PHYF214 PHYSICS LAB REPORT SEM1 2018-2019
Lab 3 Group 7: Diffraction at Single and Double Slits [DSDS]

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1 Experimental Tasks

1. To measure the intensity distribution due to diffraction at single and double slits and use it to measure the slit width (d), and slit separation (a).

2 Apparatus

Optical bench, He-Ne Laser, single slit, double slit, photocell, micro-ammeter.

3 Theory

Light from a He-Ne Laser source when diffracted by single and double slits, form distinctive fringes on the screen. The resulting intensity variation is measured by a photocell whose output is read off as a current measurement.
The resulting intensity in the case of single slit can be shown to be :

$$I = I_0 \frac{(sin^2 \beta)}{\beta^2} \tag{1}$$

Similarly the resulting intensity in the case of the double slit is:

$$I = 4I_0 \frac{sin^2 \beta}{\beta^2} cos^2 \gamma \tag{2}$$

which can be thought of as the mix of the patter produced by a single slit of width a (first term) and the interference pattern produced by two point sources separated by a distance d (the second term $cos^2 \gamma$).
The slit width (d), and slit separation (a) can be calculated using the equations:

$$\boxed{a = \lambda \frac{\sqrt{x^2 + D^2}}{x}} \tag{3}$$

$$\boxed{d = \lambda \frac{\sqrt{\frac{y^2}{4} + D^2}}{y}} \tag{4}$$

4 Observations and Analysis

4.1 Part 1: With Single slit

Table1: Showing data for the diffraction in single slit.

Position of the photo-detector (in mm)	Intensity (in V)
0	0.024
0.2	0.028
0.4	0.03
0.6	0.028
0.8	0.029
1	0.026
1.2	0.029
1.4	0.024
1.6	0.027
1.8	0.034
2	0.039
2.2	0.038
2.4	0.038
2.6	0.042
2.8	0.054
3	0.065
3.2	0.058
3.4	0.06
3.6	0.07
3.8	0.082
4	0.083
4.2	0.078
4.4	0.081
4.6	0.089
4.8	0.085
5	0.083
5.2	0.088
5.4	0.082
5.6	0.078
5.8	0.07
6	0.069
6.2	0.066

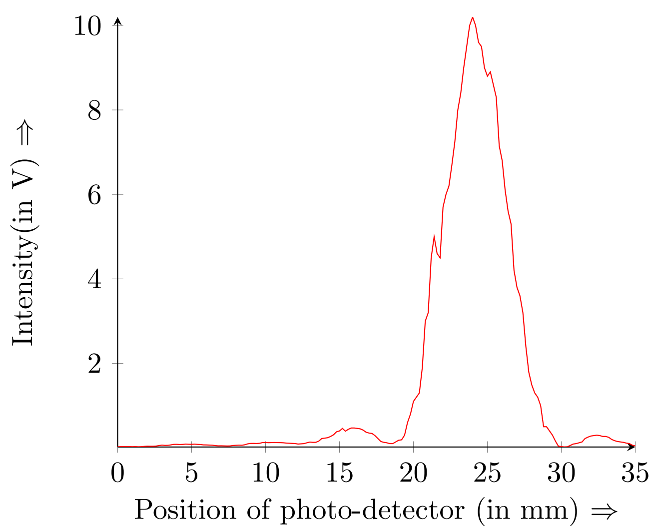
6.4	0.063
6.6	0.053
6.8	0.047
7	0.048
7.2	0.046
7.4	0.044
7.6	0.045
7.8	0.055
8	0.06
8.2	0.064
8.4	0.062
8.6	0.073
8.8	0.095
9	0.104
9.2	0.105
9.4	0.102
9.6	0.108
9.8	0.125
10	0.126
10.2	0.122
10.4	0.124
10.6	0.126
10.8	0.124
11	0.123
11.2	0.12
11.4	0.113
11.6	0.109
11.8	0.105
12	0.101
12.2	0.09
12.4	0.095
12.6	0.1
12.8	0.12
13	0.137
13.2	0.13
13.4	0.131
13.6	0.16
13.8	0.22
14	0.23
14.2	0.24
14.4	0.27
14.6	0.31

