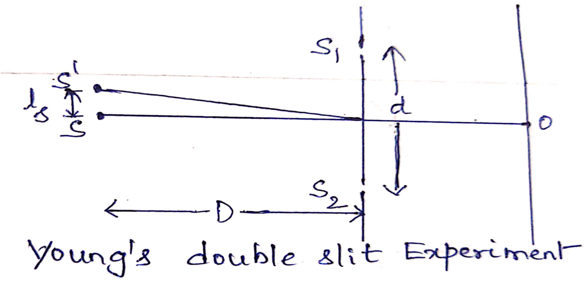
INTERFERENCE

When two or more light waves are superimposed , the intensity in the region of superposition varies from point to point between maxima. The intensity at maxima exceeds the sum of intensities of individual beams and the intensity at minima may be zero. This phenomena is known as interference.

COHERENCE: In order to produce a stable interference pattern, the individual waves must mantain a constant phase relationship with one another. Such sources are known as coherent sources. In an ordinary light, two different sources can't be coherent.

SPATIAL COHERENCE: Let us assume that at time t=0, the phase difference between the two points is k_0. At any time t>0, if the phase difference between the two points is k_0 then the light wave has *spatial coherence*. When the condition is true for any two points on the wavefront, the wave has perfect spatial coherence. We will understand the concept in detail using an interference experiment.

Let us consider Young's double slit experiment as shown in the fig. In the figure, S represents source, S_1 and S_2 are pin holes separated by a distance of d and are equidistant from S. When we observe interference pattern on the screen,fringes will be formed. Consider another source S' at a distance l from S. When S' is moved away from S slowly, we will observe that the fringes will vanish on the screen at a paticular distance. Let the wavelength of the light is λ and the distance of the point holes S_1 and S_2 from the source S is D then the distance for disappearance of fringes is given by $l=\frac{\lambda D}{2d}$



∴ For obtaining good interference pattern $d \ll \frac{\lambda D}{l_s}$

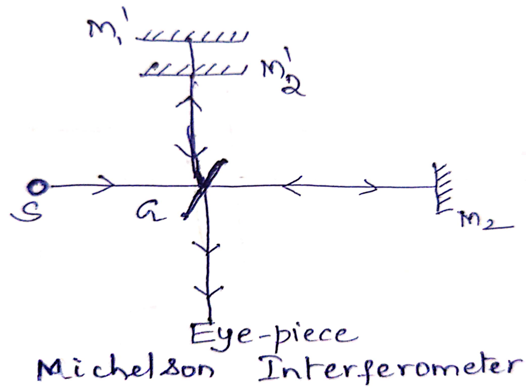
$\frac{l_s}{D}$ represents the angle made by source to slits, θ.

∴ $d \ll \frac{\lambda}{\theta}$. $\frac{\lambda}{\theta}$ is known as lateral coherence width which is the distance at which the waves have spatial coherence.

If the source has finite size , it is considered to be composed of a number of spatially separated, independently radiating point sources .

TEMPORAL COHERENCE:

At time t and t+dt, if the phase difference at a point is same then the wave has *temporal coherence*. If the condition holds true for any time difference then the wave has perfect temporal coherence. Let us understand the concept using Michelson interferometer.



In Michelson interferometer, light from the source gets split into two beams by a glass plate 'G' and travels towards mirrors M_1 and M_2. These beams get reflected from the mirrors, superimpose and produces interference pattern. Let the separation between mirrors M_1 and M_2'(mirror image of M_2) is d. If the time taken by the light beam to travel the distance d back and forth is less than coherence time i.e., $\frac{2d}{c} \ll \tau_c$ then interference fringes are formed. If the above condition is not satisfied then there won't be any definite phase difference between the beams and hence fringes are not formed.

Temporal coherence length L is given by $L = c\tau_c$

CONDITIONS FOR INTERFERENCE OF LIGHT:

1. The two light waves must be coherent i.e., they should maintain fixed phase difference over time and space.
2. The waves from the two sources must be of same frequency. If the frequency changes then the phase difference changes irregularly.
3. The sources should be placed close to each other. If the distance between them increases then the fringe width decreases and fringes can't be seen.
4. Distance between sources and screen should be large as fringe width increases with the distance.
5. If the interfering waves have same amplitudes then minimum intensity becomes zero and fringes are clearly distinguishable.
6. If the waves are plane polarised then the interfering waves should have same plane of polarisation.

TYPES OF INTERFERENCE:

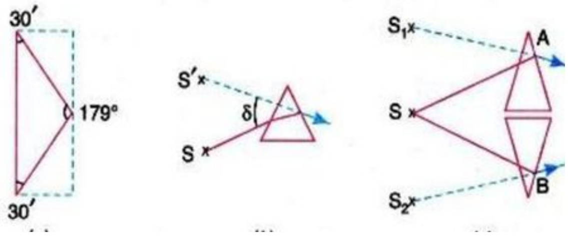
A. DIVISION OF WAVEFRONT: Wavefront emanating from a source is divided into two parts by using mirrors or prisms or lenses by the phenomena of reflection or refraction. These two parts travel different paths and gets superimpose forming interference pattern on the screen.

