Newton’s rings

Apparatus:

Traveling microscope, sodium vapour lamp, plano-convex lens, plane glass plate, magnifying lens.

Purpose of the experiment:

To observe Newton rings formed by the interface of produced by a thin air film and determine the radius of curvature of a plano-convex lens.

Basic Methodology:

A thin wedge shaped air film is created by placing a plano-convex lens on a flat glass plate. A monochromatic beam of light is made to fall at almost normal incidence on the arrangement. Ring like interference fringes are observed in the reflected light. The diameters of the rings are measured.

I. Introduction:

I.1 The phenomenon of Newton’s rings is an illustration of the interference of light waves reflected from the opposite surfaces of a thin film of variable thickness. The two interfering beams, derived from a monochromatic source satisfy the coherence condition for interference. Ring shaped fringes are produced by the air film existing between a convex surface of a long focus plano-convex lens and a plane of glass plate.

I.2. Basic Theory:

When a plano-convex lens (L) of long focal length is placed on a plane glass plate (G) , a thin film of air I enclosed between the lower surface of the lens and upper surface of the glass plate.(see fig 1). The thickness of the air film is very small at the point of contact and gradually increases from the center outwards. The fringes produced are concentric circles. With monochromatic light, bright and dark circular fringes are produced in the air film. When viewed with the white light, the fringes are coloured.

A horizontal beam of light falls on the glass plate B at an angle of 450. The plate B reflects a part of incident light towards the air film enclosed by the lens L and plate G. The reflected beam (see fig 1) from the air film is viewed with a microscope. Interference takes place and dark and bright circular fringes are produced. This is due to the interference between the light reflected at the lower surface of the lens and the upper surface of the plate G.

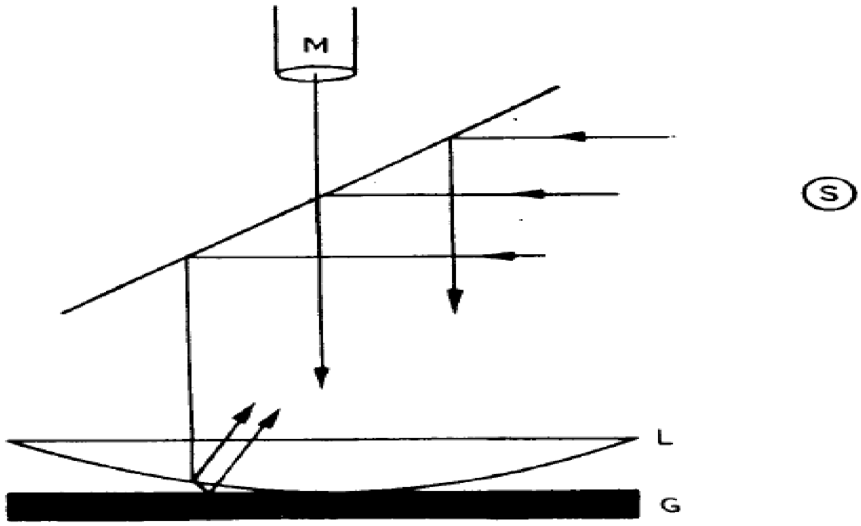

Fig 1

For the normal incidence the optical path difference between the two waves is nearly $2\mu t$, where μ is the refractive index of the film and t is the thickness of the air film. Here an extra phase difference π occurs for the ray which got reflected from upper surface of the plate G because the incident beam in this reflection goes from a rarer medium to a denser medium. Thus the conditions for constructive and destructive interference are (using $\mu = 1$ for air)

$2\,t = m\,\lambda$ for minima; $m = 0,1,2,3\ldots$ … … … … .. **-----(1)**

and $2\,t = (m+1/2\lambda)$ for maxima; $m = 0,1,2,3\ldots$ … … … … . **-------------(2)**

Then the air film enclosed between the spherical surface of R and a plane surface glass plate, gives circular rings such that (see fig 2)

