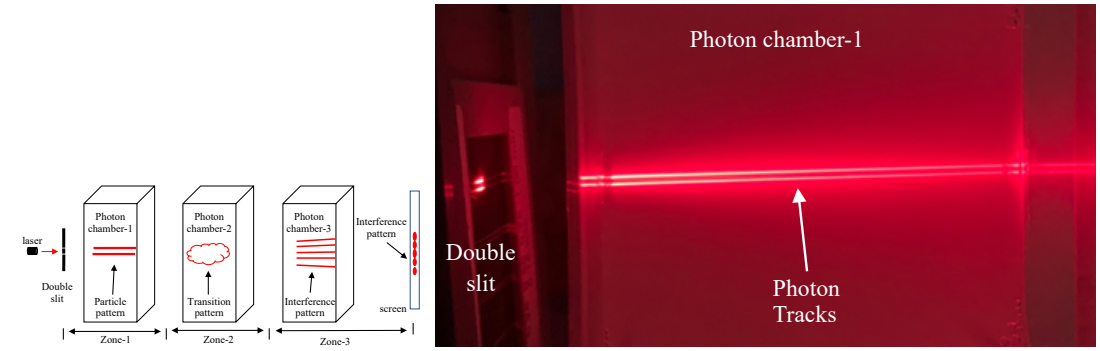
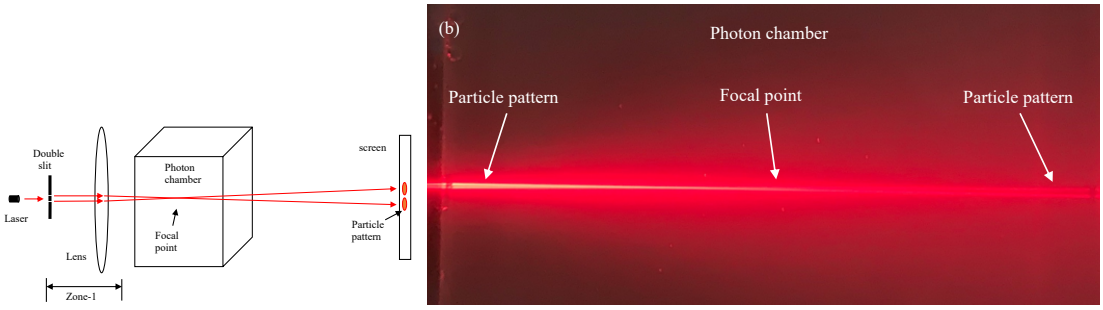
Convex Lens in Double Slit Experiment

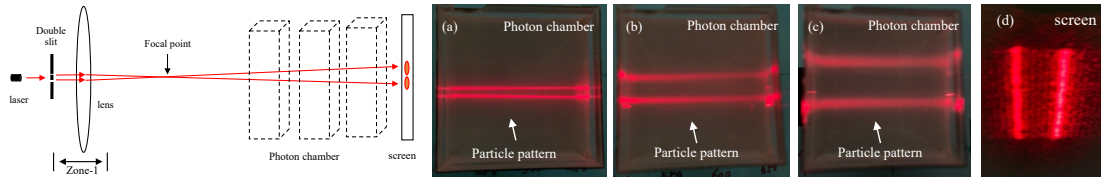
Hui Peng, davidpeng1749@gmail.com

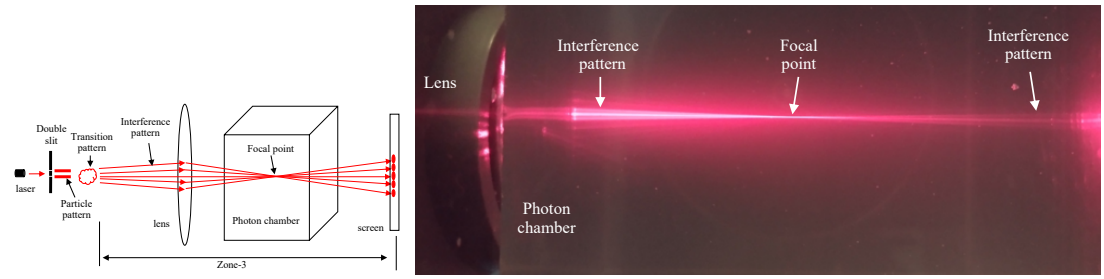
Abstract

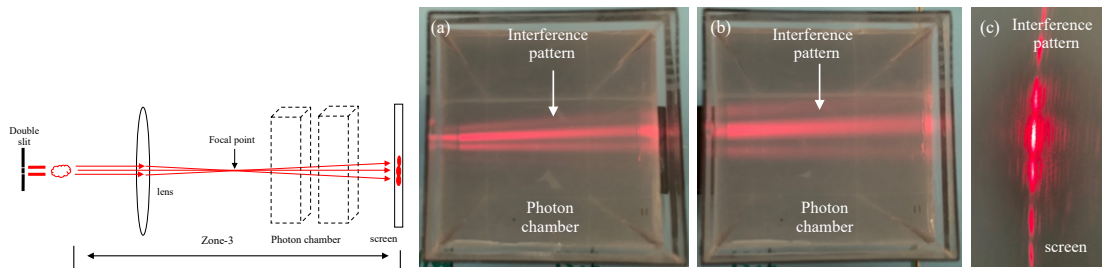
The classical interpretation of Young's double slit experiment is that, *before and after* passing through the double slit, the light behaves as waves. It is "the only mystery [of quantum mechanics] (Feynman). We proposed Postulates of convex lens for utilizing lens in wave experiments. By applying convex lens, we observed new phenomena of the double slit experiments, and referred as "new mystery".











In this article, we show the focal point related phenomena attribute to a thin lens, and confirm Postulates of convex lens. The combination of Postulates of the convex lens and the geometrical theory of the lens may describe the function of the lens in the wave experiments. The convex lens is helpful in studying the mystery of the double slit experiment. It is the challenge to interpret the convex lens related phenomena in the wave experiments.

