(PHY F214) Experiment Report (Sem-1, 2017-2018)
Exp No: 9 Exp Name: Diffraction at Single and Double Slits

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ID No: 2017B5PS0310G
Date of performing experiment: 16th August 2018
Date of submission: 21th August 2018

Aim: 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).

Theory: When monochromatic light is incident on a slit, each point on the slit starts acting as a secondary source of light (in accordance with Huygen's wave theory). The light from each source interacts with the light from other sources, resulting in the formation of an diffraction pattern, which can be observed on a screen. From an analysis of the diffraction pattern using a photodetector, the width of the slit can be calculated by using the relation:

$$a = \lambda\sqrt{(x^2 + D^2)}/x$$

where 'λ' is the wavelength of light used, 'x' is the width of the central maximum in the diffraction pattern, 'D' denotes the distance between the slit and the screen/photodetector, and 'a' gives the slit width to be calculated.

In case of the double slit experiment, light from the two slits interacts and forms an interference pattern, which in turn has an envelope corresponding to a diffraction pattern. The slit width for the two slits is calculated using the above formula. The separation between the two slits can be calculated using the relation:

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

where 'y' denotes the width of the central maximum in the interference pattern.

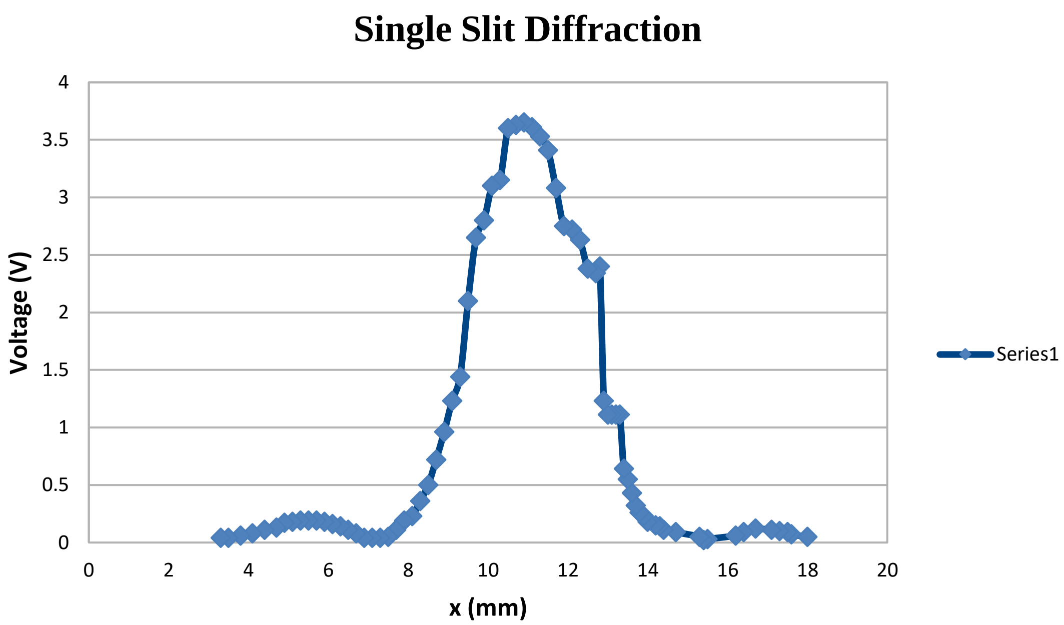
Observation table and graphs:

