DEPARTMENT OF PHYSICS

MAR THOMA COLLEGE FOR WOMEN, PERUMBAVOOR

NEWTON’S RINGS – WAVELENGTH

Aim

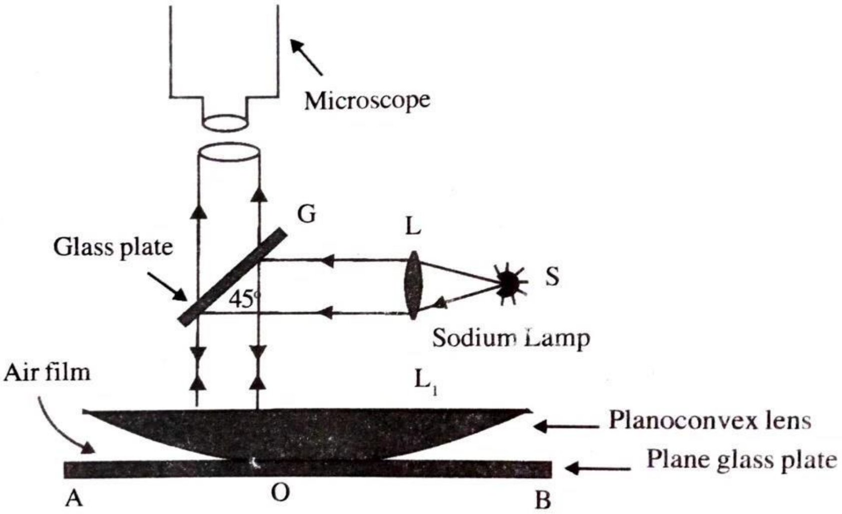
To determine the wavelength of sodium light by forming Newton’s rings using reflected light.

Apparatus

Newtons rings apparatus, sodium vapour lamp, vernier microscope and a convex lens of large focal length.

Newton’s apparatus - Description

The Newtons rings apparatus consists of an optically plane glass plate AB on which a long - focus convex lens L, is placed. Above the lens there is a glass plate G inclined at 45° to the horizontal.



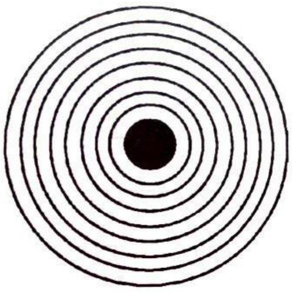
Light from a sodium lamp S is rendered parallel by a short focus focal length L These parallel rays fall on the glass plate G and get reflected vertically downward and fall on the air film (plano convex in shape) between convex lens L, and the plane glass plate AB. The light reflected from the lower surface of the lens L, and upper surface of the glass plate AB get super imposed, interference takes place and a number of concentric dark and bright rings are formed. These rings are called Newton’s rings.

Theory

Let R be the radius of curvature of the Lens. Let the dark ring be located at Q (see the figure below). Let the thickness of the air film at Q be PQ = t, and radius of the circular fringes at Q be OQ = r_n. Using Pythagoras theorem we have

$$PM^2 = PN^2 + MN^2$$

$$\text{i.e. } R^2 = r_n^2 + (R - t)^2$$



Newtons rings

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

$$\text{or } r_n^2 = 2Rt - t^2$$

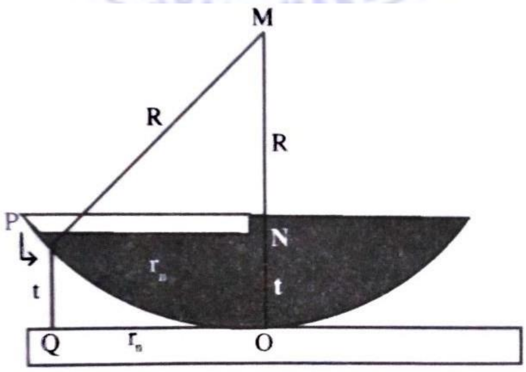
Since R > > t, 2Rt > > t^2 hence t^2 can be neglected.

$$\text{Therefore, } \quad r_n^2 = 2Rt \quad \ldots\ldots\ldots\ldots(1)$$

Using the condition for darkness

$$2\mu t \cos r = n\lambda$$

$$\text{Therefore, } 2t = n\lambda$$



Therefore, equation (1) becomes

$$r_n^2 = n\lambda R$$

$$r_n = \sqrt{n\lambda R}$$

where n = 1,2,3…..