Keyword: convex lens, double slit experiment, focal point, interference pattern, non-interference pattern, geometric optics, physical optics

1. Introduction

As a geometrical optical device, the lenses are also used in physical optics. To determine/calculate the intensity distribution for the interference/diffraction patterns produced in a wave experiment, the convex lenses are utilized. For this purpose, it was assumed that the function of the convex lens is to bring parallel light rays to a focal point *P* on the screen [1], as shown in Figure 0. This assumption is based on: (1) the geometrical optical theory of the lens; (2) the patterns of the wave experiments are distance-independent.

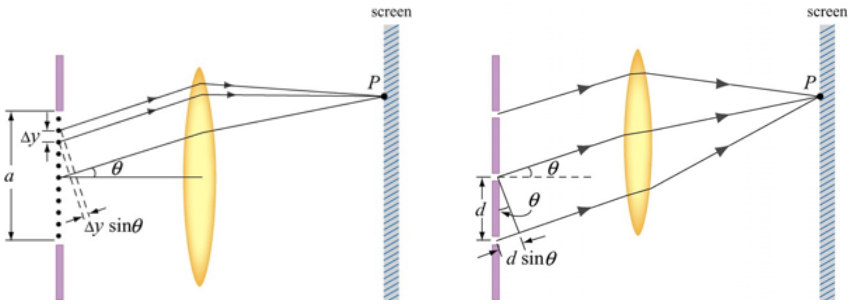


Figure 0. Single-slit and grating diffractions

For an object, the above assumptions are valid, since the image of the object does not change.

However, as we have shown, the patterns in the wave experiments are distance-dependent, i.e., the natures and characteristics of the patterns change with distance from the diaphragms of the wave experiments.

Recently, for applying the convex lenses in the wave experiments, we proposed Postulates of convex lens and then, shown for the first time that in the classical wave experiments: (1) near the diaphragm the patterns are Particle patterns, which are non-interference patterns indicating the particle nature of light; near the screen, the patterns are Interference patterns; (2) Particle patterns evolve to Transition patterns that are also non-interference patterns, and then, evolve to Interference patterns; (3) the nature and characteristics of the patterns are position-dependent. We referred the above phenomena as "new mystery" [4].

In this article, we further study how the convex lens functions in the wave experiments.

2. Reviewing Postulates of convex lens

2.1. Postulates: precise rules of convex lens in wave experiments [2,3]

The theory of convex lens is a part of the geometrical optics. In standard Textbook, the theory of the convex lens is directly applied to the wave experiments of the physical optics.

Utilizing a convex lens to study the evolution of patterns, we propose new Postulates of convex lens. In the classical wave experiments, the diaphragm stays at the same location. The light coming out the slits has the certain pattern. But we will show that the pattern changes with the distance from the

diaphragm.

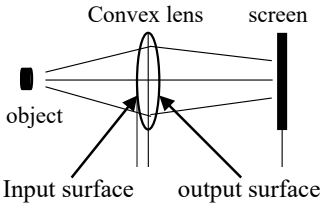


Figure 1. Convex lens enlarges the image arriving at its "input surface"

To study the evolution of the patterns, the convex lens moves and thus, the patterns arriving at the input surface of the convex lens (Figure 1) change. Namely, the light patterns arriving at the input surface of the convex lens are different.

Based on above consideration, we suggest the postulates.

Postulates: Experiments in this article are based on Postulates and confirm them.

(1) the convex lens enlarges the input image that arrives at the input surface.

(2) The convex lens breaks the evolution of the patterns.

(3) The convex lens does not change the nature of the input pattern.

Example-1: for a regular object, the shape of the image of the object does not change. Thus, the input image, that arrives at the input surface of the convex lens, is the same image of the object.

Example-2: for the wave experiments, for example, the double slit experiment, the input image that arrives at the input surface of the convex lens is the pattern that is distance-dependent and thus, the shapes of the input images are different, even in the same experiment.

Example-3: After passing a convex lens, the patterns keep the same nature: e.g.,

(a) if the input patter is a particle pattern, the output pattern is still the particle pattern, and vice versa;

(b) if the input patter is a transition pattern, the output pattern is still the transition pattern, and vice versa;

(c) if the input patter is an interference pattern, the output pattern is still the interference pattern, and vice versa.

2.2. Three Zones [2,3]

For convenience, we review the Zone. We divide the space between the source and screen into four Zones (Figure 2).

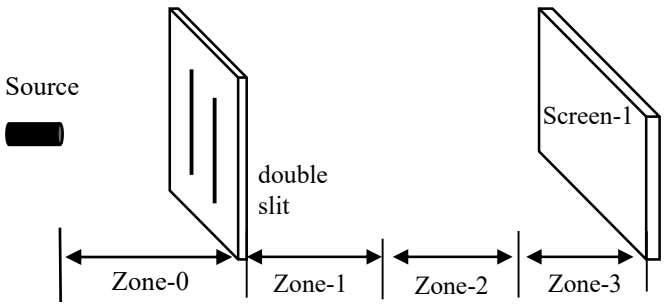


Figure 2. Four Zones

(1) **Zone-0**: between the source and the diaphragm, in which the pattern is non-wave;

(2) **Zone-1**: near the double slit, in which the pattern is *non-interference*, referred the pattern as the ***particle pattern*;**

(2) **Zone-3**: near the screen, in which the patterns are ***interference patterns***;

(3) **Zone-2**: transition Zone, between zone-1 and zone-3, in which the particle pattern evolves to the

interference pattern, referred the patterns as the ***transition patterns*** that are also the non-interference pattern.

Note that the boundaries between different Zones are not clearcut. Patterns evolve from one Zone to next gradually.

3. Double Slit Experiments

3.1 Experiment without lens

Experiment-1 (Figure 3 and Figure 4):

Experimental setup (Figure 3). Photon chamber-1, Photon chamber-2 and Photon chamber-3, the dimensions of three photon chambers are 50x50 mm, are placed in Zone-1, Zone-2 and Zone-3 respectively. For comparing with Experiments with lenses below, in Experiment-1, no lens is utilized.

