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Optics-Butterfly-Phenomenon --- Double-slit, No-parallel-double-slit, Curve-double-slit, No-parallel-curve-double-slit

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Abstract: In this article, to study the mystery, we extend: the single-slit to curve-single-slit, and double-slit to non-parallel-double-slit to curve-double-slit to non-parallel-curve-double-slit experiments. We show the phenomena that the slight differences in the structures/shapes of slits produce profound different patterns, referred to it as "Optics-Butterfly-phenomenon". The "Optics-Butterfly-Phenomenon" is helpful for thoroughly understanding the interference/diffraction phenomena of the optics. It is challenge to interpret "Optics-Butterfly-Phenomenon".

Keywords: Optics-Butterfly-phenomenon, pattern evolution

INTRODUCTION

The interference and diffraction are two fundamental phenomena in optics. Feynman called the double slit experiment the only mystery in the quantum mechanics [1]. The standard interpretation of the double slit experiment is: the light propagates as plane waves before passing through the double slit, and, after passing the double slit, propagates as two waves that interfere with each other (Figure 1).

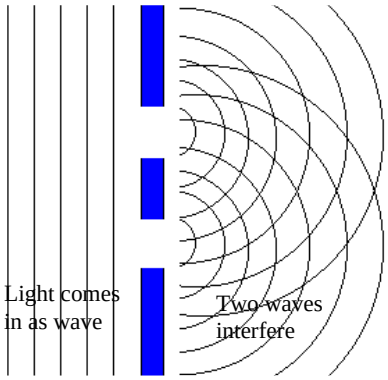


Figure 1: Standard wave interpretation of double slit experiment

In this paper, we show that the slight differences in the structures/shapes of slits produce profound different patterns, referred to it as "Optics-Butterfly-phenomenon".

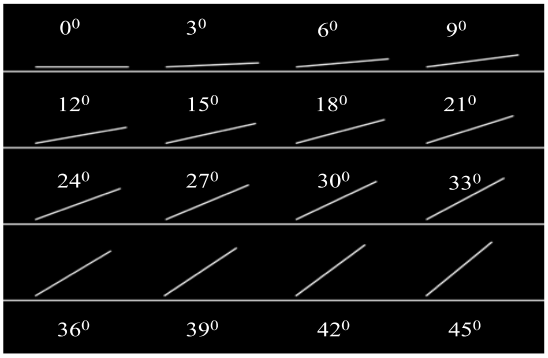
We suggest that the "Optics-Butterfly-Phenomenon" would be helpful for consistently and completely studying the interference/diffraction phenomena of optics.

OPTICS-BUTTERFLY-PHENOMENON

We extended the single-slit to cross-single-slit to curve-single slit, and the double slit to cross-double slit to non-parallel-double slit to curve-double slit to non-parallel-curve-double slit experiments (Figure 2).

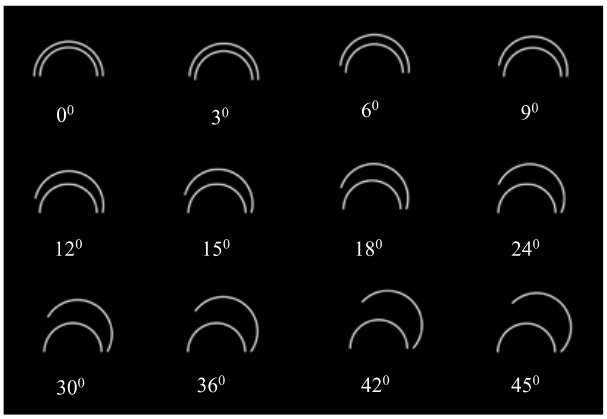
Single-slit-cross-single-slit and Curve-single-slit