The diameter of the ring

$$D_n = 2\sqrt{n\lambda R}$$

Similarly the diameter of the $(n+1)^{th}$ bright ring will be

$$D_{n+1} = 2\sqrt{(n+1)\lambda R}$$

Since the thickness of the air film at the centre is zero, the path difference at the centre is zero and a dark spot is surrounded by the first bright ring.

Let us consider the $(n+k)^{th}$ dark ring. The radius of the $(n+k)^{th}$ ring be r_{n+k}

$$\text{Then} \qquad r_n^2 = n\,\lambda\,R$$

$$D_n^2 = 4\,n\lambda\,R$$

$$D^2_{n+k} = 4(n+k)\,\lambda\,R$$

$$D^2_{n+k} - D_n^2 = 4\,k\,\lambda\,R$$

$$\therefore \lambda = \frac{D^2n+k-D^2n}{4kR}$$

Procedure

Make the experimental set up as shown in figure. The rings are observed through a microscope arranged vertically above the glass plate G. The microscope is focused well so that the rings are clearly seen. Then by working the tangential screw, the point of intersection of the cross wire is kept at the central dark. Make sure that centre is dark. Then the microscope is moved to the left and to the right in order to ensure that about 30 dark rings are clearly seen. Starting from the central spot the microscope is moved to the left by working the tangential screw. The tangential screw is slowly adjusted so that the cross wire is tangential to the 28th dark ring. The microscope reading on the horizontal scale is taken (main scale coincidence). Then by working the tangential screw the cross wire is kept tangential to the 26th, 24th, 22nd etc. dark rings up to the second ring on the left and the reading to each ring is taken. Then by working the tangential screw, the microscope is moved in the same direction until the cross wire is tangential to the second dark on the right. The corresponding readings are taken. Similarly, the cross wire is kept tangential to the 4th, 6th, 8th etc. dark rings up to the 28th dark ring on the right. The readings corresponding to each ring is taken. The tangential screw should be worked only in one direction from the position of 28th dark ring on the left to the position of the 28th dark ring on the right. This is to avoid back lash error.

The difference in readings on the left and right at each ring gives its diameters. The value of D^2 is calculated. The values of $D^2_{n+k} – D^2_n$ are calculated for value of k = 10. Then the mean value of $D^2_{n+k} – D^2_n$ is found.

The focal length of the lens is determined by the plane mirror method as it is a long focus lens. For this the convex lens is placed in front of an illuminated wire gauze with a plane mirror held behind the lens. The distance of the lens is adjusted to get a clear image of the wire gauze side by side with it. The distance between the lens and wire gauze is measured. This gives the focal length of the lens. Repeat this three or four times, take the average value.

The radius of curvature of the lower surface of the lens is found by Boy's method. For this convex lens is placed infront of an illuminated wire gauze with a piece of paper held behind the lens. The distance of the lens is adjusted to get a clear image of the wire gauze by side with it. The distance d between the lens and wire gauze is measured. The experiment is repeated three or four times and the average value of d is found. Then the radius of curvature of the convex lens is calculated using the formula (Boy's method)

$$R = \frac{fd}{f-d}$$

The wavelength of the given light is hence calculated using the formula

$$\lambda = \frac{D^2{n+k} - D^2{n}}{4kR} \text{ for } k = 10$$

Observations and tabulations

<u>Microscopic readings</u>

Value of one main scale division (MSD) =........................ cm

Number of divisions on the vernier, n = …………..

Least count, LC = $\frac{Value\ of\ 1\ MSD}{n}$ =............. cm

Number of the ring	Microscope readings						Diameter of ring D in cm	D^2	$D^2_{n+k} - D^2_n$
	Left			Right					
	MSR (cm)	VSR	TOTAL	MSR (cm)	VSR	TOTAL			
28									
26									
24									
.									
.									
.									
.									
.									
2									

Mean value of $D^2_{n+k} - D_n^2$ = ……..

<u>To find f by plane mirror method</u>

Distance of lens from the wire gauze 1 2 3 Mean f

∴ Focal length of the lens, f = ... m

<u>To find the radius of curvature of Boy's method</u>

Distance of lens from the wire gauze, d = 1 2 3 Mean d

Mean value of d = ... m

Radius of curvature of the lens, $R = \frac{fd}{f-d}$ = ...m

Wavelength of sodium light, $\lambda = \frac{D^{2}n+k-D^{2}n}{4kR}$ = ... m

Result

The wavelength of the sodium light = ...× 10^{-10}m.

References

Experimental Physics – I, For First, Second, Third and Fourth Semester, BSc Degree Programme, Dr.P.Sethumadhavan, Prof. K.C. Abraham, Prof .Sunil John, **Manjusha Publications**