Viva Voce for λ by Newton's Ring

Q. 1. What do you mean by interference of light?
Ans. The redistribution of light by superposition of light waves is called as interference. When the two or more waves superimpose over each other, resultant intensity is modified. The modification in the distribution of intensity in the region of superposition is called interference.

Q. 2. What are interference fringes?
Ans. They are alternately bright and dark patches of light obtained in the region of superposition of two wave trains of light.

Q. 3. Is there any loss of energy in interference phenomenon?
Ans. No, there is no loss of energy in interference phenomenon. Only redistribution of energy takes place. The energy absent at dark places is actually present in bright regions.

Q. 4. What is the physical significance of this phenomenon?
Ans. The phenomenon of interference of light has proved the validity of the wave theory of light.

Q. 5. What are the essential conditions for observing the interference phenomenon in the laboratory?
Ans. (*i*) The two sources should be coherent.
(*ii*) The two sources must emit waves of same wavelength and time period.
(*iii*) The sources should be monochromatic.
(*iv*) The amplitudes of the interfering waves should be equal or nearly equal.

Q. 6. What are the different classes of interference?
Ans. (*i*) Division of wavefront, the incident wavefront is divided into two parts by utilizing the phenomenon of reflection, refraction or diffraction.
(*ii*) Division of amplitude, the amplitude of incoming beam is divided into two parts either by partial reflection or refraction.

Q. 7. What is the construction of sodium lamp?
Ans. It consists of a U-shaped glass tube with two electrodes of tungsten coated with barium oxide. The tube is filled with neon gas at a pressure of 10 mm of mercury and some sodium pieces. This tube is enclosed in a vacuum jacket to avoid heat losses.

Q. 8. Why does the sodium lamp give out red light in the beginning?
Ans. First of all discharge passes through neon gas.

Q. 9. Why is the neon gas filled in it at all?
Ans. Initially, no discharge passes through sodium as its vapour pressure is low. First, the discharge passes through neon. Now the temperature rises and sodium vaporises. Now sodium gives its own characteristic yellow colour.

Q. 10. How are these rings formed?
Ans. When a plano-convex surface is placed on a glass plate, an air film of gradually increasing thickness is formed between the two and monochromatic light is allowed to fall normally on film and viewed in reflected light, alternate dark and bright rings are observed. These are known as Newton's ring.

Q. 11. Why are the rings circular?
Ans. These rings are loci of constant thickness of the air film and these loci being concentric circle hence fringes are circular. OR Since locus of constant thickness of air film about point of contact is circle so fringes are circular.

Q. 12. Why do you use in extended source of light here?
Ans. To view the whole air film, an extended source is necessary.

Q. 13. What may be the reason if the rings are not perfectly circular?
Ans. (*i*) The plate may not be optically flat.
(*ii*) The surface of the lens may not be the part of a perfect sphere and
(*iii*) The plate and the lens may not be perfectly clean.

Q. 14. In the Newton's rings system, the fringes at the centre are quite broad, but they get closer as we move outward why is it so?
Ans. This is due to the fact that the radii of dark rings are proportional to square root of natural numbers while those of bright rings are proportional to square root of odd natural numbers.

Q. 15. What are the factors which govern the radius of a ring?
Ans. The radius depends upon
(*i*) wavelength of light used.
(*ii*) refractive index 'μ' of enclosed film.
(*iii*) radius of curvature *R* of convex lens.

Q. 16. What would be your observation in transmitted light?
Ans. Where we have bright fringe in the reflected light, we shall have a dark fringe in the transmitted light and vice-versa. These two systems of fringes are complementary.

Q. 17. Do you get rings in the transmitted light?
Ans. Yes, in this case the colour of rings is complimentary of the reflected light.

Q. 18. Why is the centre of the ring dark?
Ans. Although at centre, the thickness of air film is zero but at the point of contact the two interfering rays are opposite in phase and produce zero intensity.

Q. 19. Sometimes the centre is bright, why?
Ans. This happens when a dust particle comes between the two surfaces at the point of contact.

Q. 20. What will happen if the glass plate is silvered on its front surface?
Ans. The transmitted system of fringes will also be reflected and due to the superposition of the reflected and transmitted (which is also reflected now) systems the uniform illumination will result.

Q. 21. If by chance, you get a bright central spot in your experiment, will you proceed with the experiment with the same system of fringes or will you reject them?
Ans. The system will not be rejected, but we will proceed on with measurement, because the formula employed for the evaluation of l involves the difference of the squares of the diameters of two rings and the order of fringe at the centre is immaterial.

Q. 22. What will happen when the sodium lamp is replaced by a white light source?
Ans. A few coloured fringes are observed near the centre. The violet colour will come first as we proceed away from the centre.

Q. 23. What will happen if a few drops of a transparent liquid are introduced between the lens and the plate?
Ans. The fringes will contract, with diameter reduced by a factor of $\sqrt{\mu}$.