Cross-double-slit



Non-parallel-double-slit

Curve-double-slit

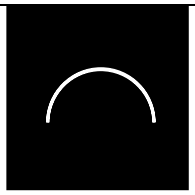
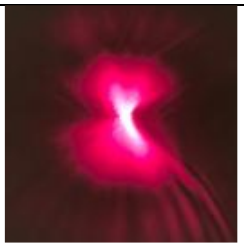
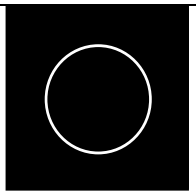
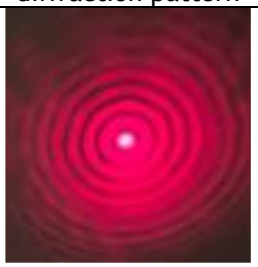
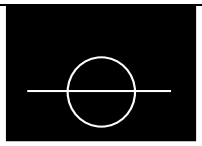
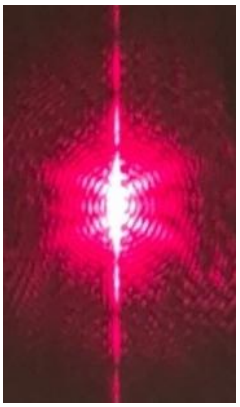
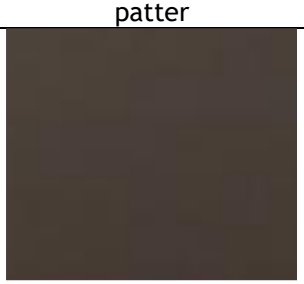


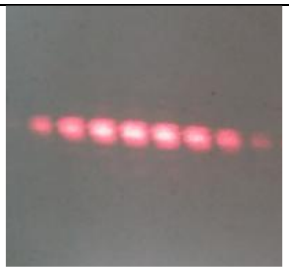
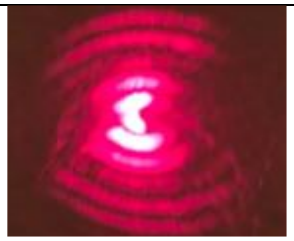
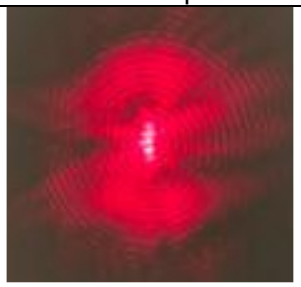
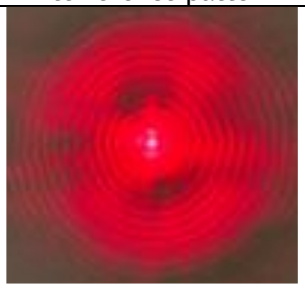
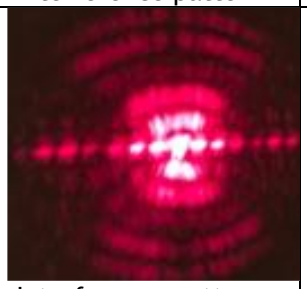
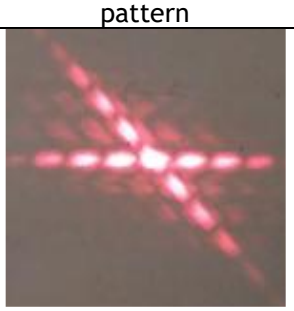
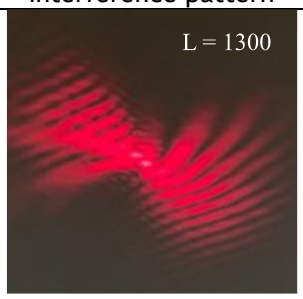
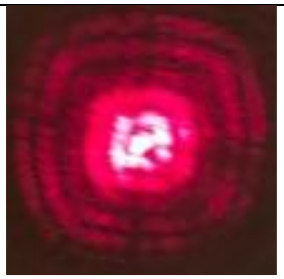
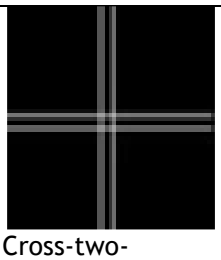
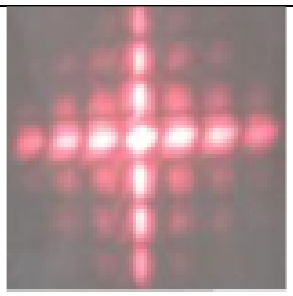
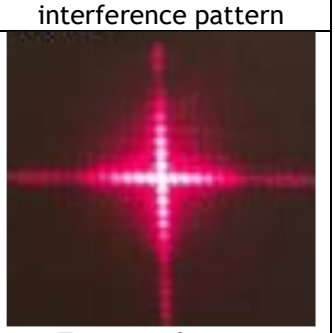
Non-parallel-curve-double-slit