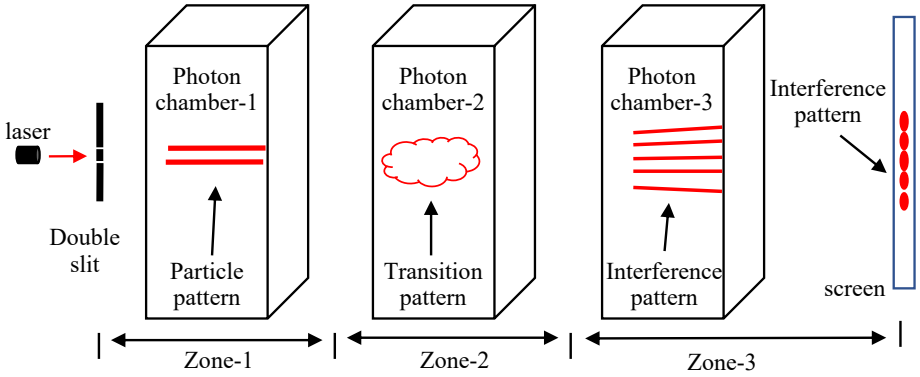
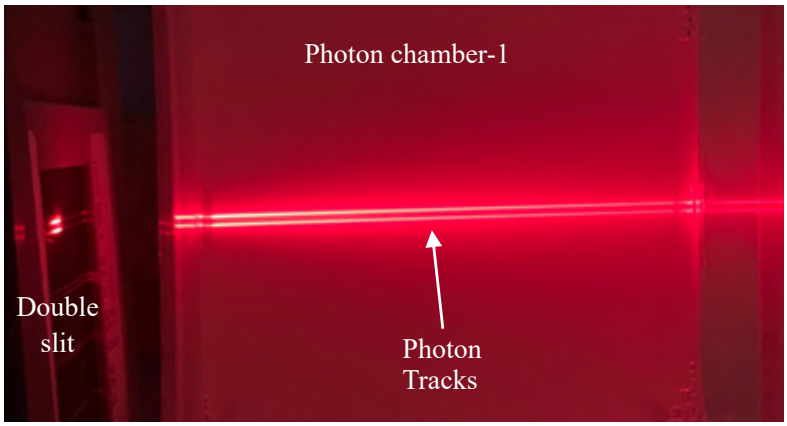
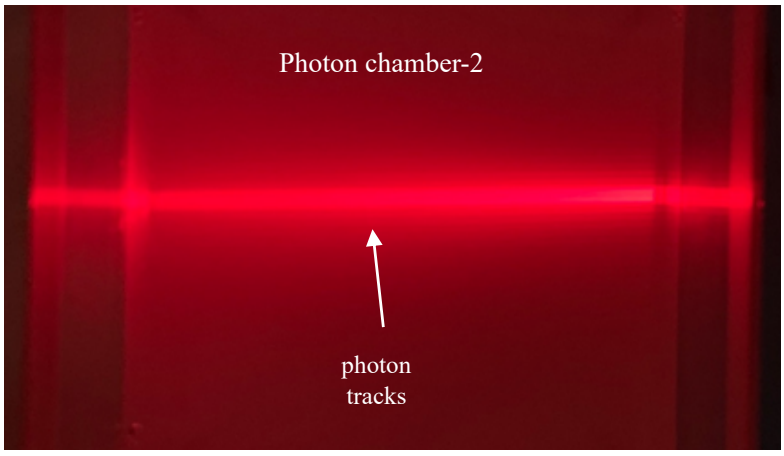


Figure 3 Schematic of Experimental setup





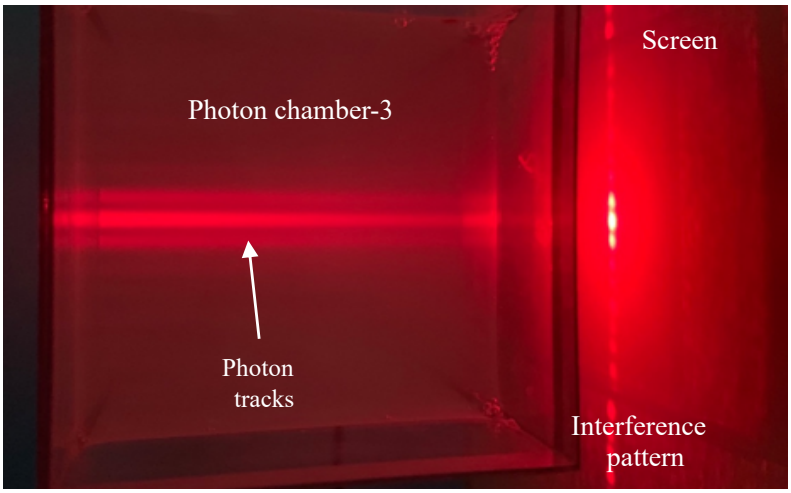


Figure 4 Patterns in different Zones

Observation: Photon chamber-1 shows the top view of the photon tracks distributing as Particle pattern. Photon chamber-2 shows the top view of the photon tracks distributing as Transition pattern. Photon chamber-3 shows the top view of the photon tracks distributing as Interference pattern.

Conclusion: The lens enlarges the pattern arriving at its input surface, but does not change the nature of the pattern. The nature and characteristics of the patterns are distance dependent. The light beams are photons, not waves. And photons distribute as wave, which is a challenge to explain.

3.2. Experiment: Placing lens in Zone-1

Experiment-2 (Figure 5 and 6): Note that in all experiments below, utilizing the lens of $F = 50$ mm. We have shown that, in Zone-1, the pattern is Particle pattern [2,3]. So, first, we place a lens in Zone-1.

Experimental setup (Figure 5)**:** Placing the lens in Zone-1. The dimension of the photon chamber is 100x100 mm.