Ex: Young's double slit experiment, Fresnel's Biprism, Lloyd's mirror.

B. DIVISION OF AMPLITUDE: The amplitude of a wave is divided into parts by reflection or refraction. These parts travel different paths and gets superimpose forming interference pattern on the screen

Ex: Newton's rings, Michelson Interferometer.

FRESNEL'S BIPRISM: A Fresnel biprism constists of two prisms of small refracting angles (30') placed base to base. This is equivalent to a single prism with one of its angle nearly 179° and the other two of 30' each. When a light ray is incident on an ordinary prism it bends through an angle known as angle of deviation. As a result of this, it is thought of coming from virtual source S' instead of from real source S. If a wavefront is incident on a biprism, the top portion deviates downwards and appears to emanate from virtual source S_1. The bottom part deviates upward and appears to come from virtual



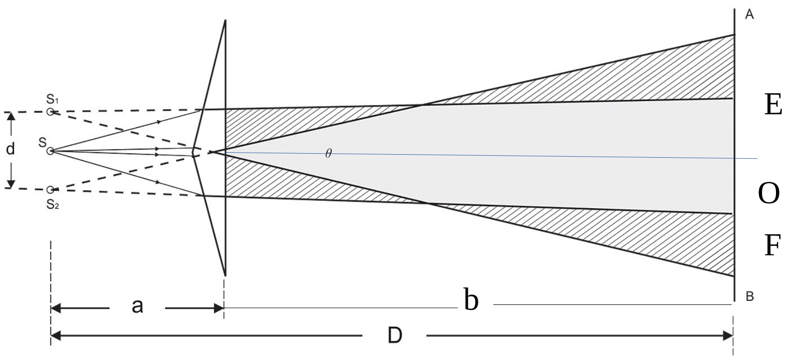
source S_2. These two virtual sources act as two coherent souces. Hence interference fringes are produced on the screen AB in the overlapping region EF. Here the interference is observed by division of wave front. Fresnel biprism can be used to determine the wavelength of a light source (monochromatic), thickness of a thin transparent sheet/ thin film, refractive index of medium etc.

AIM: DETERMINATION OF WAVELENGTH OF LIGHT USING FRESNEL'S BIPRISM:

Apparatus: An optical bench with components - slit, biprism, lens, Micrometer eyepiece on 4 uprights, Monochromatic light source.

Theory: Coherent sources S_1 and S_2 are equidistant from centre point O. Hence central bright fringe will be formed at O. Alternative bright and dark fringes are formed on either sides and the fringe width is

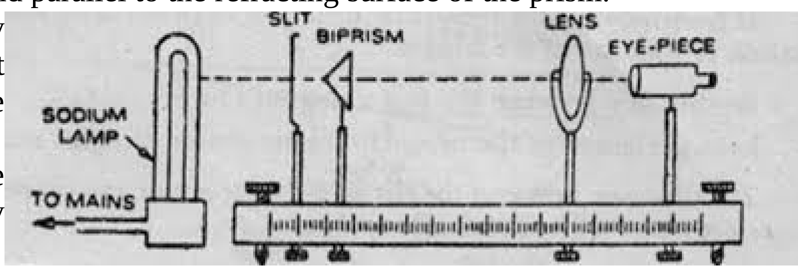
$$\beta=\frac{\lambda D}{d} \qquad \Rightarrow \lambda=\frac{\beta d}{D}$$



Where λ, wavelength of the given unknown source can be calculated using the above formula.
d is the separation between the virtual sources S_1 and S_2 ,
$D=a+b$ is the distance of the screen AB from source S where a is the separation between source and biprism; b is the separation between biprism and screen

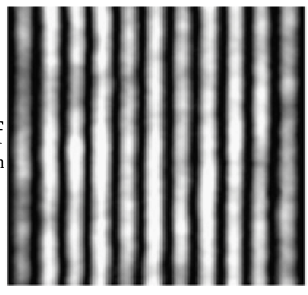
Procedure:

1. Adjust the position of the components monochromatic light source, slit, biprism and eyepiece such that all are in same line and at same height.
2. The slit is made narrow, vertical and parallel to the refracting surface of the prism.
3. The slit is illuminated by monochromatic source of light whose wavelength is to be determined.
4. The biprism and eyepiece are rotated till the fringes are clearly visible in the field of eyepiece.