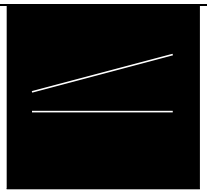
Figure 2: Different Slits

Now, we show the experiments utilizing above different slits. The experiments show that the slight differences in the structures/shapes of the slits produce profoundly different patterns (Table 1), we referred to it as **"Optics-Butterfly-Phenomenon"**.

Table 1: "Optics-Butterfly-Phenomenon"

Slit	Pattern		Slit	Pattern
 Single slit	 Diffraction pattern		 Curve-single-slit	 Hourglass-shape diffraction pattern
 Curve-single-slit	 Partial Ring-shape interference pattern		 Single-ring	 Ring-shape interference pattern
 Single-slit-cross-ring	 Interference pattern crossing ring-interference pattern		 Single-slit/curve-single-slit	 Interference pattern crossing Hourglass-shape patter
 Single-slit-cross-curve-double-slit	 Interference pattern embedded in diffraction pattern, crossing point-symmetry-interference-pattern		 Cross-single-slit	 Two diffraction patterns crossing

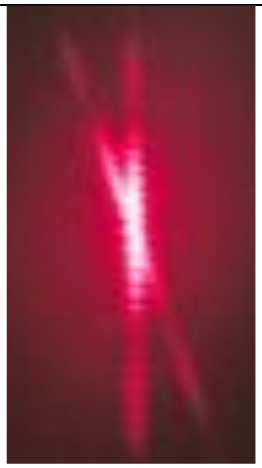
 Double slit	 Interference pattern		 Curve-double-slit	 Point-symmetry interference pattern
 Curve-double-slit	 Partial Ring-shape interference pattern		 Double-ring	 Ring-shape interference pattern
 Double-slit-cross-curve-double-slit	 Interference pattern crossing point-symmetry interference pattern		 Cross-two-double- slit	 Two interference patterns crossing
 Non-parallel-curve-double-slit	 Butterfly-shape pattern		 Curve-double-slit-cross-curve-double-slit	 Square-shape interference pattern
 Cross-two-double-slit	 Two interference patterns crossing		 Cross-two-double-slit without center-segments	 Two interference patterns crossing



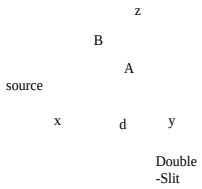
Non-parallel-double-slit

Interference pattern embeded in diffraction pattern, cross another diffraction pattern

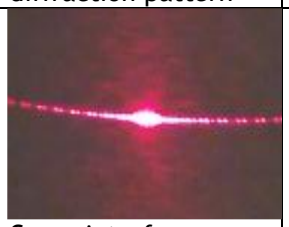
Non-parallel-triple-slit



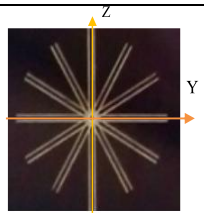
Interference pattern embeded in diffraction pattern, cross another diffraction pattern