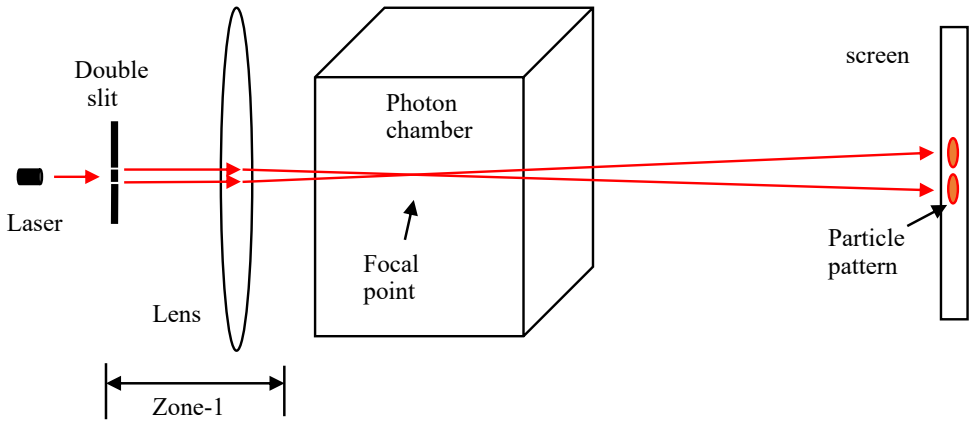


Figure 5 Experimental setup:
two light beams (Particle pattern) brought to focus by convex lens

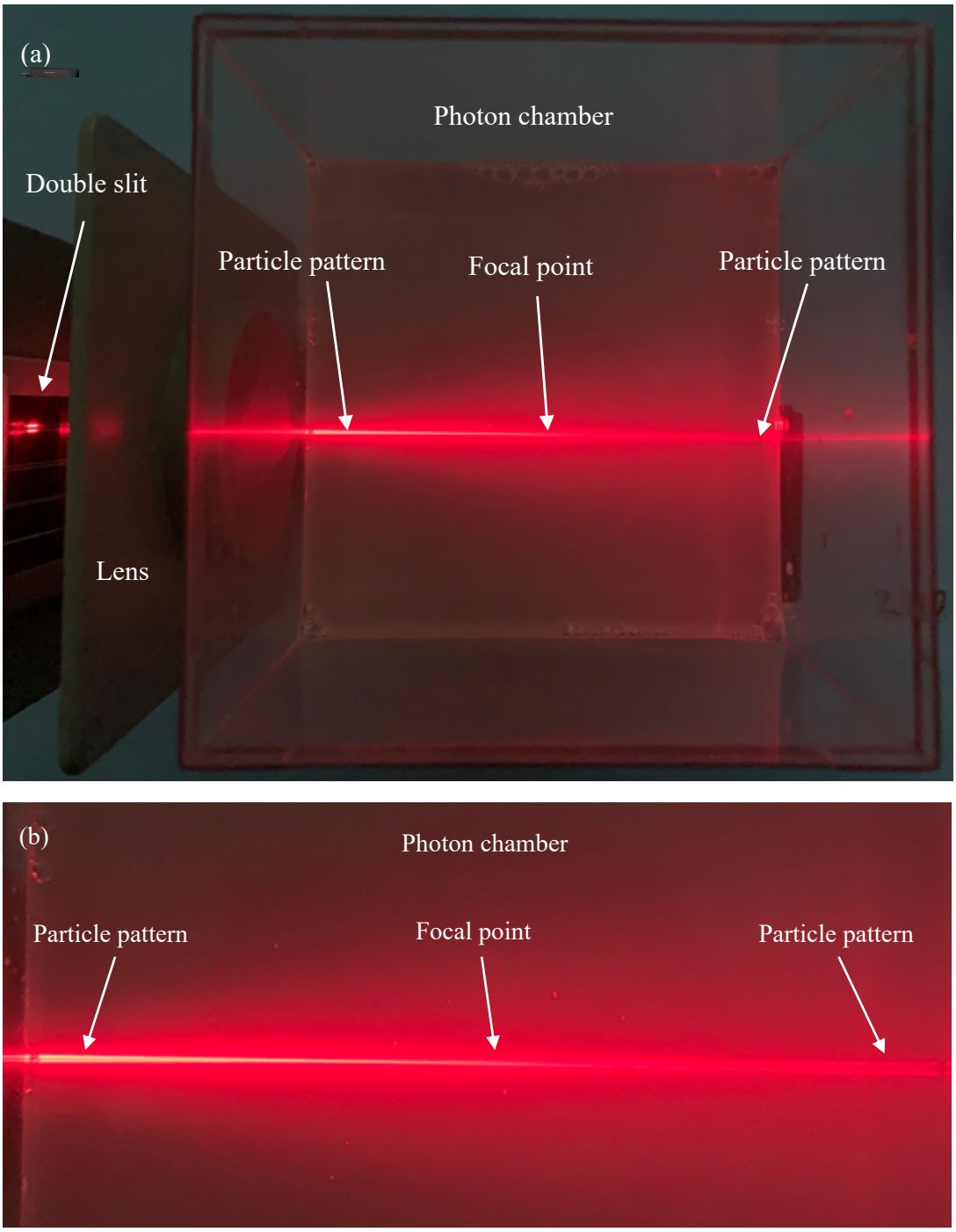


Figure 6 Light beams (Particle pattern) brought to focus by convex lens

Observation: the focal point is observed in the photon chamber, and obeys the geometrical thin lens theory. The focal point portion of the pattern of Figure 6(a) is enlarged in Figure 6(b). The pattern formed at the focal point is not Particle pattern.

Experiment-3 (Figure 7 and Figure 8):

Experimental setup (Figure 7)**:** Placing the lens in Zone-1, and the photon chamber in Zone-3. The photon chamber takes different positions in Zone-3. The dimension of the photon chamber is 50x50 mm.

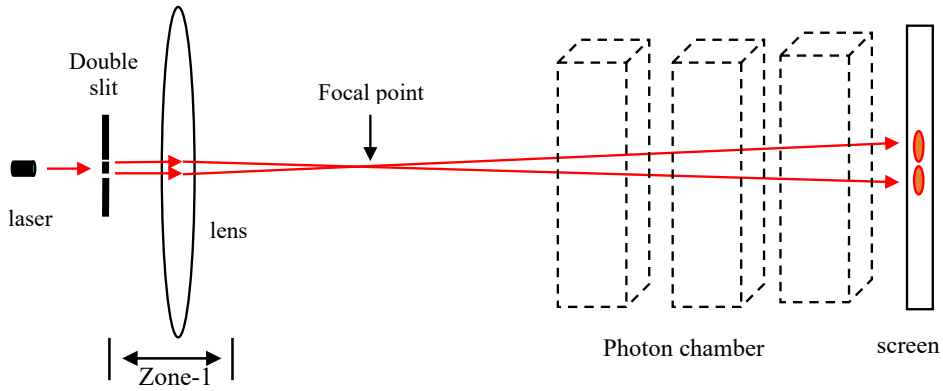


Figure 7 Experimental setup: Lens placed in Zone-1 and photon chambers placed in Zone-3