Q. 24. Can you utilise this procedure for determining the refractive index of a liquid?
Ans. Yes.

Q. 25. Will there be any change in rings if light is obliquely incident?
Ans. The diameter of the rings will increase.

Q. 26. Why do you make the light fall on the convex lens normally?
Ans. The light is allowed to fall normally so that angles of incidence and reflection may be zero so that cos q may be taken as unity.

Q. 27. In this experiment the rings are observed through the lens. Does it affect the observation of diameter?
Ans. Due to refraction through lens, the observed diameters will be different from their actual values. To avoid this thin lens should be used.

Q. 28. How can you determine R?
Ans. This can be determined either by spherometer or by Boy's method.

Q. 29. Can Newton's rings be formed with the combination of convex and concave lens?
Ans. The plane glass plate is replaced by concave lens i.e. the convex lens is placed over the concave lens.

Q. 30. What are the uses of Newton's rings?
Ans. (*i*) To determine λ of light (monochromatic).
(*ii*) To determine μ of a liquid.
(*iii*) To measure the radius of spherical surface.
(*iv*) To measure expansion coefficient of crystal.

Theory of Newton's Ring

Circular interference fringes can be produced by enclosing a very thin film of air or any other transparent medium of varying thickness between a plane glass plate and a convex lens of a large radius of curvature. Such fringes were first obtained by Newton and are known as Newton's rings.

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

S is a source of monochromatic light as shown in Fig. N1. A horizontal beam of light falls on the glass plate *B* at 45°. The glass plate *B* reflects a part of the incident light towards the air film enclosed by the lens *L* and the plane glass plate *G*. The reflected beam 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 from the lower surface of the lens and the upper surface of the glass plate *G*.

Theory:

(*i*) *Newton's rings by reflected light:* Suppose the radius of curvature of the lens is *R* and the air film is of thickness *t* at a distance of $OQ = r$ from the point of contact *O*. Here, interference is due to reflected light. Therefore, for the bright rings

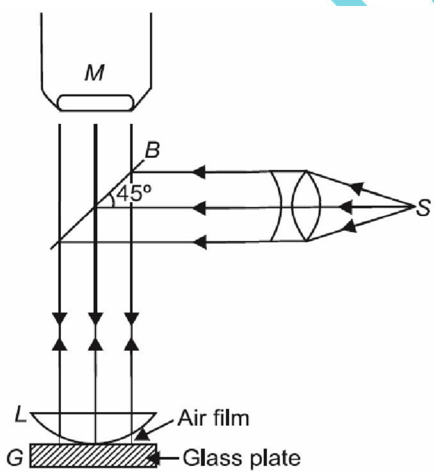


Fig.N1

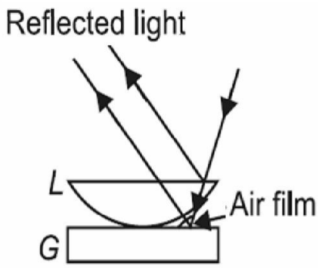


Fig.N2

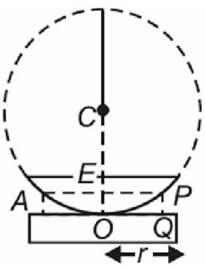


Fig.N3

$$2\mu t\cos\theta = (2n-1)\frac{\lambda}{2} \quad ...(i)$$

where $n = 1, 2, 3, ...$ etc.

Here, θ is small, therefore

$$\cos\theta = 1$$

For air, $\mu = 1$

$$2t = (2n-1)\frac{\lambda}{2} \quad ...(ii)$$

For the dark rings

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

or

$$2t = n\lambda \quad ...(iii)$$

where $n = 0, 1, 2, 3, ...$ etc.

In Fig N3, $EP \times HE = OE \times (2R - OE)$

But $EP = HE = r,\ OE = PQ = t$

and $2R - t = 2R$ (Approximately)

$$r^2 = 2R \cdot t$$

or

$$t = \frac{r^2}{2R}$$

Substituting the value of t in equations (ii) and (iii).

For bright rings $r^2 = \dfrac{(2n-1)\lambda R}{2}$

$$\boxed{r = \sqrt{\frac{(2n-1)\lambda R}{2}}}$$

For dark rings

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

$$\boxed{r = \sqrt{n\lambda R}}$$

when $n = 0$, the radius of the dark ring is zero and the radius of the bright ring is $\sqrt{\dfrac{\lambda R}{2}}$. Therefore, the centre is dark. Alternately, dark and bright rings are produced.

Result: The radius of the dark ring is proportional to

(*i*) $\sqrt{n}$, (*ii*) $\sqrt{\lambda}$ and (*iii*) $\sqrt{R}$.