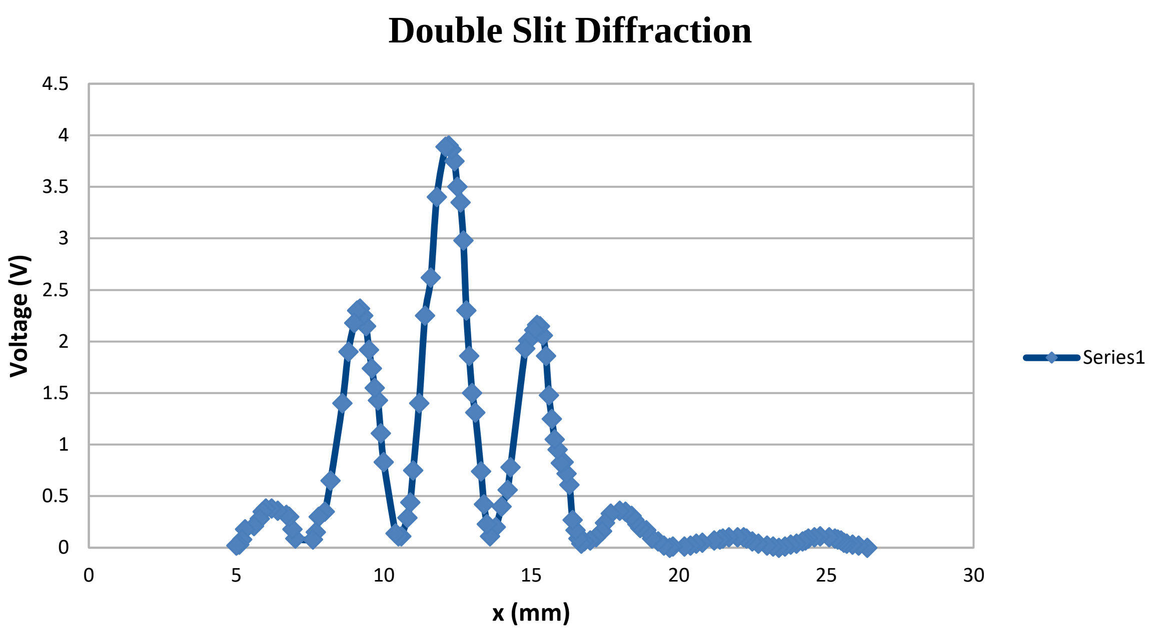
Single Slit(D = 126.8-57.6 cm)		Double Slit(D = 126.8-57.6 cm)	
x (mm)	Voltage (V)	x (mm)	Voltage (V)
18	0.05	26.4	0
17.6	0.07	26.1	0.02
17.5	0.09	25.9	0.03
17.3	0.1	25.7	0.04
17.1	0.11	25.6	0.05
16.7	0.12	25.5	0.07
16.4	0.09	25.4	0.08
16.2	0.06	25.3	0.09

15.5	0.03	25.1	0.1
15.4	0.02	24.8	0.11
15.3	0.05	24.6	0.1
14.7	0.09	24.4	0.09
14.4	0.11	24.3	0.07
14.3	0.14	24.2	0.06
14.2	0.15	24	0.04
14	0.18	23.8	0.03
13.9	0.23	23.6	0.01
13.8	0.26	23.4	0
13.7	0.32	23.2	0.01
13.6	0.43	23	0.02
13.5	0.55	22.7	0.04
13.4	0.64	22.5	0.06
13.3	1.11	22.3	0.09
13.2	1.11	22.2	0.1
13.1	1.11	22	0.1
13	1.11	21.7	0.1
12.9	1.23	21.5	0.09
12.8	2.4	21.4	0.08
12.7	2.34	21.2	0.07
12.5	2.38	20.8	0.05
12.3	2.63	20.6	0.04
12.1	2.72	20.4	0.02
11.9	2.75	20.2	0.01
11.7	3.08	19.8	0.01
11.5	3.41	19.7	0
11.3	3.53	19.5	0.02
11.1	3.61	19.3	0.06
10.9	3.65	19.1	0.09
10.7	3.63	18.9	0.17
10.5	3.6	18.7	0.19
10.3	3.15	18.6	0.23
10.1	3.1	18.5	0.27
9.9	2.8	18.4	0.31
9.7	2.65	18.2	0.35
9.5	2.1	18	0.36
9.3	1.44	17.7	0.33
9.1	1.23	17.5	0.24
8.9	0.96	17.4	0.16
8.7	0.72	17.2	0.1
8.5	0.5	17	0.07
8.3	0.36	16.8	0.06
8.1	0.23	16.7	0.04
7.9	0.19	16.6	0.09
7.7	0.11	16.5	0.17
7.5	0.05	16.4	0.27

