

# Interference

## EXPERIMENT No. 8

**Object :** To determine the wavelength of sodium light by Newton's ring.

**Apparatus required :** A plano-convex lens of large radius of curvature, optical arrangement for Newton's rings, plane glass plate, sodium lamp and travelling microscope.

**Formula used :**

The wavelength  $\lambda$  of light is given by the formula

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

where  $D_{n+p}$  = diameter of  $(n+p)$ th ring,  
 $D_n$  = diameter of  $n$ th ring,  
 $P$  = an integer number (of the rings),  
 $R$  = radius of curvature of the curved face of the plano-convex lens.

**Description of apparatus :**

The optical arrangement for Newton's ring is shown in fig. (1). Light from a monochromatic source (sodium lamp) is allowed to fall on a convex lens through a broad slit which renders it into a nearly parallel beam. Now it falls on a glass plate inclined at an angle  $45^\circ$  to the vertical, thus the parallel beam is reflected from the lower surface. Due to the air film formed by a glass plate and a plano convex lens of large radius of curvature, interference fringes are formed which are observed directly through a travelling microscope. The rings are concentric circles.

**Procedure :**

(i) If a point source is used only then we require a convex lens otherwise using an extended source, the convex lens  $L_1$  is not required.

(ii) Before starting the experiment, the glass plates  $G_1$  and  $G_2$  and the plano convex lens should be thoroughly cleaned.

(iii) The centre of lens  $L_2$  is well illuminated by adjusting the inclination of glass plate  $G_1$  at  $45^\circ$ .

(iv) Focus the eyepiece on the cross-wire and move the microscope in the vertical plane by means of rack and pinion arrangement till the rings are quite distinct. Clamp the microscope in the vertical side.

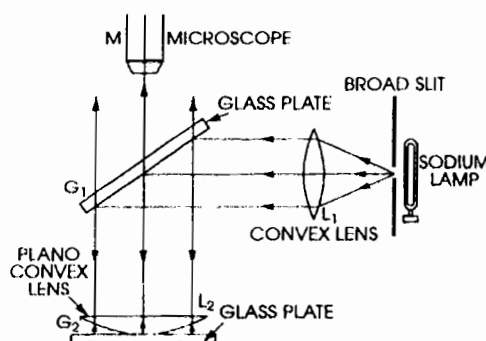


Fig. (1)

(v) According to the theory, the centre of the interference fringes should be dark but sometimes the centre appears white. This is due to the presence of dust particles between glass plate  $G_2$  and plano-convex lens  $L_2$ . In this case the lens should be again cleaned.

(vi) Move the microscope in a horizontal direction to one side of the fringes. Fix up the crosswire tangential to the ring and note this reading. Again the microscope is moved in the horizontal plane and the cross wire is fixed tangentially to the successive bright fringes noting the vernier readings till the other side is reached. This is shown in fig. (2).

(vii) The radius of curvature of the plano-convex lens is determined by Boy's method as discussed below :

If an object is placed at the principal focus of convex lens placed over a plane mirror, its image is formed at same point and the distance from the lens is equal to the focal length  $f$  of the lens as shown in fig. (3i).

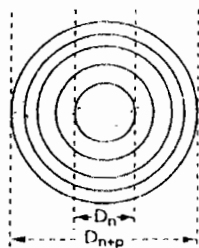
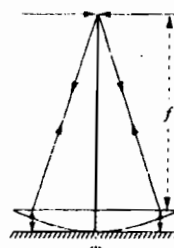
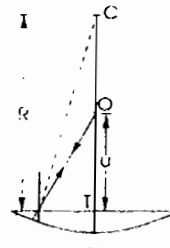


Fig. (2)



(i)



(ii)

Fig. (3)

If the mirror is removed and the object is moved along the axis, a position will come where the image of the object formed by the lens coincides with object as shown in fig. (3 ii). If the direction of a ray starting from  $O$  is such that it is incident normally on the spherical surface, the ray returns to its previous path and forms the image at the same point. Since the refracted ray is normally incident on the surface, it appears to come from the centre of curvature  $C$ . Hence in this case  $TO = u$  and  $TC = v = R$  we have

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{R} - \frac{1}{u} = \frac{1}{f}$$

or

$$\frac{1}{R} = \frac{1}{u} - \frac{1}{f} = \frac{f-u}{uf}$$

$$R = \frac{uf}{f-u}$$

Knowing the value of  $u$ , the value of  $R$  can be calculated because the value of  $f$  is already known with the help of fig. (3 i).

