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F-24

EXPERIMENT : No. 8

- Aim: To determine the wavelength of the given source by setting up & observing Newton's Rings.

- Apparatus- Travelling microscope, plano convex lens, glass plates, sodium light source etc.

- Theory -

Thin film interference : A film is said to be thin when its thickness is about the order of one wavelength of visible light, which is taken to be 550 nm, when light is incident on such a film, a small portions gets reflected from the upper surface & a major portion is transmitted into the film. Again a small part of the transmitted component is reflected back it emerges out of the film. These reflected beams reunitese to produce interference. Also the transmitted beams too interfere. This type of interference that takes place in this films is called interference by division of amplitude.

~~F~~ In the fig. the rays r_{12} & t_{21} interfere & results in a constructive or destructive interference depending on their path differences, given as,

CONSTRUCTIVE - $(2m+1)\frac{\lambda}{2} = 2\mu_2 d\cos r_{12}$

$m\lambda = 2\mu_2 d\cos r_{12}$

EXPERIMENT : No.

where μ_2 - refractive index of the medium 2 &
$m = 0, 1, 2, 3 \ldots \rightarrow$ Order of Interference

The transmitted light from t_{23} can also interfere & result in constructive or destructive interference.

Thin film interference with films of varying thickness (Newton's Rings):

Rings are fringes of equal thickness. They are observed when light is reflected from a plano convex lens by a focal length placed in contact with a plane glass plates. A thin air film is formed between the plate & the lens. The thickness of the air film varies from zero at the point of contact to som value t. If the lens plate system is illuminated with monochromatic light falling on it normally, concentric bright & dark interference rings are observed in reflected light. These circular fringes ~~a~~ were discovered by Newton & are called Newton's Rings.

From fig 2., a ray AB incident normally on the system gets partially reflected at the bottom curved surface to the lens (Ray 1) & part of the transmitted ray is partially reflected (ray 2) from the top surface of the plane glass plate. The rays 1 & 2 are derived from the same incident ray by division of amplitude & therefore are coherent. Ray 2 undergoes a phase change of p upon reflection, since it is reflected from air-to-glass boundary.

The conditions for constructive & destructive interferences are given as –
for ⊥ incidence $\cos r = 1$ & for air film $\mu = 1$

$2t = (2m+1)\frac{\lambda}{2}$ constructive Interference.

$2t = m\lambda$ destructive Interference.

Wavelength of monochromatic light can be determined as,

$$\lambda = \frac{D^2_{m+p} - D^2_m}{4pR}$$

where D_{m+p} is diameter of $(m+p)^{th}$ dark ring
D_m is diameter of m^{th} dark ring.

- Procedure :

REAL LAB

1. After experiment arrangement, the glass plate is inclined at an angle 45° to the horizontal. This glass plate reflects light from the source vertically downwards & falls normally on the convex lens.

2. Newton's rings are seen using a long focus microscope, focused on the air film.
3. The cross wire of the microscope is made tangential to the 20th ring to the left side of the center.
4. The readings of the main scale & vernier scale of the microscope are noted.
5. The cross wire is adjusted to ~~the~~ be tangential to the 18th, 16th, 14th, etc on the left and 2nd, 4th, 6th, etc on the right & readings are taken each time.
6. From this the diameter of the ring is found out which is the difference between the readings on the left and right sides. The square of the diameter & hence ~~D_n^2~~ D_n^2 & D_{m+n}^2 are found out. Then wavelength is calculated using eqn.

SIMULATION

1. The simulation virtualises the Newton's rings experiment. The user can view the effect of Newton's rings formed when the medium changes.
2. Select any one type of medium. Different ring pattern can be seen by changing the radius of curvature of the lens & wavelength of light source.

3. Click on the "light ON" button.
4. Select the lens of desirable radius.
5. Adjust the microscope position to view the Newton rings.
6. Focus the microscope to view the rings clearly.
7. Fix the cross wire on 20th ring either from right or left of the center dark ring & take the readings.
8. Move the crosswire & take the reading of 18th, 16th ... 2nd ring.
9. You have to take the reading of rings on either side of the center dark ring.
10. Enter the readings in the tabular form.
11. Calculate the wavelength of the source by using the given formula.

- Result:

Wavelength of light from the given source is found to be :

For AIR - 546nm

For WATER - 383.5nm

For ACETONE - 399 nm

Order of Ring	Microscopic (cm) Reading LEFT	Microscopic (cm) Reading RIGHT	Diameter D (cm)	D^2 (cm^2)	$D^2_{m+p} - D^2_m$ (cm^2)
MEDIUM - AIR	SOURCE - GREEN LIGHT				
1	2.365	2.475	0.110	0.0121	0.0135
2	2.34	2.51	0.16	0.0256	0.0144
3	2.318	2.518	0.2	0.04	0.01262
4	2.305	2.53	0.225	0.0506	0.0119
5	2.30	2.55	0.25	0.0625	
MEDIUM - WATER	SOURCE - GREEN LIGHT				
1	2.409	2.506	0.097	0.009409	0.010472
2	2.385	2.526	0.141	0.019881	0.009019
3	2.372	2.542	0.17	0.0289	0.009125
4	2.357	2.552	0.195	0.038025	0.008200
5	2.350	2.565	0.215	0.46225	
MEDIUM - ACETONE	SOURCE - GREEN LIGHT				
1	2.410	2.506	0.096	0.0092	0.0101
2	2.388	2.527	0.139	0.0193	0.0096
3	2.372	2.542	0.170	0.0289	0.00796
4	2.358	2.550	0.192	0.03686	0.01066
5	2.349	2.567	0.218	0.047524	

↑

OBSERVATION TABLE

Calculations :

1 MSD = 0.05 cm

No. of VSD = 50

$LC = \frac{0.05}{50} = 0.001\ cm$

Medium	Source	Mean of $D^2_{m+p} - D^2_p$	$\lambda = \frac{D^2_{m+p} - D^2_p}{4pR}$
AIR	GREEN	$\frac{0.0135 + 0.0144 + 0.01262 + 0.0119}{4}$ $= 0.013105\ cm^2$	$\frac{0.013105 \times 10^{-4}}{4(1)\,60 \times 10^{-2}}$ $= 383.5\ nm$
WATER	GREEN	$\frac{0.010472 + 0.009019 + 0.009125 + 0.0082}{4}$ $= 0.009204\ cm^2$	$\frac{0.009204 \times 10^{-4}}{4(1)\,60 \times 10^{-2}}$ $= 546\ nm$
ACETONE	GREEN	$\frac{0.0101 + 0.0096 + 0.00796 + 0.01066}{4}$ $= 0.00958\ cm^2$	$\frac{0.00958 \times 10^{-4}}{4(1)\,60 \times 10^{-2}}$ $= 399\ nm$