Rotating double slit around y axis 75^0

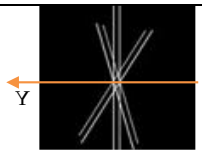


Curve interference patterns

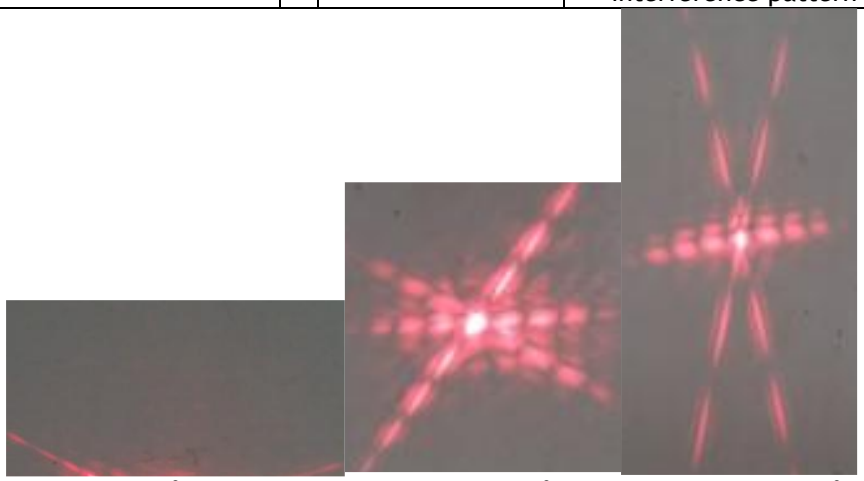


Rotating cross-double-slit around y axis 60^0

Expanded-inclined interference pattern

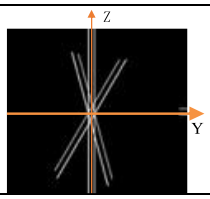


Rotating cross-double-slit around y axis



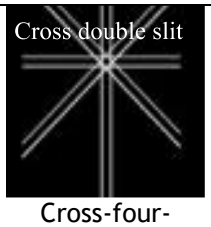
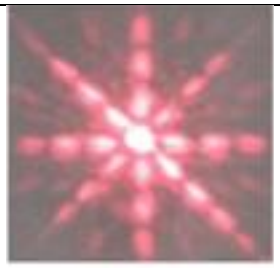
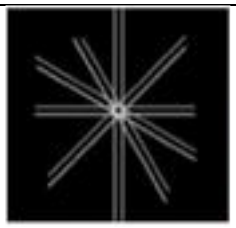
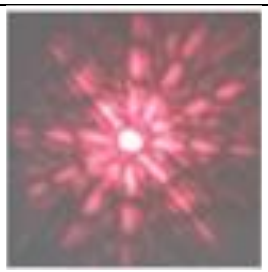
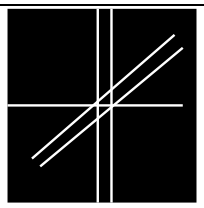
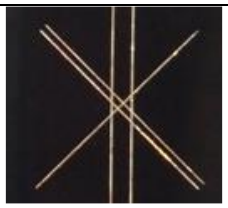
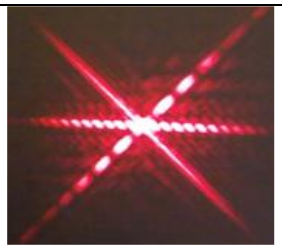
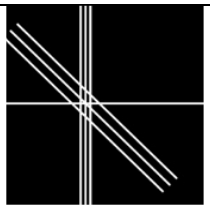
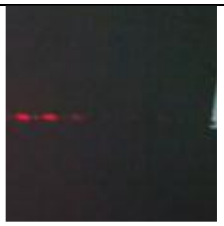
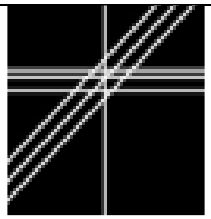
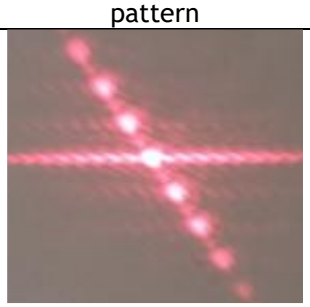
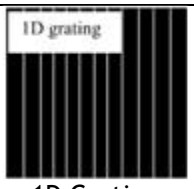
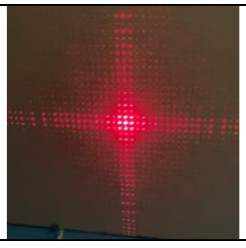
Rotating 0^0, rotating 60^0, rotating 75^0

