Date : 19-06-2021

Expt. No : 3 Page No :

3. SLIT WIDTH

AIM:

To determine the slit width of single slit and blade using He-Ne Laser and travelling Microscope.

APPARATUS:

1. Meter bench
2. He-Ne Laser
3. Travelling Microscope
4. Slits - single slit, blade
5. Board or Vertical paper holder
6. Graph paper.

THEORY:

In our day-to-day life we are coming across five types of light phenomenons. They are

1. Reflection
2. Refraction
3. Interference
4. Scattering
5. Diffraction

1. Bouncing back of the wave from a smooth polished surface is known as "Reflection".
2. Bending of light when the light is moving from one medium to another medium is known as "Refraction".
3. When two or more waves passing on a medium they

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Superimpose each other and gives differ in their amplitudes (either Maxima or minima). This phenomena is known as "interference".

4. The deviation of light from straight path on striking an obstacle is known as "Scattering"

5. Deviation of the light from its straight path by passing close to edges of opaque obstacles and narrow slits is known as "Diffraction".

In this diffraction phenomena, the obstacle or aperture need to be smooth so that proper diffraction will takes place. Diffraction of light is classified into two types.

1. Frensel Diffraction
2. Fraunhoffer Diffraction

Frensel Diffraction : In this case, the source of light or screen or both are at a finite distance from obstacle and the incident light / wavefront is either spherical or cylindrical.

Fraunhoffer Diffraction : In this case, the source of light and the screen are effectively at infinite distance from the obstacle (or aperture) causing diffraction and the incident wavefront is always a plane wavefront.

Now we are doing Fraunhoffer diffraction,

The light is coming from infinite distance, fall on aperture and undergoes diffraction. The diffraction pattern

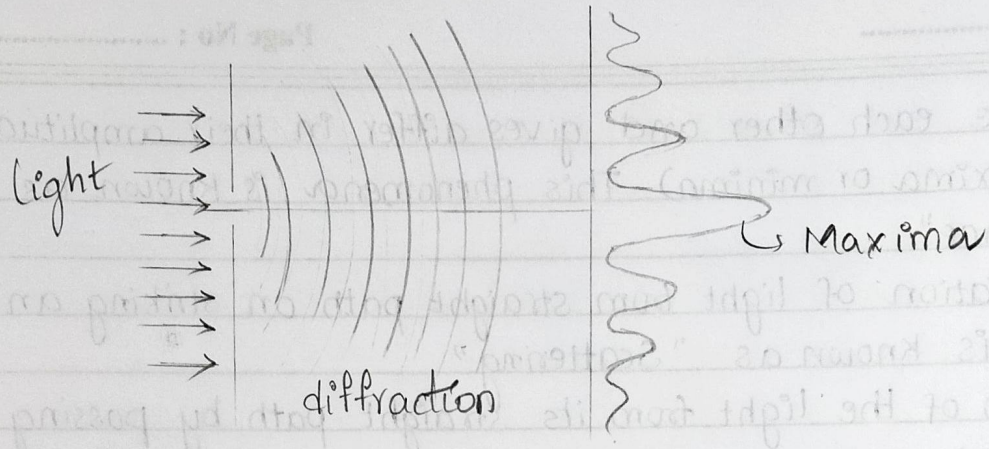

Fig 1. Diffraction pattern

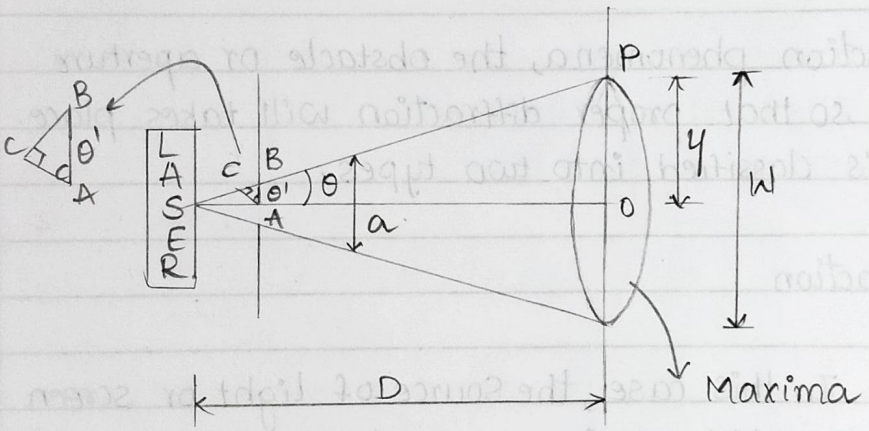

Fig 2. Mathematical Model of Diffraction pattern

is copied on the screen. In the diffraction pattern there will be a central maxima and then minima, maxima ---- as shown in Fig-1.

Mathematical model of this diffraction pattern is shown in Fig-2.

Consider, ΔABC, ΔSOP

In ΔBC, $\angle BCA = 90^\circ$

$\angle BAC = \theta'$

In ΔSOP, $\angle SOP = 90^\circ$

$\angle PSO = \theta$

From the ΔABC, $\sin\theta' = \theta = \frac{BC}{AB}$

$$BC = AB\sin\theta$$

$$BC = \frac{a}{2}\sin\theta$$

phase difference $(\phi) = \frac{2\pi}{\lambda}$ path difference (BC)

$$\phi = \frac{2\pi}{\lambda} BC$$

$$\phi = \frac{2\pi}{\lambda} \frac{a}{2} \sin\theta$$

$$\phi = \frac{\pi a}{\lambda} \sin\theta$$

Here BC is the path difference between the direct ray and the diffracted ray.