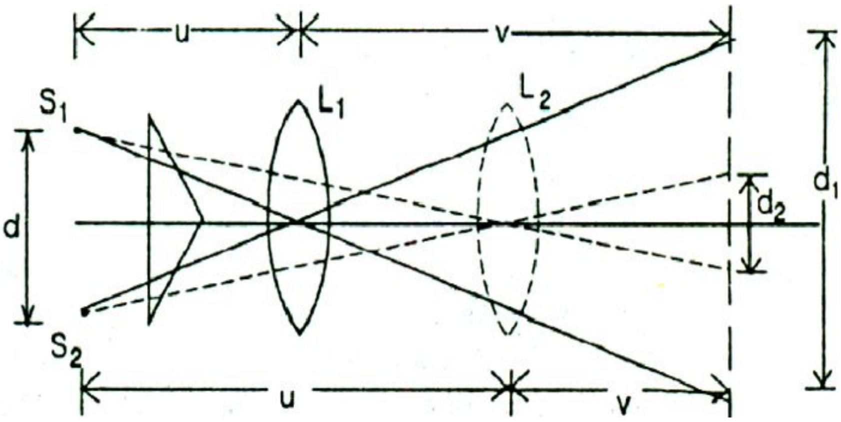
A. DETERMINATION OF FRINGE WIDTH:

1. Place the vertical crosswire at the centre of one of the bright fringes.
2. The position of the eyepiece is noted say x_0
3. Move the micrometer screw of the eyepiece and count the number of fringes crossed ,say n. Coincide the crosswire with the centre of n^{th} fringe.
4. The position x_n of the eyepiece is noted.



5. The fringe width is calculated using the formula $\beta = \frac{x_n - x_0}{n}$

B. **DETERMINATION OF DISTANCE BETWEEN SOURCES:**



1. A convex lens of short focal length (1/4th of distance between biprism and eyepiece) is placed between biprism and eyepiece.
2. Adjust the position of lens nearer to the biprism, position L_1 till two sharp images of S_1 and S_2 are observed in the eyepiece.
3. Set the vertical crosswire on each of the images and measure the positions of crosswire. The distance between them, say d_1
4. From the figure, applying the equation of magnification $\frac{v}{u} = \frac{d_1}{d}$
5. Adjust the position of lens nearer to the eyepiece, position L_2, till sharp images of S_1 and S_2 are observed.
6. From the figure, applying the equation of magnification for position L_2 $\frac{u}{v} = \frac{d_2}{d}$. Note the distance between them using micrometer say d_2
7. From the magnification equations, (multiply) $\frac{d_1 d_2}{d^2} = 1$

   ∴ Distance between sources is $d = \sqrt{d_1 d_2}$

The distance between source and eyepiece D is measured using the scale on optical bench.

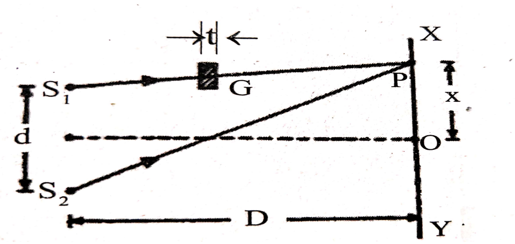
RESULT: Wavelength of given light is calculated using formula $\lambda = \frac{\beta d}{D}$ from the above calculated values of D, d and β.

AIM: TO DETERMINE THE THICKNESS OF A GIVEN GLASS PLATE/ MICA SHEET USING FRESNEL'S BIPRISM EXPERIMENT.

Apparatus: An optical bench with slit, biprism, lens, Micrometer eyepiece on 4 uprights, Monochromatic light source, white light source, Glass plate of unknown thickness.

Theory:In the absence of glass plate central bright fringe will be formed at O. (since optical path $S_1O = S_2O$).

In the presene of glass plate, one wave traverse an extra optical path and the path difference between the two waves is not same and entire fringe pattern shifts. Let the fringe is formed at a new point P.



When light ray is travelling along the path S_1P it travels in air and glass mediums in a time which is given by

$$\frac{(S_1P-t)}{c}+\frac{t}{v}=\frac{S_1P}{c}+(\mu-1)\frac{t}{c}$$

Time taken for the wave S_2P is $\frac{S_2P}{c}$

For central bright fringe, both waves should reach point P at same time $\frac{S_1P}{c}+(\mu-1)\frac{t}{c}=\frac{S_2P}{c}$

$$\Rightarrow S_2P-S_1P=(\mu-1)t \quad ...(1)$$

According to optical path difference condition (x is shift of the fringe) $S_2P-S_1P=\frac{xd}{D}$ ...(2)

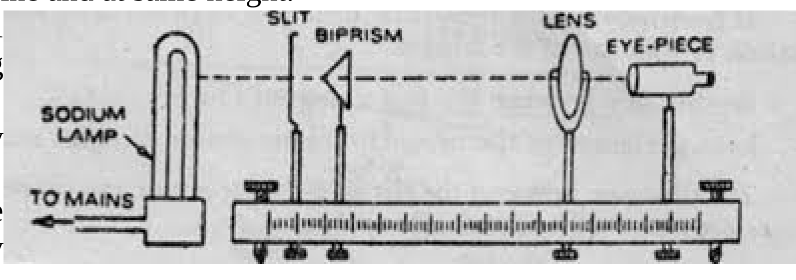
From equations (1) and (2) $\frac{xd}{D}=(\mu-1)t \quad \Rightarrow t=\frac{xd}{D(\mu-1)}$

shift of the fringe $x=n\beta$

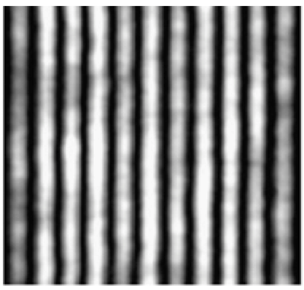
$\therefore \ t=\frac{n\beta d}{D(\mu-1)}$ or $\Rightarrow t=\frac{n\lambda}{(\mu-1)}$ $\left(\because \ \beta=\frac{\lambda D}{d}\right)$