Expanded-inclined interference pattern



Rotating 0^0, rotating 60^0, rotating 75^0

Expanded-inclined interference pattern

 Cross-four-double-slit	 Four interference patterns crossing	 Cross-five-dounle-slit	 Five interference patterns crossing
 Single-slit-cross-two-double-slit	 Diffraction pattern crossing two interference patterns	 Single-slit-cross-two-double-slits of different wides	 Diffraction pattern crossing two interference patterns of different wide double slit
 Triple slit	 Interference pattern	 Single-slit-cross-triple slit	 Interference pattern crossing diffraction pattern
 Single-slit-cross-double-slit-cross-Triple-slit	 Diffraction patterns cross interference patterns	 Double-slit-cross-Triple-slit	 Interference pattern crossing interference pattern
 1D Grating		 2D grating	

The “Optics-Butterfly-Phenomenon” is helpful for thoroughly studying the interference/diffraction phenomena of optics. It is challenge to completely interpret “Optics-Butterfly-Phenomenon”.

PATTERN EVOLUTION

Pattern Evolution of Single Slit Experiment

To study the pattern evolution, we utilize a lens.

Experiment setup: Figure 3 shows the experimental setup.

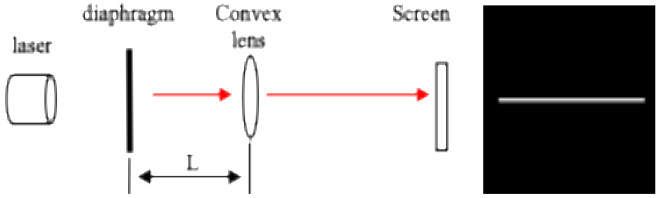


Figure 3: Experimental setup

Observation: Figure 4 shows the pattern evolution.

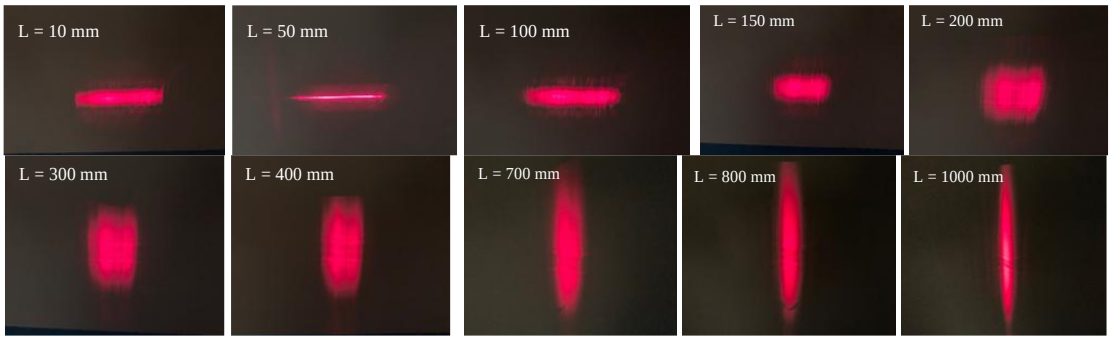


Figure 4: Evolution of pattern of single slit experiment

Figure 4 shows the Particle patterns at L = 10 - 100 mm; the Transition patterns at L = 150 – 700 mm; and the diffraction pattens at $L \geq$ 1000 mm.