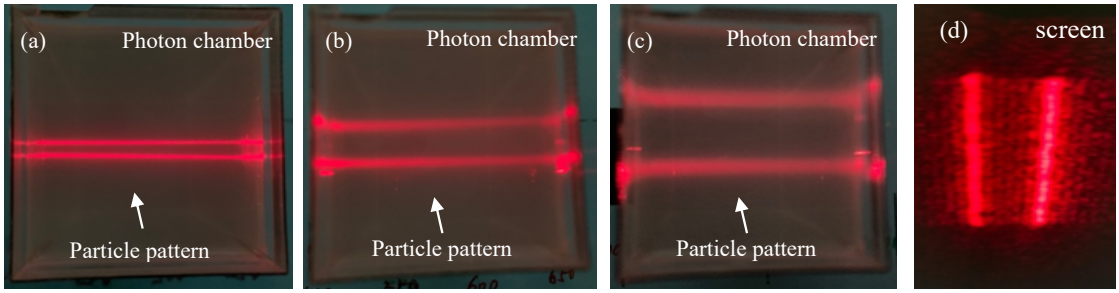


Figure 8 Particle patterns (photon chamber placed at difference positions)

Observation (Figure 8): Figure 8 (a), (b) and (c) show the top view of the photon tracks of Particle patterns in the photon chamber, when placing the photon chamber at the difference distance from the lens: the farther the larger pattern. Figure 8 (d) shows the cross-section view of Particle patterns on the screen.

Conclusion: the lens enlarges the pattern arriving at its input surface, but does not change the nature of the pattern. The lens stops the evolution of the patterns. Postulates are confirmed experimentally. The pattern at the focal point is neither interference pattern nor non-interference pattern.

3.3. Experiment: Placing lens in Zone-3

We have shown that the interference patterns show in Zone-3. Now let us place the lens in Zone-3. The purpose is to prove that the lens enlarges the patterns arriving at its input surface.

Experiment-4 (Figure 9 and Figure 10):

Experimental setup (Figure 9). Let us place the lens in Zone-3. Using 100x100 mm photon chamber.

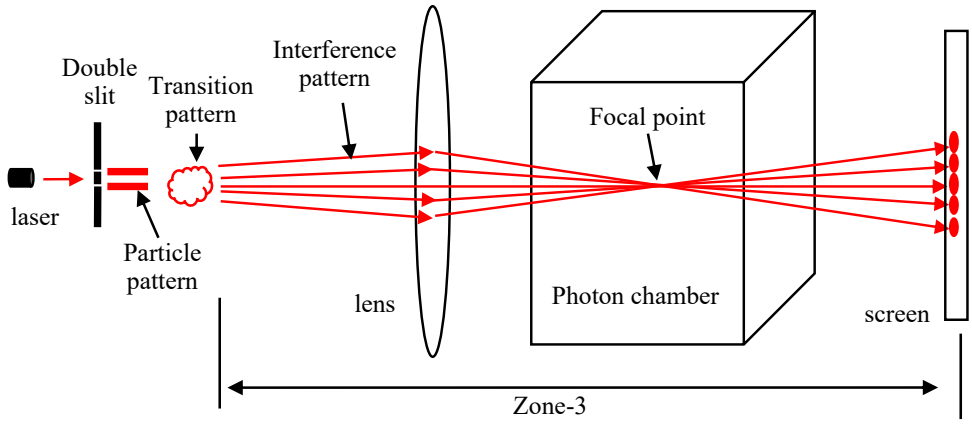


Figure 9 Experimental setup:
light beams (Interference pattern) brought to focus by convex lens