Procedure:

1. Adjust the position of the components monochromatic light source, slit, biprism and eyepiece such that all are in same line and at same height.
2. The slit is made narrow, vertical and parallel to the refracting surface of the prism.
3. The slit is illuminated by monochromatic source of light.
4. The biprism and eyepiece are rotated till the fringes are clearly visible in the field of eyepiece.



A. DETERMINATION OF FRINGE WIDTH:



1. Place the vertical crosswire at the centre of one of the bright fringes.
2. The position of the eyepiece is noted say x_0
3. Move the micrometer screw of the eyepiece and count the number of fringes crossed ,say n. Coincide the crosswire with the centre of n^{th} fringe.

4. The position x_n of the eyepiece is noted.
5. The fringe width is calculated using the formula $\beta = \frac{x_n - x_0}{n}$

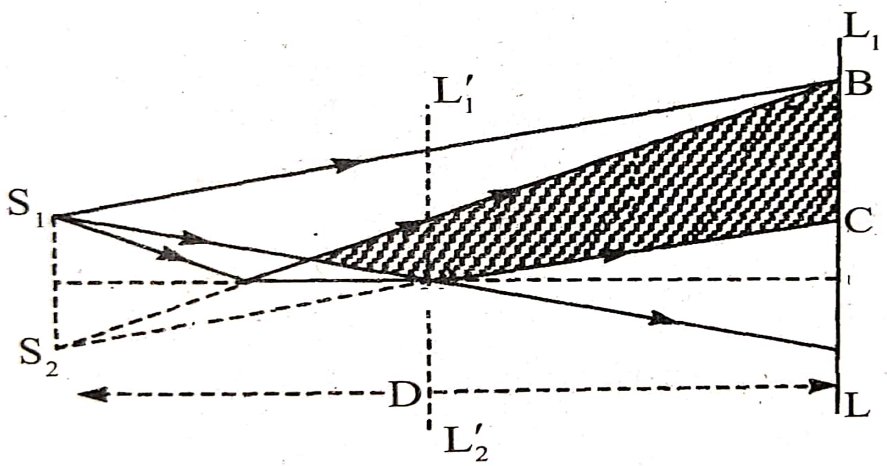
B. DETERMINATION OF LATERAL SHIFT OF CENTRAL MAXIMA:

1. Replace monochromatic light by white light. Adjust the apparatus for interference fringes. In this case the fringe pattern consists of several fringe patterns corresponding to all wavelength and the resultant of this is a central white fringe surrounded by dark region.
2. Coincide the central bright spot with vertical crosswire and note the reading of the micrometer say x_1.
3. A thin transparent glass plate of unknown thickness(t) and refractive index (μ) is placed in one of the two interfering beams (such that it blocks the one half of biprism).
4. Now the fringes gets dispalced to a new position.
5. Coincide the crosswire to the central bright spot in the new position, note down the micrometer reading say x_2.
6. The difference $x_1 \sim x_2$ gives the lateral shift (x) of the central bright fringe due to the presence of glass plate.

RESULT: Thickness of the glass plate can be calculated using $t = \frac{x\lambda}{\beta(\mu - 1)}$ cm using the above experimental parameters and λ is wavelength of the monochromatic light.

LLOYD MIRROR EXPERIMENT:

1. Light from source S_1 is allowed to fall on a plane mirror at grazing angle.
2. The part of reflected light from mirror can be thought of coming from source S_2.
3. S_1 and S_2 act as coherent sources.
4. The light directly coming from source interferes with the reflected light from mirror and produces interference pattern on the screen at BC.
5. The distance of the screen from source is D.
6. The central fringe cannot be observed on the screen.
7. Move the position of the screen to $L_1'L_2'$ till it touches the end of mirror to observe the central fringe.
8. If the source is white light then the central fringe can be identified. But the central fringe is observed to be dark.



9. This shows that reflected light undergoes a phase change of π on reflection at denser medium.
10. For a point P on the screen, because of this additional phase change due to reflection, when $S_2P - S_1P = n\lambda$ there will be minima.
11. Similarly when $S_2P - S_1P = (2n+1)\frac{\lambda}{2}$ there will be maxima.

AIM: TO DETERMINE THE WAVELENGTH OF GIVEN MONOCHROMATIC LIGHT

Apparatus: Monochromatic light source, An optical bench with components – slit, Lloyd mirror, micrometer eyepiece.