14.8	0.38
15	0.4
15.2	0.46
15.4	0.394
15.6	0.44
15.8	0.47
16	0.47
16.2	0.46
16.4	0.45
16.6	0.42
16.8	0.37
17	0.35
17.2	0.34
17.4	0.29
17.6	0.22
17.8	0.15
18	0.13
18.2	0.12
18.4	0.1
18.6	0.1
18.8	0.14
19	0.18
19.2	0.19
19.4	0.3
19.6	0.6
19.8	0.8
20	1.1
20.2	1.2
20.4	1.3
20.6	1.9
20.8	3
21	3.2
21.2	4.5
21.4	5
21.6	4.6
21.8	4.5
22	5.7
22.2	6
22.4	6.2
22.6	6.7
22.8	7.25
23	8

23.2	8.4
23.4	9
23.6	9.5
23.8	10
24	10.2
24.2	10
24.4	9.6
24.6	9.5
24.8	9
25	8.8
25.2	8.9
25.4	8.6
25.6	8.3
25.8	7.15
26	6.8
26.2	6.1
26.4	5.6
26.6	5.3
26.8	4.2
27	3.8
27.2	3.6
27.4	3.2
27.6	2.4
27.8	1.79
28	1.49
28.2	1.3
28.4	1.2
28.6	1
28.8	0.5
29	0.5
29.2	0.4
29.4	0.3
29.6	0.16
29.8	0.04
30	0.03
30.2	0.02
30.4	0.025
30.6	0.056
30.8	0.09
31	0.1
31.2	0.12
31.4	0.14

31.6	0.22
31.8	0.254
32	0.28
32.2	0.29
32.4	0.3
32.6	0.29
32.8	0.27
33	0.27
33.2	0.25
33.4	0.2
33.6	0.17
33.8	0.15
34	0.14
34.2	0.13
34.4	0.112
34.6	0.101
34.8	0.063
35	0.045

Figure 1: Single slit diffraction



Analysis:

Width of central maximum $(x) = 30.2 - 18.6 = 11.6mm$
Distance of screen from slit $(D) = 126.857.6cm = 69.2cm$
Wavelength of light $(\lambda) = 632.8nm$
Width of slit (a) is given by $a = \lambda\frac{\sqrt{x^2+D^2}}{x} = 3.77e-5 = 0.037mm$

The expected error can be calculated as follows:
Least count of multimeter = 0.01 V.
Least count of translation stage (photodetector) = 0.02 mm
Least count of workbench = 0.01 m
For single slit diffraction,
Error in measuring slit width= ± 1 x $10^{-3} mm$
Thus $a = (3.7 \pm 0.1)$x$10^{-2} mm$

4.2 Part 2: With double slit

Table2: Showing data for the diffraction in double slit.

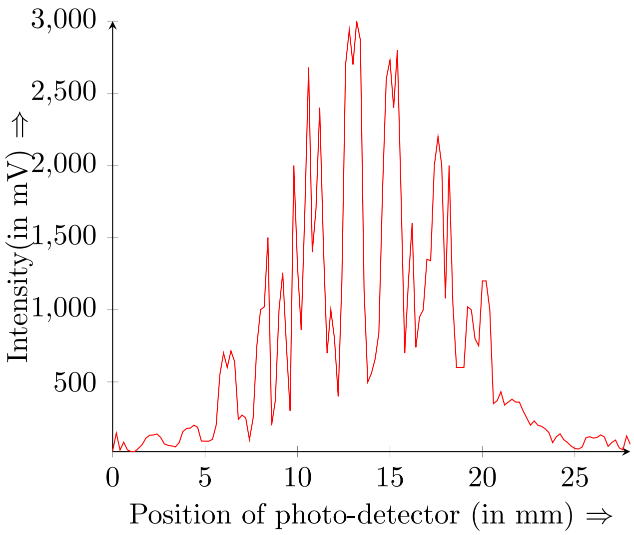
Position of the photo-detector (in mm)	Intensity (in mV)
0	21
0.2	146
0.4	28
0.6	82
0.8	29
1	17
1.2	17.6
1.4	40
1.6	66
1.8	110
2	130
2.2	132
2.4	139
2.6	115
2.8	70
3	60
3.2	56
3.4	50
3.6	80
3.8	156
4	177
4.2	180
4.4	200
4.6	185
4.8	90
5	89
5.2	89
5.4	102
5.6	200
5.8	550

