Name : Prathapani Satwika

Reg : 20BCD7160

Title of the experiment:

Verification of Heisenberg's Uncertainty Principle

Objective :

1. To observe the diffraction pattern due to single slits and to calculate the slit widths.

2. To calculate the uncertainty in momentum from the patterns of different slits and to confirm uncertainty principle.

Equipment list :

1. Optical Rail
2. Diode laser
3. kinematic laser Mount
4. Power supply for laser
5. cell mount with Diffraction cell
6. Pinhole detector
7. output measurement unit

8. Linear translation stage

9. slit box

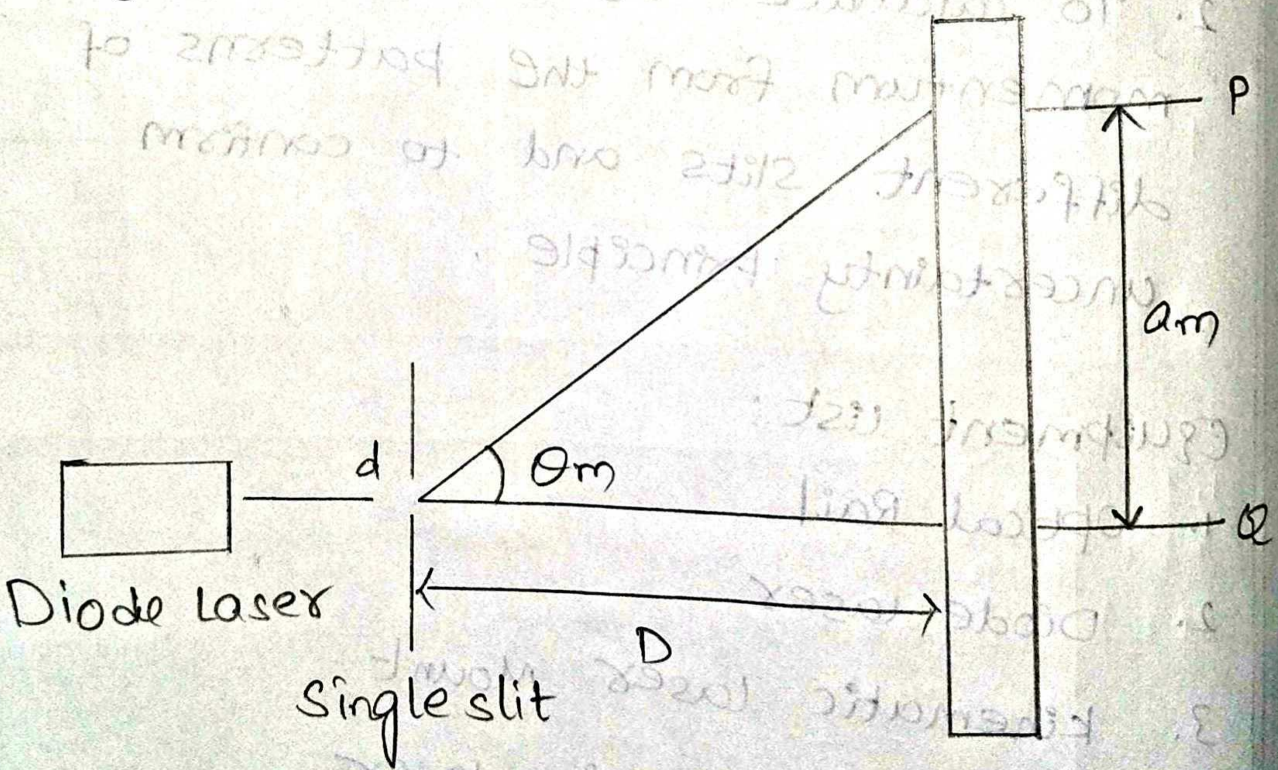
The condition for destructive interference or for minima is

$$d \sin\theta_m = n\lambda$$

the slit width as

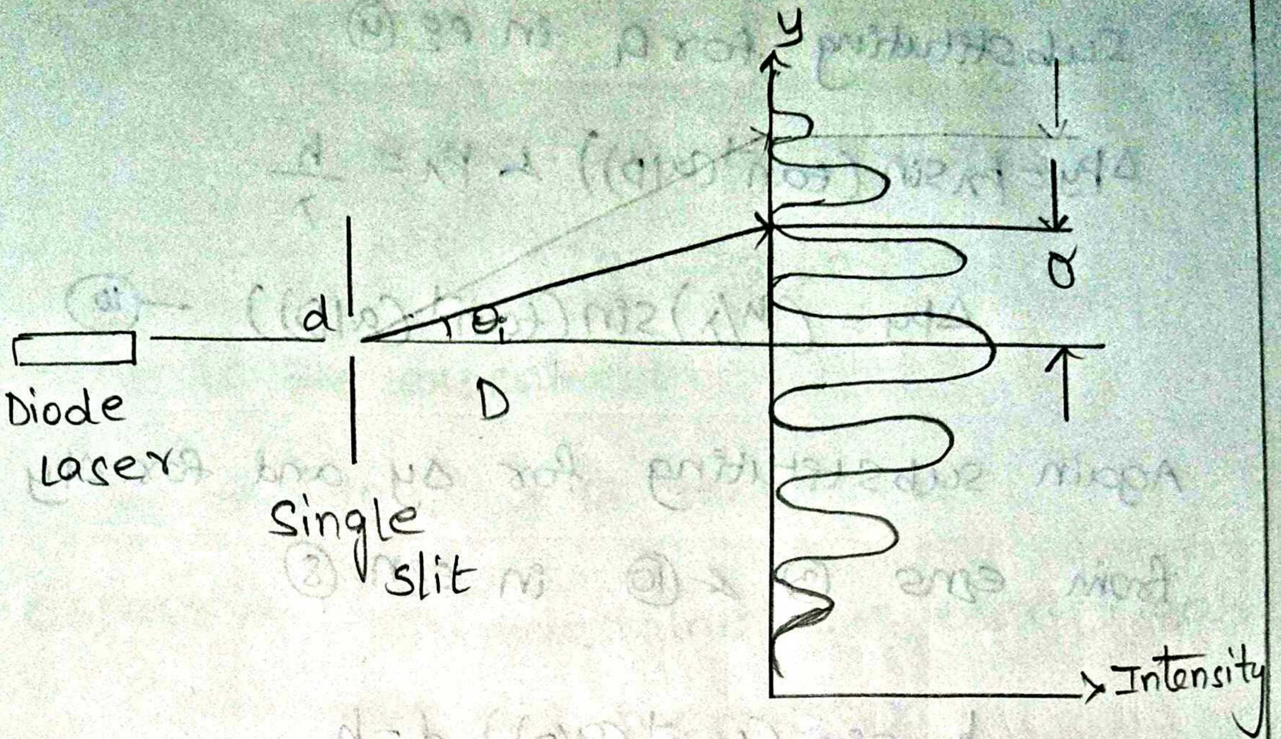
$$d = \frac{n\lambda}{\sin\theta_m} \quad —①$$