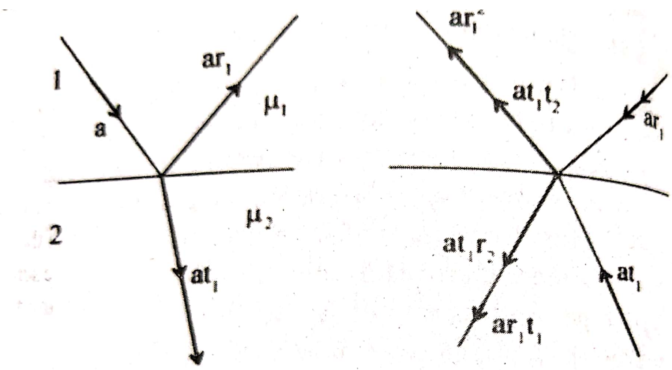
Procedure:
1. Lloyd mirror is placed on an upright along the length of the optical bench.
2. All the apparatus are arranged on uprights of the optical bench in the order - slit, Lloyd mirror, micrometer eyepiece.
3. Slit is illuminated with monochromatic light whose wavelength is to be determined.
4. The mirror is rotated such that slit and plane of reflecting surface are parallel.
5. Interference fringes are observed on the micrometer eyepiece.
6. Fringe width (β) is measured as in the case of biprism.
7. Distance between sources (d) is measured using lens displacement method as we did in Fresnel biprism experiment.

Result: Wavelength of the given light is measured using the formula $\lambda = \frac{\beta d}{D}$

PHASE CHANGE ON REFLECTION:

According to the principle of optical reversibilty, a reflected or refracted light ray retraces its original path if the direction of the ray is reversed.

Consider a light ray which is incident at the boundary of two mediums with μ_1 and μ_2 as refractive indices of the medias. Let the amplitude of the incident ray is 'a' then the amplitudes of refracted and reflected rays will be 'at_1' and 'ar_1' where t_1 and r_1 are transmission and reflection coefficients.



Let us consider the reverse process. A ray of amplitudes 'ar_1' and 'at_1' are incident on medium 2 and 1 respectively. A ray of amplitude 'at_1' gets into transmitted and reflected rays of amplitude 'at_1t_2' and 'at_1r_2' respectively. 'r_2' and 't_2' are reflection and transmission coefficients when ray is incident from medium 2 to medium 1.

Similarly a ray of amplitude ar_1 gives 'ar_1t_1' and 'ar_1^2 refracted and reflected light rays.

From the principle of optical reversibilty $ar_1^2 + at_1t_2 = a \quad \Rightarrow t_1t_2 = 1 - r_1^2$ ...(1)

Also the rays at_1r_2 and ar_1t_1 must cancel each other $at_1r_2 + ar_1t_1 = 0 \quad \Rightarrow r_2 = -r_1$ ...(2)

It has been observed from Lloyd mirror experiment that a phase change of π occurs when light gets reflected at denser medium. There won't be any phase change when the light ray gets reflected at rarer medium. Equations (1) and (2) are known as Stokes relations.

PROBLEMS:

1. In a biprism experiment the eyepiece was placed at a distance of 120 cm from the source. The distance between two virtual images was found to be equal to 0.075 cm. Find the wavelength of light source. When the eyepiece micrometer is moved through a distance of 1.888 cm, 20 fringes cross the field of view.

Hint: $\beta = \frac{\lambda D}{d} \qquad \beta = \frac{1.888}{20}$ **Ans:** 5900 $\mathring{A}$

2. In a double-slit interference arrangement one of the slits is covered by a thin mica sheet whose refractive index is 1.58. The distances between sources and source to screen are 0.1 and 50 cm, respectively. Due to the introduction of the mica sheet the central fringe gets shifted by 0.2 cm. Determine the thickness of the mica sheet.

Hint: $t = \frac{xd}{D(\mu - 1)}$ **Ans:** 6.9 x 10^{-4} cm

3. A biprism forms interference fringes with monochromatic light of wavelength 5450 $\mathring{A}$. On introducing a thin glass plate of refractive index of 1.5 in the path of one of the interfering beams the central bright band shifts to the position previously occupied by third bright fringe. Find the thickness of glass plate.

Sol: $t = \frac{n\lambda}{(\mu - 1)}$

Given λ = 5450 x 10^{-8} cm, μ=1.5, n=3

$$t = \frac{3 \, x \, 5450 \, x \, 10^{-8}}{(1.5 - 1)} = 3.27 \, x \, 10^{-4} \, cm$$

4. Consider a point P in Young's double slit experiment such that $S_2P - S_1P$ = l/3. Find the resultant displacement at point P.