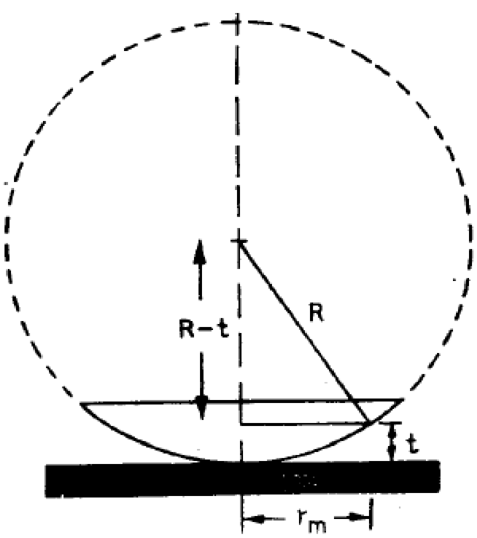

Fig. 2

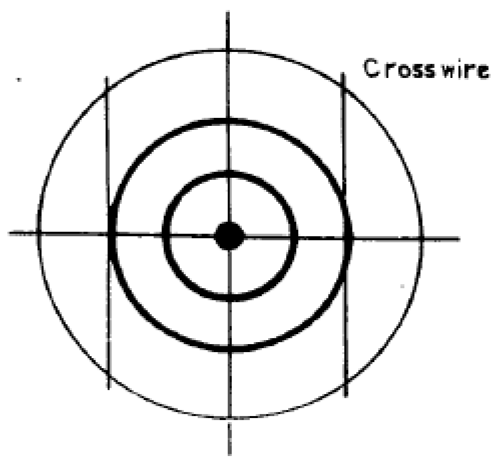

Fig. 3

If D_m is the diameter of the m^{th} bright ring from the centre then

$$\frac{D_m^2}{4R} = (2m+1)\frac{\lambda}{2} \qquad (3)$$

Where R is the radius of curvature of the plano convex lens, λ is wave length of light. For the $(m+n)^{th}$ bright ring from the centre,

$$\frac{D_{m+n}^2}{4R} = (2m+2n+1)\frac{\lambda}{2} \qquad (4)$$

Where D_{m+n} is the diameter of the $(m+n)^{th}$ ring. From Equs. 3 and 4

$$R = \frac{D_{m+n}^2 - D_m^2}{4n\lambda} \qquad (5)$$

II. Setup and Procedure:

1. Clean the plate G and lens L thoroughly and put the lens over the plate with the curved surface below B making angle with G(see fig 1).

2. Switch in the monochromatic light source. This sends a parallel beam of light.

3. Look down vertically from above the lens and see whether the center is well illuminated. On looking through the microscope, a spot with rings around it can be seen on properly focusing the microscope.

4. Once good rings are in focus, rotate the eyepiece such that out of the two perpendicular cross wires, one has its length parallel to the direction of travel of the microscope. Let this cross wire also passes through the center of the ring system.

5. Now move the microscope to focus on a ring (say, the 20th order dark ring). On one side of the center. Set the crosswire tangential to one ring as shown in fig 3.

Note down the microscope reading *(Make sure that you correctly read the least count of the vernier in mm units)*

6. Move the microscope to make the crosswire tangential to the next ring nearer to the center and note the reading. Continue with this purpose till you pass through the center. Take readings for an equal number of rings on the both sides of the center.

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Table: Measurement of the diameter of the rings

Ring No. (m)	Microscope reading		Diameter $D_m=R_1 \sim R_2$ (cm)
	Left reading (R_1)	Right reading (R_2)	

Precautions:

Notice that as you go away from the central dark spot the fringe width decreases. In order to minimize the errors in measurement of the diameter of the rings the following precautions should be taken:

i) The microscope should be parallel to the edge of the glass plate.

ii) If you place the cross wire tangential to the outer side of a perpendicular ring on one side of the central spot then the cross wire should be placed tangential to the inner side of the same ring on the other side of the central spot.(See fig 3)

iii) The traveling microscope should move only in one direction to avoid backlash error.

Reference: Practical Physics by R.K. Shukla and A. Srivatsava, New Age International Ltd.