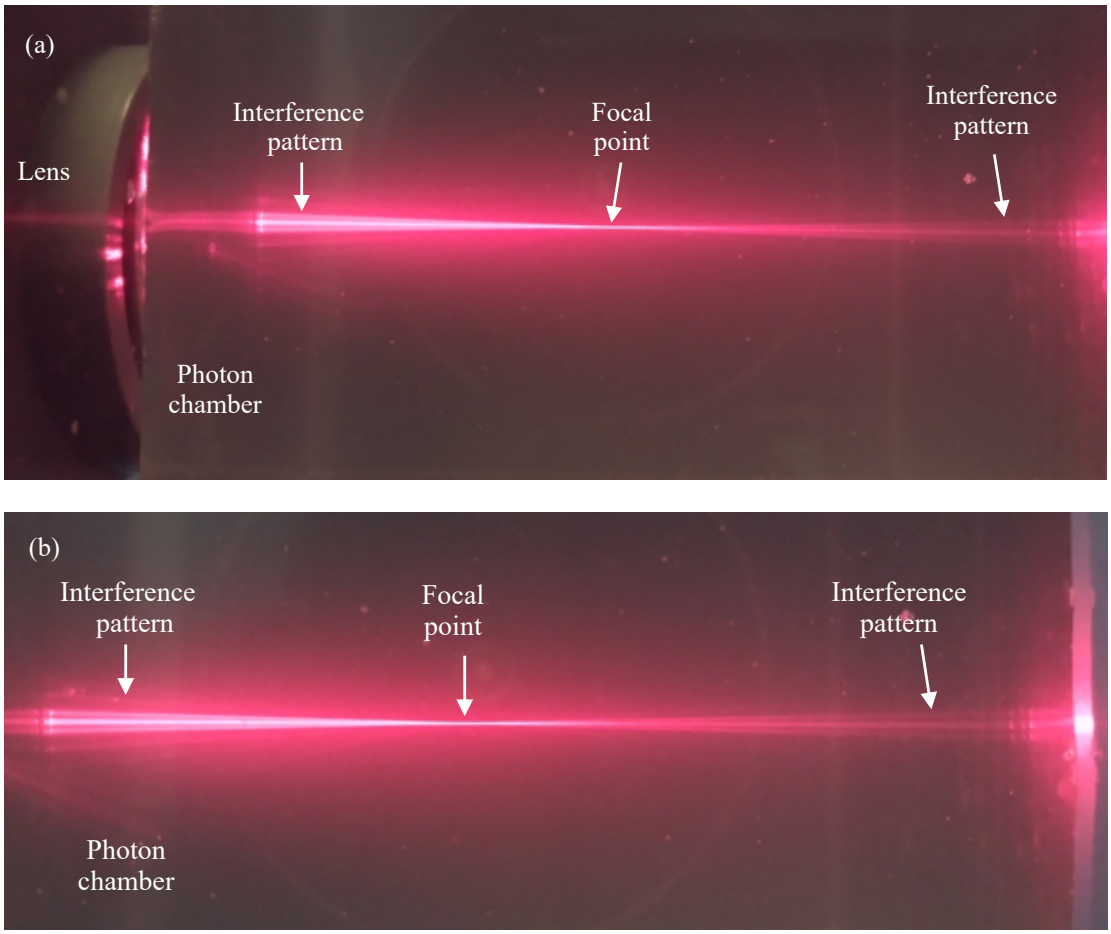


Figure 10 Light beams (Interference pattern) brought to focus by convex lens

Observation: the focal point is observed in the photon chamber, and obeys the geometrical thin lens theory. The focal point portion of the pattern of Figure 10(a) is enlarged in Figure 10(b). The pattern formed at the focal point is not an interference pattern.

Experiment-5 (Figure 11 and Figure 12):

Experimental setup (Figure 10)**:** Placing both the lens the photon chamber in Zone-3, such that the patterns are the interference patterns. The photon chamber takes different positions in Zone-3. Using the 50x50 mm photon chamber.

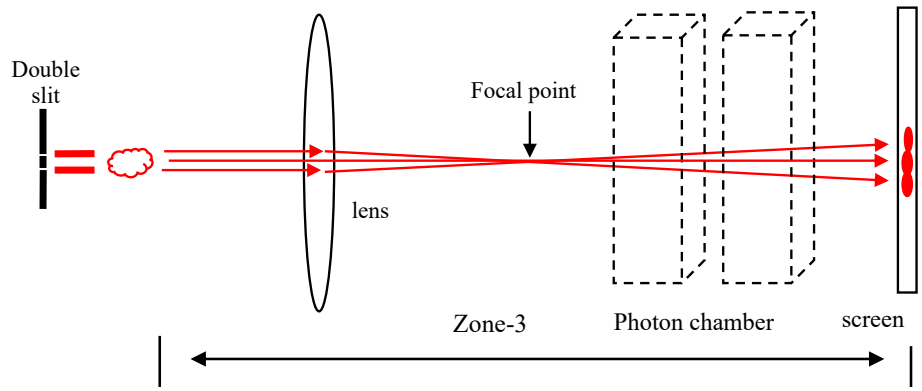


Figure 11 Experimental setup: Both lens and photon chambers placed in Zone-3

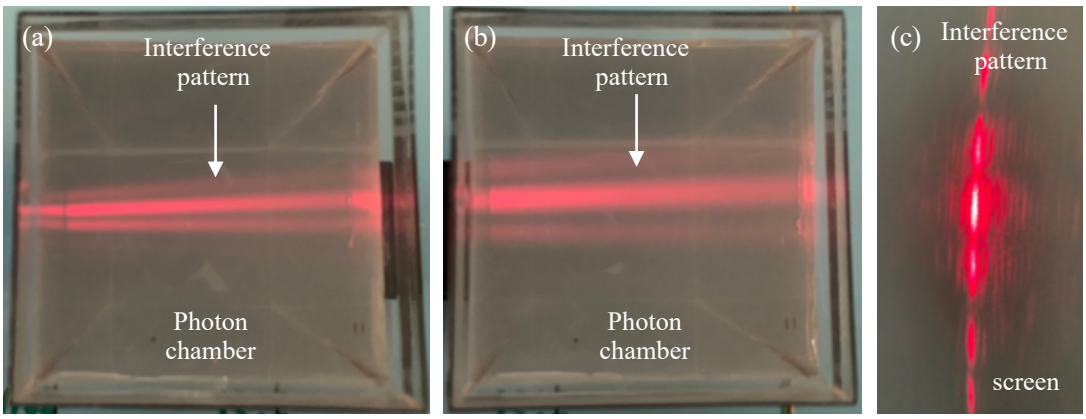


Figure 12 Photons distributing in photon chambers and on screen as interference patterns

Observation (Figure 12): Figure 12 (a) and (b) show the top view of the photon tracks distributing as Interference patterns in the photon chamber, when placing the photon chamber at the difference distance from the lens: the farther the larger. Figure 12 (c) shows the Interference patterns on the screen.

Conclusion: the lens enlarges the pattern arriving at its input surface, but does not change the nature of the pattern. The lens stops the evolution of the patterns. Postulates are confirmed experimentally.

Experiment-6 (Figure 13 and Figure 14): lens is placed in Zone-3. Arranging the photon chamber of 50x50 mm, such that the focal point is on the right-side wall of the photon chamber (Figure 13).

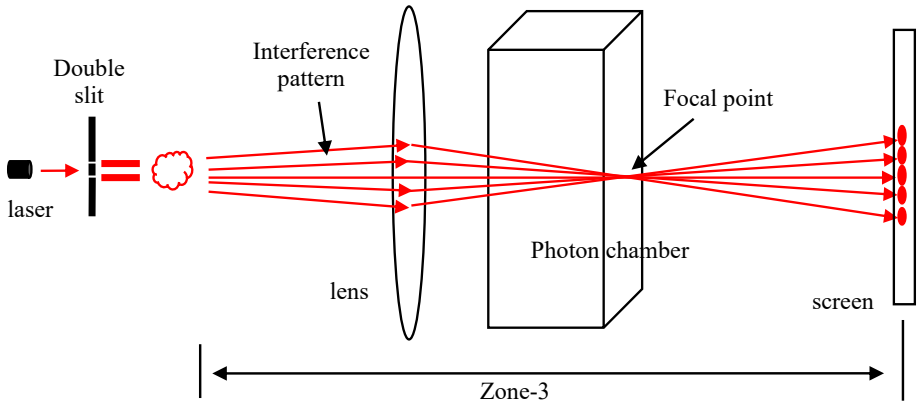


Figure 13 Experimental setup: the focal point at right-side wall of photon chamber