Single slit Diffraction:



The uncertainty principle:

$$\Delta x \cdot \Delta p_x = \frac{h}{4\pi} \quad —②$$



i.e $\Delta y = d$ —③

$$\Delta p_y = p_x \sin\theta_m \quad —④$$

$$\sin\theta_1 = \frac{\lambda}{d} \quad —⑤$$

compare ③ & ⑤

$$d = \frac{\lambda}{\sin\theta_1} = \Delta y$$

$$\therefore \Delta p_y \cdot \Delta y = p_x \sin\theta_1 \cdot \frac{\lambda}{\sin\theta_1} = p_x \lambda \quad —⑥$$

$$\lambda = \frac{h}{p_x} \quad —⑦$$

$$\Delta p_y \cdot \Delta y = h \quad —⑧$$

$$\tan\theta_1 = \frac{a}{D}$$

$$\theta_1 = \tan^{-1}(a/D) \quad —⑨$$

Substituting for θ_1 in eq 4

$\Delta p_y = p_x \sin(\tan^{-1}(a/D))$ & $p_x = \frac{h}{\lambda}$

$$\Delta p_y = (h/\lambda)\sin(\tan^{-1}(a/D)) \quad \text{--- } 10$$

Again substituting for Δy and for Δp_y from eqns 3 & 10 in eqn 8

$$\frac{h}{\lambda}\sin(\tan^{-1}(a/D)).d = h$$

$$\frac{d}{\lambda}\sin(\tan^{-1}(a/D)) = 1 \quad \text{--- } 11$$

Table:-

S.No	Micrometer reading (mm)	output current (μA)
1	0	0.3
2	1	0.3
3	2	0.4
4	3	0.6
5	4	0.6
6	5	0.3
7	6	0.2
8	7	0.7
9	8	1.6
10	9	2.2
11	10	1.5
12	11	0.6
13	12	1.8
14	13	15.7
15	14	55
16	15	109.5
17	16	157.4
18	17	135.2
19	18	95
20	19	43.8
21	20	10.4

S.NO	Micrometer reading (mm)	output current (μA)
1	0	0.2
2	1	0.3
3	2	0.3
4	3	0.3
5	4	0.4
6	5	0.3
7	6	0.2
8	7	0.3
9	8	0.7
10	9	0.7
11	10	0.6
12	11	0.9
13	12	6.7
14	13	36.4
15	14	89.5
16	15	105.9
17	16	52.4
18	17	2
19	18	13
20	19	19.5
21	20	2.3

wave length $\lambda = 650nm$

order m	Distance between the detector and screen, D (mm)	Distance between central maximum & m^{th} order minimum, a (mm)	$\theta_m = \tan^{-1}\left(\frac{a}{D}\right)$	$\sin\theta_m$	$d = m\lambda / \sin\theta_m$ (micron)
1	800	16 − 11 = 5	0.3580	6.24×10^{-3}	104.9
1	800	15 − 10 = 5	0.3580	6.24×10^{-3}	104.9
1	800	14 − 11 = 3	0.2148	3.74×10^{-3}	173.3

Verifying Uncertainity principle :-

Slit width (μm)	Distance between detector & slit, D (mm)	Distance between central maxima & 1st order minima a (mm)	$\theta_1 = \tan^{-1}\left(\frac{a}{D}\right)$	$\Delta P_y = \frac{h}{\lambda}\left(\sin\left[\tan^{-1}\frac{a}{D}\right]\right)$	$\frac{d}{\lambda}\sin\left(\tan^{-1}\left(\frac{a}{D}\right)\right)$
104.9	800	5	0.3580	6.36×10^{-30}	1.007
104.9	800	5	0.3580	6.36×10^{-30}	1.007
173.3	800	3	0.2148	3.81×10^{-30}	0.997

Mean slit width, d = 127.7 mm

Results:-

1. Diffraction pattern due to different single slit have been observed and calculated their slit widths.
2. Momentum distribution of photons had been observed and found that as the slit width decreases momentum distribution increases and vice versa and this uncertainty in momentum verifies Heisenberg's uncertainity Principle.