First Minima will form at π,

$$\pi = \frac{\pi a}{\lambda} \sin\theta$$

$$\frac{\lambda}{a} = \sin\theta \simeq \theta$$

Teacher's Signature : _____

Date : .....

Expt. No : .....

Page No : .....

$\lambda/a = \theta$

From ΔSOP, $\tan\theta = \frac{y}{D} \Rightarrow \theta = \frac{y}{D}$

$$\frac{\lambda}{a} = \frac{y}{D}$$

$$a = \frac{\lambda D}{y}$$

We know that, $W = 2y \Rightarrow y = \frac{W}{2}$

$$a = \frac{\lambda D}{y} = \frac{\lambda D}{(W/2)} = \frac{2\lambda D}{W}$$

$$\therefore a = \frac{2\lambda D}{W}$$

where, a is the width of the slit

λ is the wavelength (6328 A°) of He-Ne laser

W is the width of central maxima

D is the distance between screen and aperture.

PROCEDURE :

1. Arrange the slit, screen and source in such a way that laser focussing on the slit and the phenomenon can observe on the screen.
2. Lens of focal length is to be placed between the slit and the screen
3. Place a graph paper on the screen such that we can copy

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OBSERVATION:

Using laser for slit,

S.R	W (mm)	D (cm)	a (mm)
1	6	40	0.084
2	9	60	0.084
3	13.5	90	0.084

Using laser for Blade,

S.r	W(mm)	D(cm)	a(mm)
1	7	80	0.145
2	9	100	0.141
3	6	70	0.148

Using T.M for slit,

S.R no.	MSR(cm)	VSR	TR (mm)	2-1
1	7.2	13	7.213X10	0.09 mm
2	7.2	22	72.22	

Using T.M for Blade,

SR no	MSR(cm)	VSR	T.R (mm)	2-1
1	6.8	2	6.802X10	0.09 mm
2	6.8	11	68.11	

Calculations:

Using laser for slit,

$$a_1 = \frac{2\lambda D}{w} = \frac{2 \times 6328 \times 10^{-10} \times 40 \times 10^{-2}}{6 \times 10^{-3}}$$

$$= 0.084 \times 10^{-3} m$$

$$= 0.084 mm$$

$$a_2 = \frac{2\lambda D}{w} = \frac{2 \times 6328 \times 10^{-10} \times 60 \times 10^{-2}}{90 \times 10^{-3}} = 0.084 \times 10^{-3} m$$

$$= 0.084 mm$$

$$a_3 = \frac{2 \times 6328 \times 10^{-10} \times 90 \times 10^{-2}}{13.5 \times 10^{-3}} = 0.084 \times 10^{-3} m$$

$$= 0.084 mm$$

Using laser for blade,

$$a_1 = \frac{2 \times 6328 \times 10^{-10} \times 80 \times 10^{-2}}{7 \times 10^{-3}} = 0.1145 \times 10^{-3} m$$

$$= 0.145 mm$$

$$a_2 = \frac{2 \times 6328 \times 10^{-10} \times 100 \times 10^{-2}}{9 \times 10^{-3}} = 0.1461 \times 10^{-3}$$

$$= 0.141 mm$$

$$a_3 = \frac{2 \times 6328 \times 10^{-10} \times 70 \times 10^{-2}}{6 \times 10^{-3}} = 0.148 \times 10^{-3} m$$

$$= 0.148 mm$$

$$a_{avg} = \frac{0.145 + 0.148 + 0.141}{3} = 0.145 mm$$

Using TM for blade,

$$TR_1 = 6.8 + 2 \times 0.001$$

$$= 6.802 cm$$

$$= 68.02 mm$$

$$TR_2 = 6.8 + 11 \times 0.001$$

$$= 6.811 cm = 68.11 mm$$

$TR_2 - TR_1 = 0.09mm$

Using TM for slit,

$TR_1 = 7.2 + 13 \times 0.001$

$= 7.213\ cm$

$= 72.13\ mm$

$TR_2 = 7.2 + 22 \times 0.001$

$= 7.222\ cm$

$= 72.22\ mm$

$TR_2 - TR_1 = 0.09\ mm$

Slit width of single slit $= \frac{0.084 + 0.09}{2} = 0.087\ mm$

Slit width of blade $= \frac{0.145 + 0.09}{2} = 0.1175\ mm$

the diffraction patterns (dark and bright fringes).

4. Note down the readings by changing the value of D (i.e distance between screen and the aperture).
5. Now repeat the experiment by considering travelling microscope. Place the microscope in such a way that it focusses the slit.
6. Note the readings within the table.
7. Repeat the whole process for the blade instead of single slit and note the readings in a table.

RESULT:

Slit width of single slit by using Laser = 0.084 mm

Slit width of single slit by using T.M = 0.09 mm

Slit width of blade using Laser = 0.145 mm

Slit width of blade using T.M = 0.09 mm

CONCLUSION:

Final slit width of single slit = 0.087 mm

Final slit width of blade = 0.1175 mm

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