Construct, Conduct & Comprehend Physics Experiments

LEOK-3-12 Studying on Young's Double-Slit Interference

- *Complete set*
- *Cost effective solution*
- *Detailed instructional manual*
- *Easy alignment*

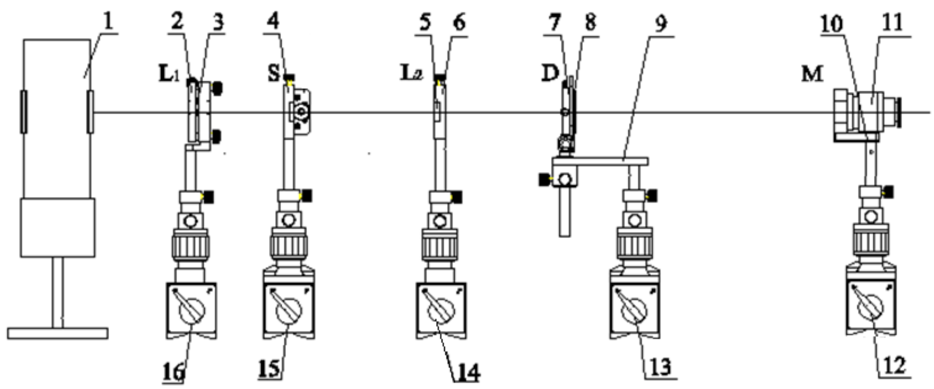

Figure 12-1 Schematic of experiment setup

1: Sodium Lamp (LLE-2, w/small hole)
2: Lens L_1 (f'= 50 mm)
3: Lens Holder (SZ-08)
4: Adjustable Slit S (SZ-27)
5: Lens L_2 (f'= 150 mm)
6: Lens Holder (SZ-08)
7: Biprism Holder (SZ-41)
8: Double-slit Plate D
9: Adapter Piece (SZ-09)
10: DMM Holder (SZ-36)
11: Eyepiece of DMM
12-16: Magnetic Base (SZ-04)

Theory

To get an interference pattern, the two beams leaving from the slits must have same frequency and a definite phase relation. Generally speaking, most light sources cannot satisfy this condition. In 1801, Thomas Young allowed a single, narrow beam of light to fall on two narrow, closely spaced slits. He placed a viewing screen opposite to the slits. When the light from the two slits struck the screen, a regular pattern with alternative dark and bright rings appeared. When first performed, Young's experiment offered an important evidence for the wave nature of light. The schematic of Young's double-slit interference is shown in Figure 12-2.

In this way, the light emitted from S_2 and S_3 has a definite phase relation because the secondary wave sources from the same wave surface S_1 are always coherent. The light path difference (d is the distance between the two slits of the double-slit plate) is:

$$\delta = r_2 - r_1 \approx d\sin\theta \approx d\tan\theta = d\frac{x}{D} \tag{12-1}$$

Where D is the distance between the viewing screen and the slits, x is the vertical distance between the viewing location and the center of the double slits, and θ is a half of the viewing angle between the lines from the viewing point on the screen to the two slits.

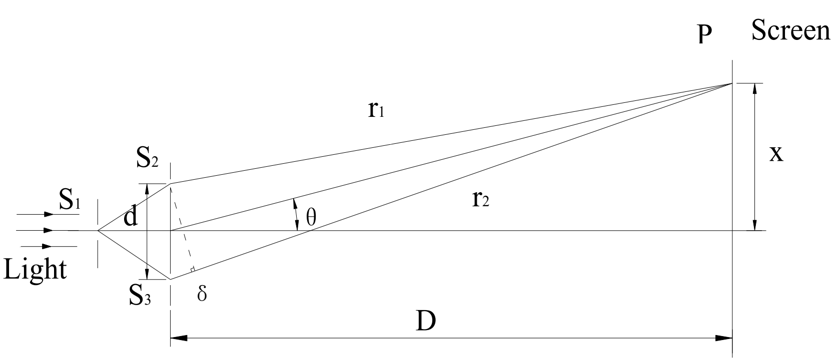

Figure 12-2 Schematic of Young's double-slit experiment

If the path difference between a particular point on the screen to the two slits is equivalent to a half of the wavelength (or multiples thereof) of the light, then complete destructive interference will occur at that point, and thus a dark spot will be observed.

$$\delta = d\frac{x}{D} = \pm(2k+1)\frac{\lambda}{2}$$ (Dark interference fringes) (12-2)

Conversely, if the path difference is equivalent to an integer multiple of the wavelength of the light, then complete constructive interference will occur, and a bright spot will appear on the screen.

$$\delta = d\frac{x}{D} = \pm k\lambda$$ (Bright interference fringes) (12-3)

So the distance between two adjacent dark fringes (or bright fringes) is:

$$\Delta x = \frac{D}{d}\lambda$$ (12-4)

In this formula Δx and D can be measured, so if we know one of d and λ, we can calculate the other. In this experiment, if a laser rather than a Sodium lamp is used as the source, the experiment will be easier to conduct and the interference fringes will be observed more obviously.

Experiment Procedures

1. Refer to Figure 12-1, align all components in same height along a straight line;
2. Focus the small hole of the light source onto the single slit S by lens L_1 (i.e. collect as more as possible light power to the single slit);
3. Remove the double-slit D temporary, adjust S to relatively wide (e.g. 0.5 mm), use lens L_2 to image single slit S onto the scale plane of the eyepiece M (note: the distance between S and M must be larger than 4 times focal length of L_2).
4. Place back the double-slit D and let it close to L_2, look into the eyepiece M, narrow single slit S, finely rotate D to make S parallel to D in vertical direction strictly. Double-slit interference pattern with equal-interval bright/dark pairs will be observed;
5. Further finely adjust single slit width and distances between components to optimize interference fringe.
6. Measure the interval *e* between two adjacent fringes using direct measurement microscope, also measure the distance *L* between double-slit plate and the microscope;
7. Use the known value of double-slit interval ***t*** and expression of $e = \frac{L\lambda}{t}$, so that the wavelength λ of the illumination light can be obtained.

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