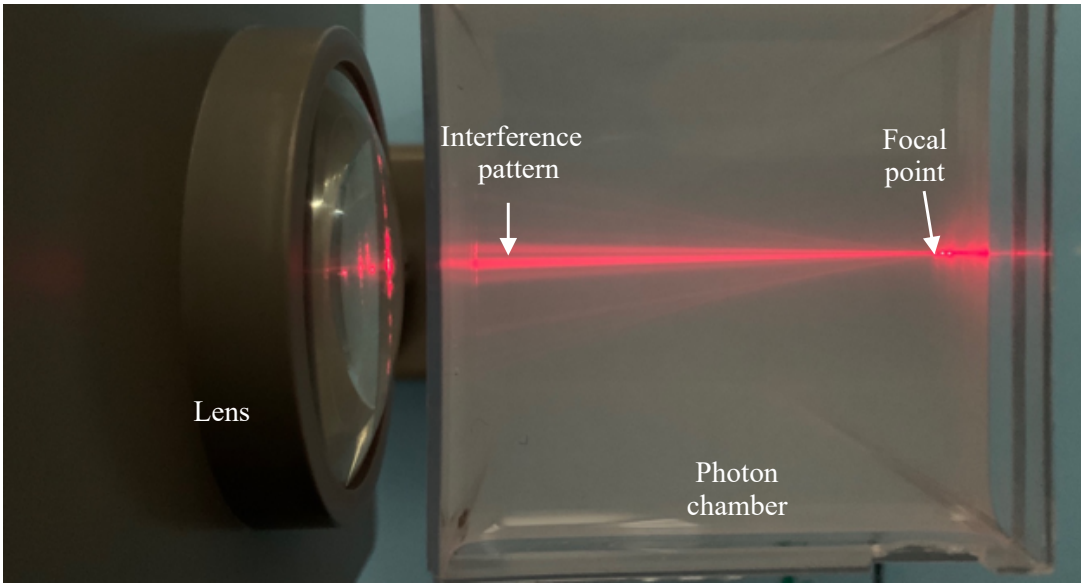


Figure 14 Light beams brought to focus at right-side wall by convex lens in double slit experiment

Observation: after the interference pattern incidents in the photon chamber, the focal point is formed on the right-side wall. The pattern formed at the focal point is not an interference pattern.

Experiment-7 (Figure 15 and Figure 16): lens is placed in Zone-3. Arranging the photon chamber of 50x50 mm, such that the focal point is on the left-side wall of the photon chamber (Figure 15).

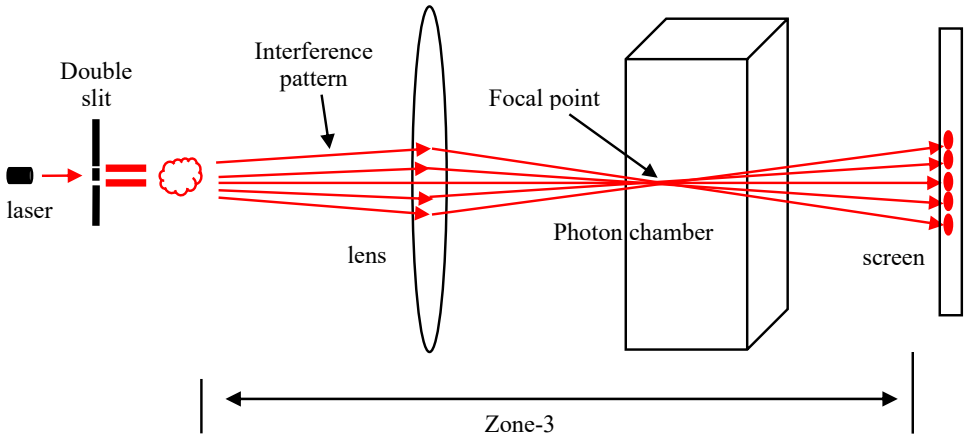


Figure 15 Experimental setup: the focal point at left-side wall of photon chamber

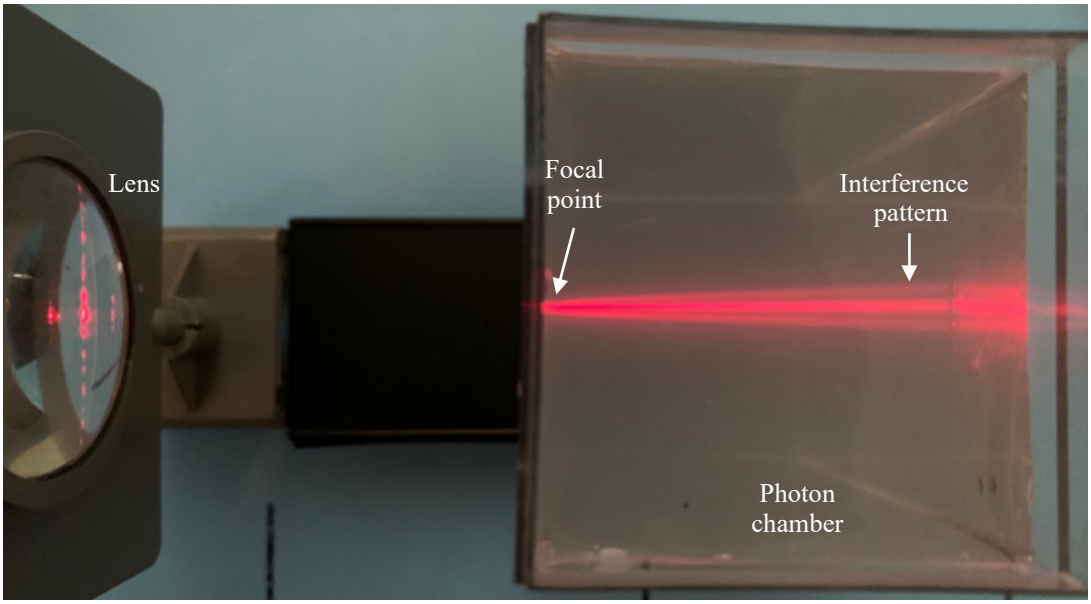


Figure 16 Light beams brought to focus at left-side wall by convex lens

Observation: after the interference pattern incidents in the photon chamber, the focal point is formed on the left-side wall. The pattern formed at the focal point is not an interference pattern.