Similarly the radius of the bright ring is proportional to

(*i*) $\sqrt{\dfrac{(2n-1)}{2}}$, (*ii*) $\sqrt{\lambda}$ and (*iii*) $\sqrt{R}$.

If D is the diameter of the dark ring

$$D = 2r = 2\sqrt{n\lambda R}$$

For the central dark ring

$$n = 0$$

$$D = 2\sqrt{n\lambda R} = 0$$

This corresponds to the centre of the Newton's rings.

While counting the order of the dark rings 1, 2, 3 etc, the central ring is not counted.

Therefore for the first dark ring

$$n = 1$$

$$D_1 = 2\sqrt{\lambda R}$$

For the second dark ring

$$n = 2$$

$$D_2 = 2\sqrt{2\lambda R}$$

and for the n^{th} dark ring

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

Take the case of 16^{th} and 9^{th} rings

$$D_{16} = 2\sqrt{16\lambda R} = 8\sqrt{\lambda R}$$

$$D_9 = 2\sqrt{9\lambda R} = 6\sqrt{\lambda R}$$

The difference in diameters between the 16th and the 9th rings,

$$D_{16} - D_9 = 8\sqrt{\lambda R} - 6\sqrt{\lambda R} = 2\sqrt{\lambda R}$$

Similarly the difference in the diameters between the fourth and first rings,

$$D_4 - D_1 = 2\sqrt{4\lambda R} - 2\sqrt{\lambda R} = 2\sqrt{\lambda R}$$

Therefore, the fringe width decreases with the order of the fringe and the fringes get closer with increase in their order.

For bright rings,

$$r_n^2 = \frac{(2n-1)\lambda R}{2}$$

$$D_n^2 = \frac{2\,(2n-1)\,\lambda R}{2}$$

$$r_n = \sqrt{\frac{(2n-1)\,\lambda R}{2}}$$

In above equation, substituting $n = 1, 2, 3$ (number of the ring) the radii of the first, second, third etc., bright rings can be obtained directly.

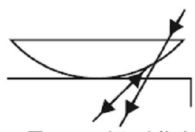
(ii) *Newton's rings by transmitted light:*

In the case of transmitted light, the interference fringes are produced such that for bright rings,

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

and for dark rings

$$2\mu t \cos\theta = (2n-1)\,\frac{\lambda}{2}$$



Here, for air $\mu = 1$, and $\cos\theta = 1$

For bright rings $2t = n\lambda$

and for dark rings $2t = (2n-1)\,\frac{\lambda}{2}$

Taking the value of $t = \frac{r^2}{2R}$, where r is the radius of the ring and R the radius of curvature of the lower surface of the lens, the radius for the bright and dark rings can be calculated.

For bright rings, $r^2 = n\lambda R$

For dark rings, $r^2 = \frac{(2n-1)\,\lambda R}{2}$

where $n = 1, 2, 3, \ldots$, etc.

When $n = 0$, for bright rings $r = 0$

Therefore, in the case of Newton's rings due to transmitted light, the central ring is bright i.e. just opposite to the ring pattern due to reflected light.

DETERMINATION OF THE WAVELENGTH OF SODIUM LIGHT USING NEWTON'S RINGS

The arrangement used is shown earlier. In Figure S is a source of sodium light. A parallel beam of light from the lens L_1 is reflected by the glass plate B inclined at an angle of 45° to the horizontal. L is a plano-convex lens of large focal length. Newton's rings are viewed through B by the travelling microscope M focussed on the air film. Circular bright and dark rings are seen with the centre dark. With the help of a travelling microscope, measure the diameter of the n^{th} dark ring.

Suppose, the diameter of the n^{th} ring = D_n

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

But $$r_n = \frac{D_n}{2}$$

$\therefore$ $$\frac{(D_n)^2}{4} = n\lambda R$$

or $$D_n^2 = 4n\lambda R \qquad \text{...(i)}$$

Measure the diameter of the $(n + m)$th dark ring.

Let it be D_{n+m} $\therefore$ $$\frac{(D_{n+m})^2}{4} = (n + m)\,\lambda R$$

or $$(D_{n+m})^2 = 4\,(n + m)\,\lambda R \qquad \text{...(ii)}$$

Subtracting (i) from (ii)

$$(D_{n+m})^2 - (D_n)^2 = 4m\lambda R$$

$$\lambda = \frac{(D_{n+m})^2 - (D_n)^2}{4mR}$$

Hence, λ can be calculated. Suppose the diameters of the 5^{th} ring and the 15^{th} ring are determined. Then $m = 15 - 5 = 10$.

$\therefore$ $$\lambda = \frac{(D_{15})^2 - (D_5)^2}{4 \times 10\,R}$$

The radius of curvature of the lower surface of the lens is determined with the help of a spherometer but more accurately it is determined by Boy's method.

Hence the wavelength of a given monochromatic source of light can be determined.