   Sol: Let the wave reaching point P from S_1 is given by $y_1 = a\cos(\omega t)$

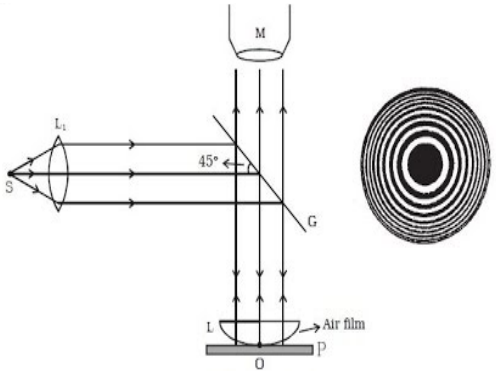
   we know that a path difference of λ corresponds to a phase difference of 2π

Hence the wave from S_2 is given by $y_2 = a\cos(\omega t - \frac{2\pi}{3})$

Resultant displacement $y = y_1 + y_2 = a\cos\omega t + a\cos(\omega t - \frac{2\pi}{3})$

on solving $y = a\cos(\omega t - \frac{\pi}{3})$

Q. Newton's Rings in Reflected light – Determination of Wavelength of light

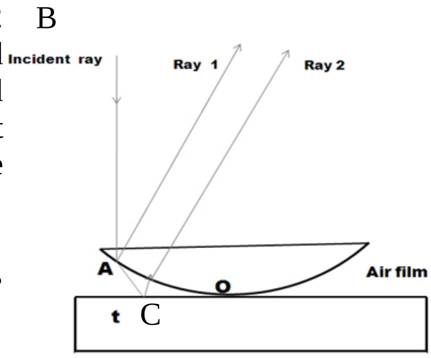


AIM: To determine the wavelength of a given source using Newton's rings apparatus in reflected light.

APPARATUS: Light source (S), glass plate (G), Travelling Microscope (M), Plano convex Lens (L) and flat glass plate (P).

THEORY: A thin air film is formed between plano-convex lens (L) and flat glass plate (P). The thickness of the air film varies from zero at the point of contact to some value t. The lens-plate system is illuminated with monochromatic light falling on it normally.

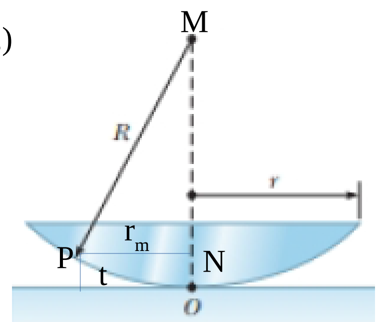
A ray AB, incident normally on the system gets partially reflected at the bottom curved surface of plano-convex lens at A (Ray 1) and part of the transmitted ray is partially reflected (Ray 2) from the top surface of flat glass plate at C. The rays 1 and 2 are derived from the same incident ray formed by division of amplitude and therefore are coherent. Ray 2 undergoes a phase change of π upon reflection since it is reflected from rarer-denser boundary. These reflected rays interfere and interference pattern is observed in the microscope. Concentric bright and dark interference rings are observed. These circular fringes were discovered by Newton and are called Newton's rings.



From cosine law, the optical path difference between rays 1 and 2 is $2\mu t \cos r$. For normal incidence cos r = 1 and for air film μ = 1.

For constructive interference $2t+\frac{\lambda}{2}=m\lambda \quad \Rightarrow 2t=(2m+1)\frac{\lambda}{2}$ ...(1) (bright ring is formed)

For destructive interference $2t+\frac{\lambda}{2}=(2m+1)\frac{\lambda}{2} \quad \Rightarrow 2t=m\lambda$ ...(2) (dark ring is formed)



From the figure $PM^2=PN^2+MN^2 \quad \Rightarrow R^2=r_m^2+(R-t)^2$

on neglecting t^2 term $\Rightarrow r_m^2=2Rt$ ...(3)

From the condition for dark ring $2t=m\lambda \quad \Rightarrow \frac{r_m^2}{R}=m\lambda$ $\Rightarrow r_m=\sqrt{mR\lambda}$

The radius of a dark ring is proportional to the square root of natural numbers.

The diameter of a dark ring is $D_m=2\sqrt{mR\lambda}$

∴ Rings get closer as the order increases (m increases), since the diameter of rings does not increase in the same proportion.

Central dark spot: At the point of contact of lens with glass plate, the thickness of air film is negligible (t=0) when compared to the wavelength of light. Thus a dark spot is produced at the centre.

From the condition for bright ring $2t=(2m+1)\frac{\lambda}{2}$

Substituting 2t value from eqn (3) $\Rightarrow \frac{r_m^2}{R}=(2m+1)\frac{\lambda}{2}$ $\Rightarrow r_m=\sqrt{(2m+1)R\frac{\lambda}{2}}$

The radius of a bright ring is proportional to the square root of odd natural numbers.