3.4. Experiment: Placing lens in Zone-2

We have shown that Transition patterns show in Zone-2. Now let us place the lens in Zone-2. The purpose is to prove that the lens enlarges the patterns arriving at its input surface, and stops the evolution of the pattern.

Experiment-8 (Figure 17 and Figure 18):

Experimental setup (Figure 17). Let us place the lens in Zone-2. Using 100x100 mm photon chamber.

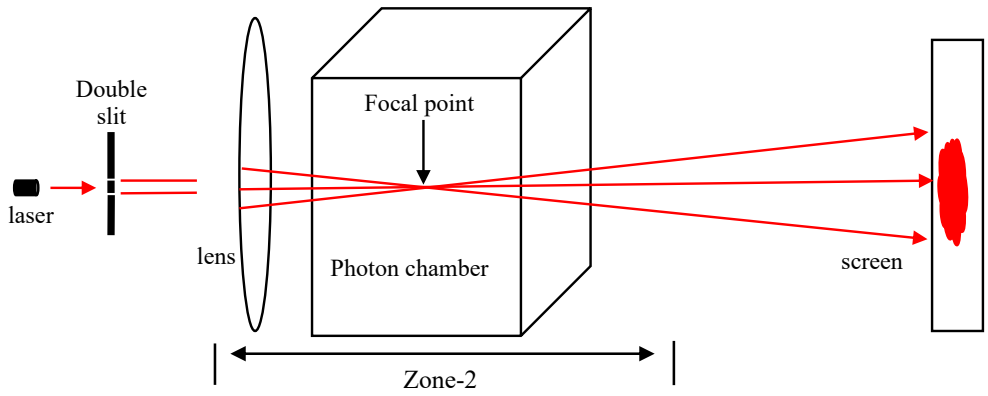
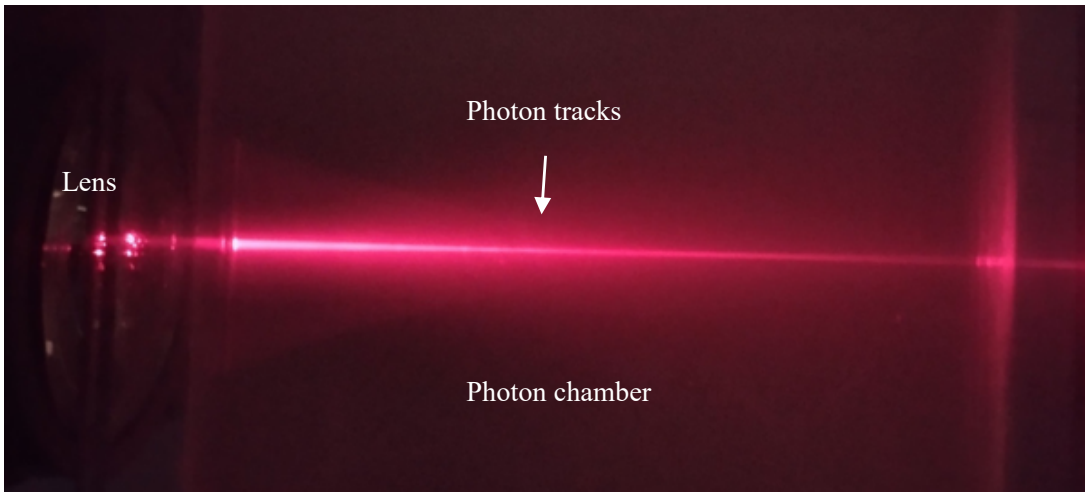


Figure 17 Experimental setup: lens placed in Zone-2



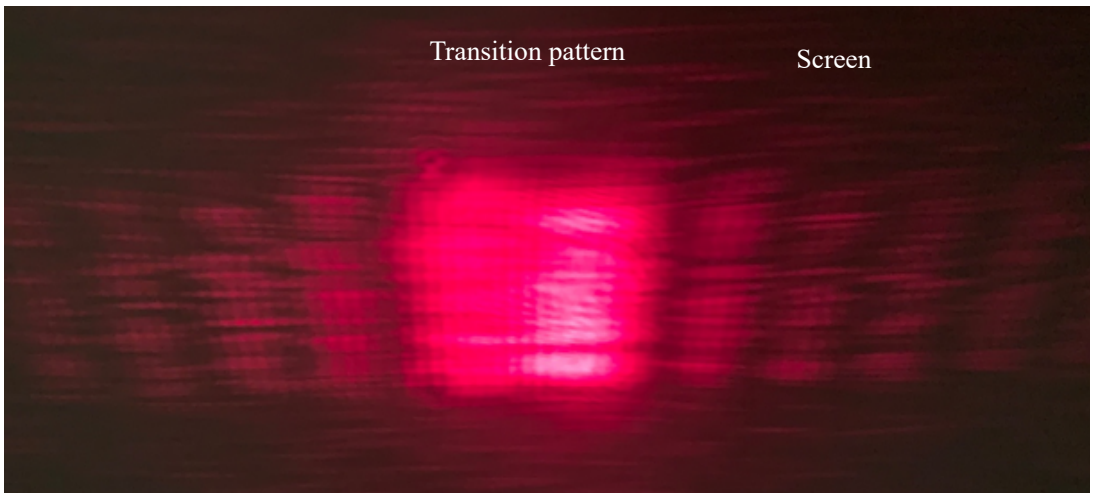


Figure 18 Patterns

Observation: Figure 18 shows Transition patterns in the photon chamber and on the screen, respectively. Note that there is no sharp focal point shown in the top figure of Figure 18.

3. Summary

As we show in this article, one of the functions of the convex lens in the double slit experiments is to bring the light rays to the screen, not to the focal point of the lens. Also, as shown in this article, the pattern formed at the focal point is neither interference pattern nor non-interference pattern.

We suggest that the combination of Postulates of convex lens [2,3] and the geometrical theory of the lens may be used to describe the functions of a convex lens in the double slit wave experiments.

Reference

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