Discussion: it is a challenge to intemperate how the horizontal Particle pattern (for example, at L = 50 mm) gradually evolves to the vertical diffraction pattern (for example, at L = 1000 mm)

Pattern Evolution of Double Slit Experiment

Experimental setup: Figure 5 shows the experimental setup.

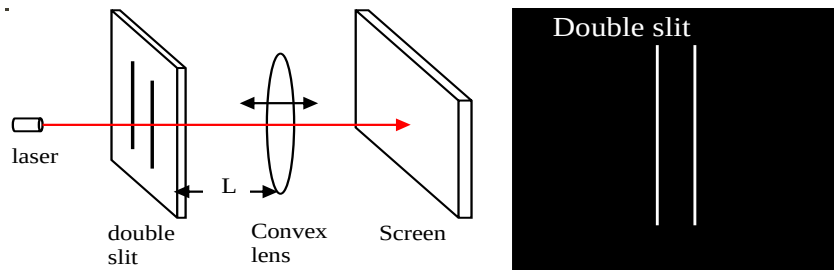


Figure 5: Experimental setup and double slits

When placing the lens at different positions L, we have the following patterns.

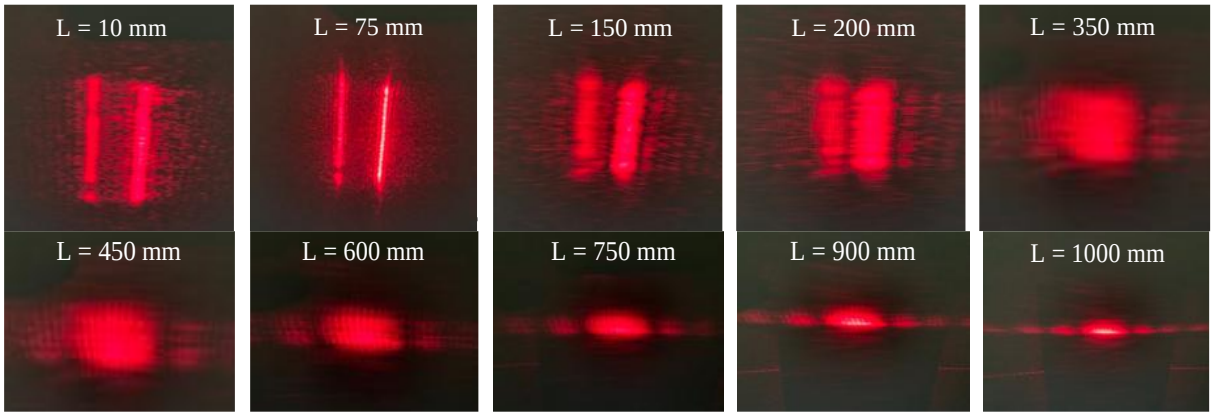


Figure 6: Evolution of patterns of double slit experiment

Observation (Figure 6): When L = 75 mm, the vertical pattern is the typical image of double-slit, referred to it as "Particle pattern". When L = 350 mm, the pattern is the typical "Transition patterns". Both the Particle pattern and the Transition patterns are the non-interference patterns and thus, indicate that the light is particles after passing through the double slit (from L = 10 mm to L = 600 mm). When $L \geq$ 750 mm, the patterns are the horizontal Interference patterns.

DISCUSSION

In this article, we show: (1) the "Optics-Butterfly-Phenomenon"; (2) The pattern evolution, i.e., from the non-interference pattern evolves to interference pattern in the same experiment. To completely and consistently interpret both the "Optical-Butterfly-Phenomenon" and the pattern-evolution is a challenge. "Optical-Butterfly-Phenomenon" is helpful for further understanding the double slit and interference phenomena of the optics.

REFERENCES

[1]. R. Feynman, R. Leighton, and M. Sands, "The Feynman Lectures on Physics" (Addison-Wesley, Reading), Vol. 3. (1965).