. 5 becomes

$[D_{m+p}^2 - D_m^2]_{air} = 4p R \lambda$ -------6

Eq.(5) /Eq. (6)

$[D_{m+p}^2 - D_m^2]_{liquid} / [D_{m+p}^2 - D_m^2]_{air} = 4p R \lambda /\mu\, 4p R \lambda$

Or

$\mu = [D_{m+p}^2 - D_m^2]_{air} / [D_{m+p}^2 - D_m^2]_{liquid}$ ------7

This expression is used to determine the Refractive Index of a given Liquid.