The radius of the curvature can also be determined by using a spherometer. In this case

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

where  $l$  is the distance between the two logs of the spherometer as shown in fig. (4).

$h$  is the difference of the readings of the spectrometer when it is placed on the lens as well as when placed on plane surface.

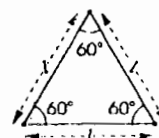


Fig. (4)

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Observations : Value of one division of the main scale = ... cm.  
No. of divisions on the vernier scale = ...  
Least count of the microscope = ...

Table for the determination of  $(D_{n+p}^2 - D_n^2)$

No. of the rings	Micrometer reading		Diameter $D$ ( $a - b$ ) cm.	$D^2$ ( $a - b$ ) <sup>2</sup> cm <sup>2</sup>	$(D_{n+p}^2 - D_n^2)$ cm <sup>2</sup>	Mean cm <sup>2</sup>	$p$
	Left end $a$ cm.	Right end $b$ cm.					
20	...	...	...	...		...	8
19	...	...	...	...			
18	...	...	...	...			
17	...	...	...	...			
16	...	...	...	...			
15	...	...	...	...			
14	...	...	...	...			
13	...	...	...	...			
12	...	...	...	...			
11	...	...	...	...			
10	...	...	...	...			
9	...	...	...	...			
8	...	...	...	...			
7	...	...	...	...			
6	...	...	...	...			
5	...	...	...	...			

Table for the determination of  $R$  :

(Either use Boy's method or spherometer method)

Using Boy's method :

S. No.	Position of object	Position of lens placed on plane mirror	$f$ cm.	Position of lens in absence of plane mirror	$u$	$R = \frac{uf}{f-u}$ cm.
1	...	...	...	...	...	...
2	...	...	...	...	...	...
3	...	...	...	...	...	...

Using spherometer method :

L.C. of spherometer = ... cm.

S. No.	Spherometer Reading						$h = (b - a)$ cm.	Mean $h$ cm.
	Zero reading on plane surface			Reading on lens				
	M.S.	V.S.	Total cm.	M.S.	V.S.	Total cm.		
			(a)			(b)		
1	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...

Distance between the two legs of spherometer  $l = ...$  cms.

**Calculations :**

Using Boy's method

$$R = \frac{uf}{f-u}$$

$$= \dots \text{ cm.}$$

Using Spherometer method

$$R = \frac{r^2}{h} + \frac{h}{2}$$

$$= \dots \text{ cm.}$$

The wavelength of sodium light is given by

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

$$= \dots \text{ A.U.}$$

The value of  $(D_{n+p}^2 - D_n^2)$  can also be obtained using a graph as shown in fig. (5). The graph is plotted between the square of diameter of the ring along Y-axis and corresponding number of ring along X-axis.

**Result :** The mean wavelength  $\lambda$  of sodium light

$$= \dots \text{ A.U.}$$

Standard mean wavelength

$$\lambda = \dots \text{ A.U.}$$

Percentage error

$$= \dots \%$$

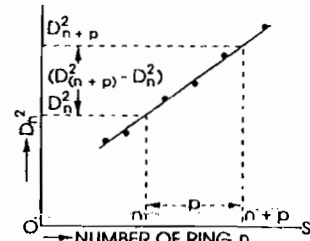


Fig. (5)

**Sources of Error and Precautions :**

- (i) Glass plates and lens should be cleaned thoroughly.
- (ii) The lens used should be of large radius of curvature.
- (iii) The source of light used should be an extended one.
- (iv) Before measuring the diameter of rings, the range of the microscope should be properly adjusted.
- (v) Crosswire should be focussed on a bright ring tangentially.
- (vi) Radius of curvature should be measured accurately.

**Theoretical error :**

In our case

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

Taking logarithm of both sides and differentiating

$$\frac{\delta\lambda}{\lambda} = \frac{\delta(D_{n+p}^2 - D_n^2)}{D_{n+p}^2 - D_n^2} + \frac{\delta R}{R}$$

$$= \frac{2\{D_{n+p}(\delta D_{n+p}) + D_n(\delta D_n)\}}{D_{n+p}^2 - D_n^2} + \frac{\delta R}{R}$$

$$= \dots$$

$$= \dots \%$$