A04-311E-Y22

Interference and Diffraction of Laser (B)

Purpose：

1. Measure the wavelength of laser light using double-slit interference phenomenon.
2. Measure the width of single-slit using single-slit diffraction.
3. Extend the experiment to observe the diffraction of grating.

Accessory：

No.	Item	Qty	No.	Item	Qty
1	Experiment track	1	2	Fixable slider	2
3	Fixable fine tuning slider	1	4	Semiconductor laser light (With light adjustor, power supply 5DCV)	1
5	Laser holder	1	6	Iron screen with handle	1
7	Screen with handle	1	8	Single and double slit sheet	1
9	Grating sheet	1	10	Illumination sensor (With column , quick release screen)	Optional (1)
11	Light Data logger (With power supply 12DCV、USB cable)	Optional (1)			

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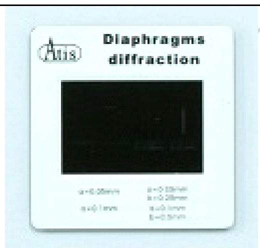

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Theory：

I. Double-slit interference：

In the figure-1, d as the spacing between two slits S_1 and S_2. L as the distance from the slit to the screen. θ as the angle between two straight line $\overline{QP}$ and $\overline{QO}$, perpendicular Bisector between $\overline{QO}$ and $\overline{S_1S_2}$. If $L >> d$, $\overline{S_1P}$ and $\overline{S_2P}$ would almost become parallel.

Therefore the optical path difference δ of lightwave which travels from the two slits to point P is: $\delta = d\sin\theta$

(1)

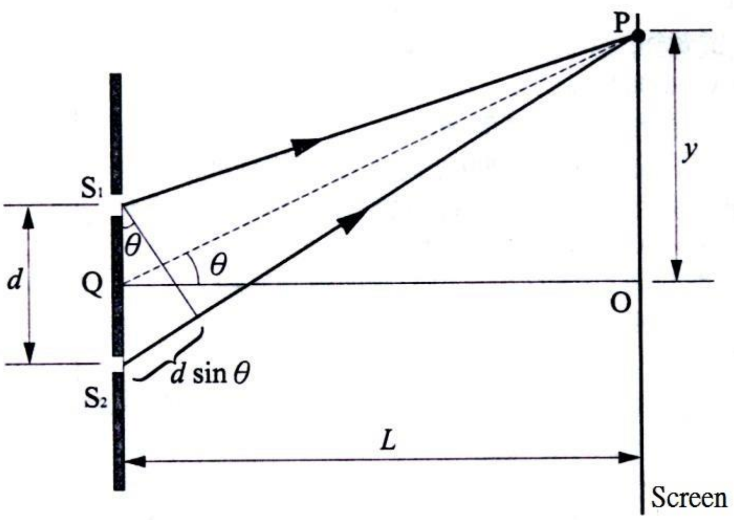

Figure-1 Young's double-slit

The condition to form bright band (complete constructive interference) on the screen is:

$$d\sin\theta = m\lambda \quad (m = 0、\pm1、\pm2、\cdots\cdots) \qquad (2)$$

The condition to form dark band (complete destructive interference) on the screen is:

$$d\sin\theta = (m + \frac{1}{2})\lambda \quad (m = 0、\pm1、\pm2、\cdots\cdots) \qquad (3)$$

Since the distance d between two slits is far greater than the wavelength λ, thus the θ is expected to be small, therefore: $\sin\theta \approx \tan\theta = \frac{y}{L}$, from equation (2) we can rewrite as:

$$y_{\text{Bright}} = m\frac{\lambda L}{d} \qquad (4)$$

from equation (3) we can rewrite as:

$$y_{\text{Dark}} = (m + \frac{1}{2})\frac{\lambda L}{d} \qquad (5)$$

from equation (5) we can get the distance between two connecting dark bands (or bright bands):

$$\Delta y = \frac{\lambda L}{d} \qquad (6)$$

Measure Δy and L from the experiment, with the slits spacing d, use the above equation to get the light wavelength λ.

II. Single-slit diffraction：

If the light sources projected to the single-slit are parallel, once they go through the slit and along any direction to the screen, they are considered parallel to each other. The diffraction in this condition is known as *Fraunhofer diffraction*.

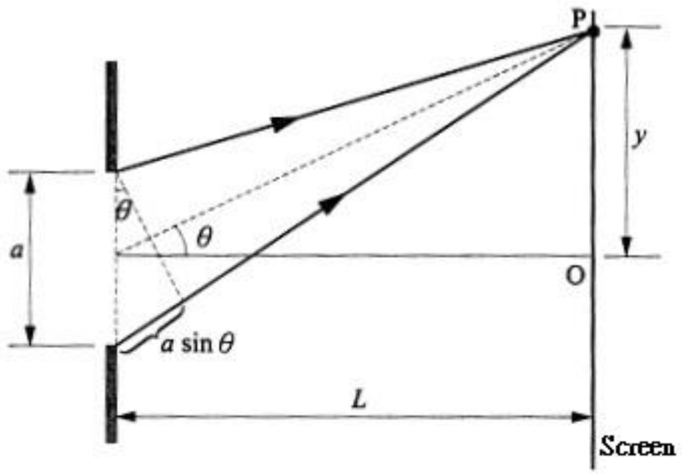

Figure -2 Single-slit diffraction

He-ne laser is being used as the light source in the experiment and its projected light is similar to parallel light ray. When the screen is placed far away from the slit: $L >> a$ (a as the width of the single slit). The light goes through the slit is considered from a series of point sources. If θ is the angle formed in between the light projecting direction and the perpendicular line in the slit, the condition to create dark bands on the screen is called complete destructive interference:

$$a\sin\theta = m\lambda \qquad (m = \pm1、\pm2、\pm3、\cdots\cdots) \qquad (7)$$

Note that the above equation does not include $m = 0$ (if $m = 0$, the optical path difference of each light ray is zero. When encounter on the screen, complete constructive interference is created and the central bright band is formed.) θ is small, therefore $\sin\theta \approx \tan\theta = \frac{y}{L}$.

From equation (7), we can rewrite as:

$$y_{Dark} = m\frac{\lambda L}{a} \qquad (8)$$

From equation 8 we know, the distance of the two dark bands which sit next to the center bright band is:

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