The diameter of a bright ring is $D_m=2\sqrt{(2m+1)R\frac{\lambda}{2}}$

The diameter of mth dark ring is $D_m=4mR\lambda$

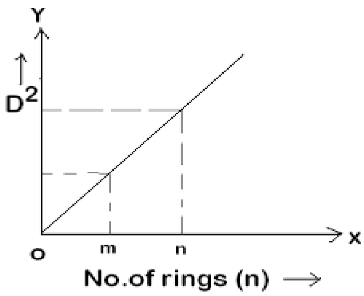
The diameter of (m+p)th the dark ring is $D_{m+p}=4(m+p)R\lambda$

∴ The wavelength of monochromatic light can be determined as $\lambda=\frac{D_{m+p}^2-D_m^2}{4pR}$

PROEDURE:

1. Light from the given source of light S becomes parallel by lens L_1. This parallel beam is incident on a glass plate G at 45^0 to the horizontal.
2. This glass plate reflects light from the source vertically downwards and falls normally on the convex lens (L)-glass plate (P) system. The convex face is kept on flat glass plate.
3. Newton's rings are seen using a long focus microscope, focussed on the air film.
4. The cross-wire of the microscope is made to coincide with the 20th ring on the left side by turning the screw of the microscope.
5. The cross wire is adjusted to coincide with the 18th, 16th, 14th, ... 2nd on the left and 2nd, 4th, 6th, ...18th on the right. Readings of the main scale and the vernier scale of the microscope are noted each time.
6. From the above readings, the diameter of the ring is found out which is the difference between the readings on the left and right sides.
7. The square of the diameters are found out.

8. Radius of curvature of the convex surface is determined using spherometer $R=\frac{l^2}{6h}+\frac{h}{2}$.
9. The wavelength of given source of light is calculated using equation $\lambda=\frac{D_{m+p}^2-D_m^2}{4pR}$.



GRAPH: Plot a graph with square of diameter D^2_m on Y-axis and order of the ring m on X-axis. Slope of this graph is 4λR. Hence wavelength is $\lambda = \frac{slope}{4R}$

AIM: Determination of refractive index of liquid using Newton's rings in reflected light.

THEORY: The liquid medium, whose refractive index is to be determined is placed between the plano-convex lens and the flat glass plate. From the condition for optical path difference between two rays for dark ring in a medium of refractive index μ is $2\mu t = m\lambda$

we know that the radius of a dark ring m is given by $r_m^2 = 2Rt$

From the above two eqns. $(r_m^2)_l = \frac{m\lambda R}{\mu}$

Diameter of m[th] ring is $(D_m^2)_l = \frac{4m\lambda R}{\mu}$

Diameter of (m+p)[th] ring is $(D_{m+p}^2)_l = \frac{4(m+p)\lambda R}{\mu}$

$\therefore \quad (D_{m+p}^2)_l - (D_m^2)_l = \frac{4p\lambda R}{\mu}$

In air medium $D_{m+p}^2 - D_m^2 = 4pR\lambda$

∴ The refractive index of a given liquid can be determined using formula $\frac{D_{m+p}^2 - D_m^2}{(D_{m+p}^2)_l - (D_m^2)_l} = \mu$

MICHELSON – INTERFEROMETER:

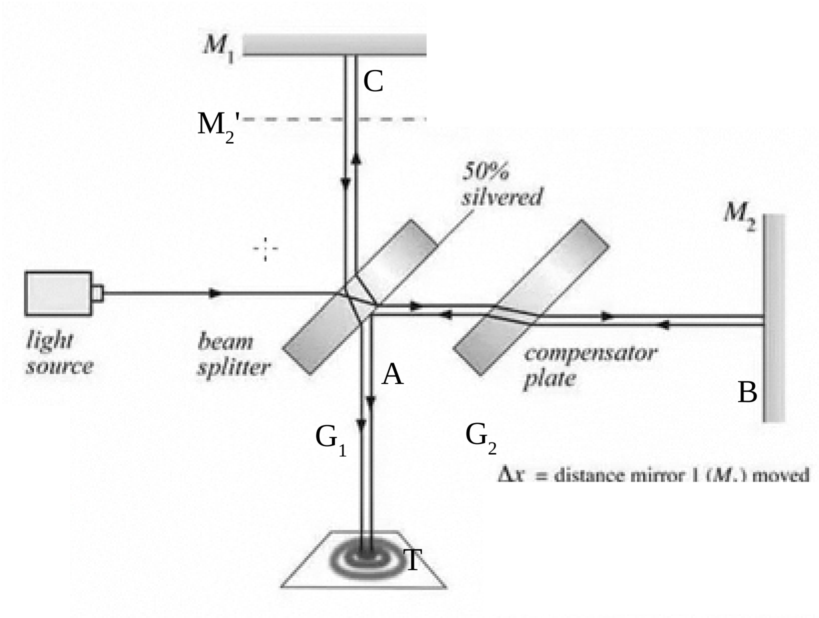
APPARATUS: A monochromatic source of light (S), collimating lens (L), beam splitter G_1, compensating glass plate G_2, two plane mirrors M_1 and M_2, Telescope.