7.3	0.04	16.3	0.61
7.1	0.04	16.2	0.72
6.9	0.04	16.1	0.83
6.7	0.08	16	0.82
6.5	0.11	15.9	0.95
6.3	0.14	15.8	1.05
6.1	0.16	15.7	1.25
5.9	0.18	15.6	1.48
5.7	0.19	15.5	1.86
5.5	0.19	15.4	2.06
5.3	0.19	15.3	2.15
5.1	0.18	15.2	2.16
4.9	0.17	15.1	2.11
4.7	0.13	14.9	2.01
4.4	0.11	14.8	1.93
4.1	0.08	14.3	0.78
3.8	0.06	14.2	0.56
3.5	0.04	14	0.4
3.3	0.04	13.8	0.2
		13.6	0.11
		13.5	0.23
		13.4	0.42
		13.3	0.74
		13.1	1.31
		13	1.5
		12.9	1.86
		12.8	2.3
		12.7	2.98
		12.6	3.35
		12.5	3.5
		12.4	3.75
		12.3	3.86
		12.2	3.9
		12.1	3.89
		11.8	3.4
		11.6	2.62
		11.4	2.25
		11.2	1.4
		11	0.75
		10.9	0.44
		10.8	0.29
		10.6	0.11
		10.5	0.11
		10.4	0.14
		10	0.83
		9.9	1.11
		9.8	1.43

9.7	1.55
9.6	1.74
9.5	1.92
9.4	2.15
9.3	2.25
9.2	2.32
9.1	2.3
9	2.18
8.8	1.9
8.6	1.4
8.2	0.65
8	0.35
7.8	0.3
7.7	0.15
7.6	0.08
7	0.09
6.9	0.18
6.8	0.3
6.7	0.32
6.4	0.36
6.2	0.38
6	0.38
5.9	0.35
5.8	0.28
5.6	0.21
5.3	0.18
5.2	0.08
5.1	0.03
5	0.02





Analysis:

Single slit diffraction:

Width of central maximum (x) = 15.4 – 7.1 = 8.3 mm
Distance of screen from slit (D) = 126.8 – 57.6 cm
Wavelength of light (λ) = 632.8 nm
Width of slit (a) is given by

a = $\lambda\sqrt{(x^2 + D^2)}/_x$ = 0.06 mm

Double slit diffraction:

Width of central diffraction envelope (x) = 15 mm
Fringe width of maximum (y) = 13.8 – 10.6 = 3.2 mm
Distance of screen from slit (D) = 126.8 – 57.6 = 69.2 cm
Wavelength of light = 632.8 nm
Width of slit (a) is given by

a = $\lambda\sqrt{(x^2 + D^2)}/_x$ = 0.03 mm

Slit separation (d) is given by

d = $\lambda\sqrt{\frac{y^2}{4} + D^2}/y$ = 0.14 mm

Results with error:

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 = $\pm 1 \times 10^{-3}$ mm
Thus,
$a = (6 \pm 0.1) \times 10^{-2}$ mm

For double slit diffraction,

Error in measuring slit width = $\pm 4.8 \times 10^{-4}$ mm
Error in measuring slit separation = $\pm 2.9 \times 10^{-3}$ mm
So,
$a = (3 \pm 0.05) \times 10^{-2}$ mm
$y = (1.4 \pm 0.03) \times 10^{-1}$ mm

The slit width and the separation between the slits (for double slit diffraction) have been calculated and reported with the corresponding errors.