6	700
6.2	600
6.4	715
6.6	640
6.8	240
7	270
7.2	250
7.4	100
7.6	250
7.8	750
8	1000
8.2	1020
8.4	1500
8.6	200
8.8	370
9	1000
9.2	1256
9.4	750
9.6	300
9.8	2000
10	1300
10.2	860
10.4	1700
10.6	2680
10.8	1400
11	1700
11.2	2400
11.4	1450
11.6	700
11.8	1000
12	800
12.2	400
12.4	1200
12.6	2700
12.8	2940
13	2700
13.2	3000
13.4	2870
13.6	1140
13.8	500
14	560
14.2	660

14.4	840
14.6	1830
14.8	2600
15	2730
15.2	2400
15.4	2800
15.6	1800
15.8	700
16	1200
16.2	1600
16.4	740
16.6	950
16.8	1000
17	1350
17.2	1340
17.4	2000
17.6	2200
17.8	2000
18	1080
18.2	2000
18.4	1050
18.6	600
18.8	600
19	600
19.2	1020
19.4	1000
19.6	800
19.8	750
20	1200
20.2	1200
20.4	1000
20.6	350
20.8	370
21	432
21.2	340
21.4	360
21.6	380
21.8	360
22	360
22.2	300
22.4	250
22.6	200

22.8	230
23	200
23.2	192
23.4	175
23.6	148
23.8	79
24	120
24.2	140
24.4	100
24.6	80
24.8	55
25	39
25.2	35
25.4	49
25.6	113
25.8	120
26	111
26.2	115
26.4	133
26.6	118
26.8	53
27	80
27.2	97
27.4	43
27.6	29
27.8	125
28	68

Figure 2: Double slit diffraction



Analysis:

Width of central envolope $(x) = 25 - 5 = 20mm$
Fringe width of maximum $(y) = 13.8 - 15.8 = 2mm$ Distance of screen from slit $(D) = 126.857.6cm = 69.2cm$
Wavelength of light $(\lambda) = 632.8nm$
Width of slit (a) is given by $a = \lambda \frac{\sqrt{x^2+D^2}}{x} = 2.19e-5 = 0.022mm$
Slit separation (d) is given by $d = \lambda \frac{\sqrt{\frac{y^2}{4}+D^2}}{y} = 0.219mm$

The expected error can be calculated as follows:
Least count of multimeter = 0.01 V.
Least count of translation stage (photodetector) = 0.02 mm
Least count of workbench = 0.01 m
For single slit diffraction,
Error in measuring slit width= ± 5 x $10^{-4}mm$
Thus $a = (2 \pm 0.05)$x$10^{-2}mm$ Error in measuring slit separation = ± 3 x $10^{-3}mm$
Thus $y = (2.2 \pm 0.03)$x$10^{-1}mm$

5 Precautions

- Ensure that eye-level is always higher than the laser beam.
- Ensure that beam is propagating parallel to the base plane.
- Never look into the laser beam directly or even reflected from an optical surface.

- The measurements should be made moving the micrometer screw in the same direction.
- The photocell should be as away from the slit as possible.

6 Conclusions and Results

- The slit width and the separation between the slits (for double slit diffraction) have been calculated and reported with the corresponding errors.
- For the single slit experiment it is found that slit width $a = (3.7 \pm 0.1)$x$10^{-2}mm$.
- For the double slit experiment it is found that slit width $a = (2 \pm 0.05)$x$10^{-2}mm$ and slit separation $y = (2.2 \pm 0.03)$x$10^{-1}mm$.