THEORY: Light from the given source S is made parallel by collimating lens L. This light is incident on the beam splitter G_1 which is kept at an angle of 45^0. It gets partially reflected (AC) and partially transmitted (AB). M_1 and M_2 are mirrors with very high reflectivity. One of the mirrors (M_2) is fixed and the other (M_1) is capable of moving away from or towards G_1 .

1. The reflected light AC undergoes further reflection at M_1 and travels the same path. This light partly gets transmitted at G_1 as AT.
2. The transmitted light AB undergoes further reflection at M_2 and travels the same path. This light gets partly reflected at G_1 and travels as AT.
3. These two beams are produced from a single source through division of amplitude and are coherent. Hence they interfere and produce interfere pattern.
4. The interference pattern may be considered as formed due to light reflected from surfaces M_1 and M_2'.

<u>COMPENSATING GLASS PLATE G_2:</u> From point A, the reflected light travels through glass plate thrice, while the transmitted light travels only once through the glass plate G_1. Hence inorder to compensate the path difference travelled by two light beams, a compensating glass plate G_2 of same thickness is inserted in the path of transmitted light. It is not important when the source is monochromatic light. It's role becomes important for a white light source.

AIM: To determine the wavelength of a given monochromatic light source using Michelson Interferometer.



THEORY & PROCEDURE:

1. Adjust the positions of mirrors M_1 and M_2 such that they are equidistant from G_1 and perpendicular to each other. Hence circular fringes are formed.
2. The position of mirror M_1 is adjusted such that a bright spot is formed at the centre of view.
3. Let the distance between M_1 and M_2' is x and m is the order of the obtained central fringe. $2d=m\lambda$
4. Now move the position of M_1 from M_2 to a distance of $\frac{\lambda}{2}$. In this case the distance 2d changes by λ forming (m+1) bright spot at the centre therby expanding the fringe pattern. $2(d+\frac{\lambda}{2})=(m+1)\lambda$.
5. If the mirror M_1 is moved by a distance of x such that the fringe pattern expand by N fringes then $x=N\frac{\lambda}{2}$ or $\lambda=\frac{2x}{N}$.
6. The wavelength of the given source of light can be calculated using the above formula where x can be measured using the micrometer screw of the eyepiece and N is the number of fringes that crossed the field of view.

AIM: To determine the difference in wavelength of the sodium D_1 and D_2 lines using Michelson Interferometer. Michelson interferometer is used for measurement of closely spaced wavelengths.

THEORY & PROCEDURE:

1. Adjust the positions of mirrors M_1 and M_2 such that they are equidistant from G_1 and perpendicular to each other. Hence circular fringes are formed.
2. The interferometer is set for zero path difference hence the fringes overlap i.e., bright fringe of λ_1 coincides with the bright fringe of λ_2.
3. Now the mirror M_1 is moved till the fringes disappear. In this position, the maxima of λ_1 coincides with the minima of λ_2. This is the position of maximum indistinctness.
4. On moving the mirror M_1 further, again the position of clear visibility occurs (position of

maximum distinctness).

5. Let x be the distance moved by M_1 for two consecutive positions of maximum distinctness then the corresponding path difference changes by 2x.
6. If m is the change in order for λ_1 then (m+1) be the change in order for λ_2.

   $2x = m\lambda_1 = (m+1)\lambda_2$ or $m = \frac{\lambda_2}{\lambda_1 - \lambda_2}$

   $2x = \frac{\lambda_2}{\lambda_1 - \lambda_2}\lambda_1$ or $\lambda_1 - \lambda_2 = \frac{\lambda_1\lambda_2}{2x}$

   since λ_1 and λ_2 are nearly same $\lambda_1\lambda_2 = \lambda^2$ $\lambda_1 - \lambda_2 = \frac{\lambda^2}{2x}$
7. Hence change in wavelength of sodium D_1 and D_2 lines can be calculated using the above formula.

<u>AIM: To determine the thickness of a thin transparent plate using Michelson Interferometer.</u>

<u>THEORY & PROCEDURE:</u>

1. A thin glass plate of thickness t and refractive index μ is placed in one of the paths of the interfering beams.
2. The corresponding path travelled by the beam increases because of the glass plate.
3. The path difference between beams is $2(\mu - 1)t$, as the beam passes twice through the glass plate.
4. Because of the introduction of glass plate, let m fringes are displaced from the field of view. Hence $2(\mu - 1)t = m\lambda$
5. If white light is used then the location of central fringe becomes easy.
6. In the absence of the glass plate, the position of central fringe is measured by coinciding the crosswire with the central fringe.
7. By introducing glass plate, the fringe pattern gets shifted.
8. Now by moving the screw of the micrometer, again the central fringe is made to coincide with the cross-wire. The corresponding distance 'x' is measured.
9. Now the white light is replaced by monochromatic source of light whose wavelength is λ.
10. Move the mirror M_1 by a distance 'x' and the number of fringes crossed 'm' is counted.
11. The thickness of given glass plate can be calculated by using the formula $t = \frac{m\lambda}{2(\mu - 1)}$